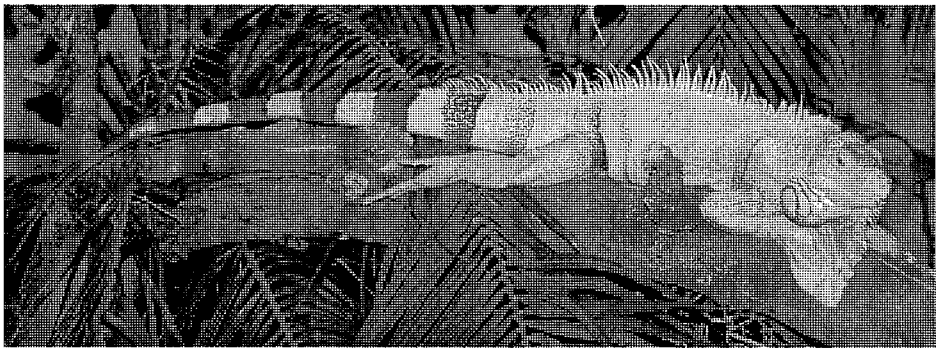
Dear Teacher,

Amphibians and reptiles have existed on earth for millions of years and were the first vertebrate animals to colonize land. These animals exhibit a variety of adaptations and are key players in many of the world's habitats. For these reasons, reptiles and amphibians provide diverse opportunities for teaching and learning about the natural world.

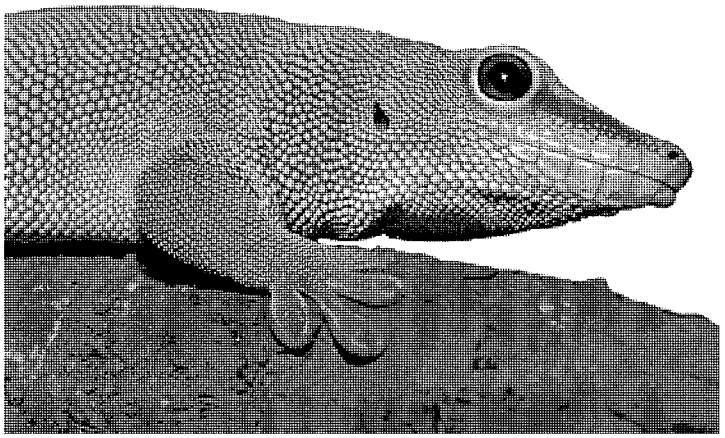


green iguana — Agnes Overbaugh

This packet was designed to provide you with thorough background information and multidisciplinary activities about reptiles and amphibians. With this information, and these activities, you can help your students gain an awareness, understanding and appreciation of reptiles and amphibians and their habitats. Today, reptiles and amphibians face increasing threats to their survival. It has recently come to light that many species of amphibians around the world have suffered drastic population declines. There have also been several discoveries surrounding deformities and other health issues in reptiles and amphibians. Amphibians, especially, and reptiles, as well, can be key indicators of the health of the environment. By understanding the characteristics and habitat requirements of reptiles and amphibians, we can increase our awareness of the world around us, our impacts on the environment, the health of ecosystems, and ultimately how the health of the environment affects our own health and well-being. By becoming aware of how our actions and choices affect the earth's habitats and species, we can become better stewards of the earth's habitats, plants and animals such as reptiles and amphibians.

This packet includes:

- Teacher background information
- Vocabulary list
- Resources list
- Activities
- Animal fact sheets



day gecko — Gerry Ellis

Please call the zoo's Teacher Resource Center at (206) 684-4850 if you have any questions or would like additional information.

We hope this packet will make the study of reptiles and amphibians inspiring and enjoyable for you and your students.

Thank you to The Boeing Company, Washington Mutual and the Western Pond Turtle Project for supporting the production of this packet.

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Reptiles & Amphibians

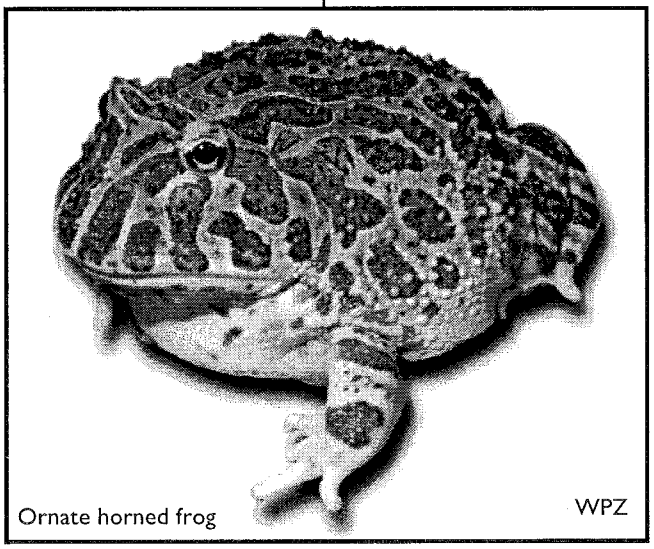
Introduction

If you heard the word "**herpetology**," would you guess that it refers to the study of reptiles and amphibians? The word herpetology is derived from a Greek word, "herpeton," which means "crawling thing." Although reptiles and amphibians are not closely related taxonomically, these two groups of animals are often considered together in books and other materials, as they are in this teacher packet. This may be due to the fact that some amphibians and reptiles, such as salamanders and lizards, closely resemble one another. Amphibians and reptiles do have some similarities: most species of reptiles and amphibians lay eggs, both reptiles and amphibians are vertebrates, and both are **ectothermic** (often called "cold-blooded"), meaning they rely on the outside environment to control their body temperature. But there are also many significant differences between reptiles and amphibians, from their body structures to the habitats to which they are adapted.

This packet will explore the worlds of amphibians and reptiles, looking at taxonomic classification, life cycles, physical characteristics and adaptations of these two classes of animals. Both reptiles and amphibians are faced by specific, human-posed threats throughout the world. This packet will examine some of these threats and their effects on populations of amphibians and reptiles. More specifically, we will investigate reptiles and amphibians of Washington state, discovering why some of them have become endangered and what each one of us can do to ensure their continued survival.

Amphibians

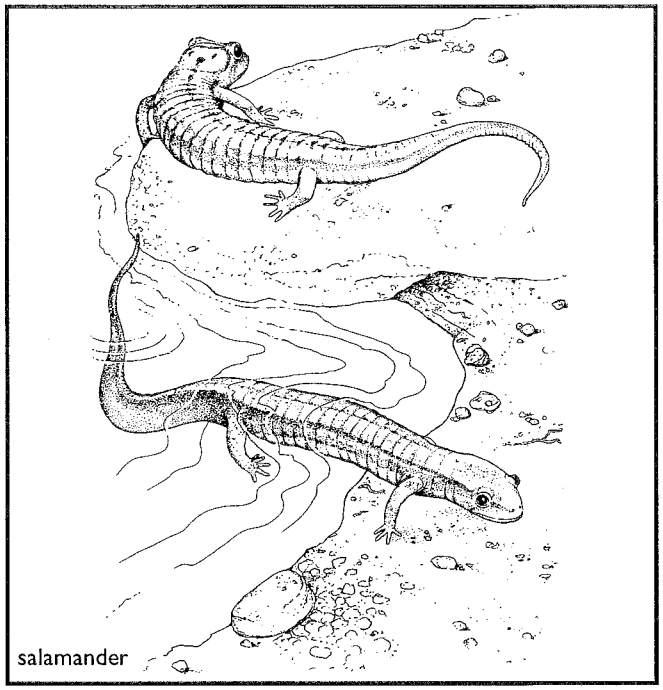
Most people are probably familiar with the word "amphibious," which refers to the ability to live or function in water and on land, and is derived from Greek words "amphi" meaning "both" and "bios" meaning "life." "Amphibian" is the word for a class of animals, Amphibia, that literally lives a double life — with a gilled, aquatic **larval** stage and, usually, an air-breathing, terrestrial adult stage. However, there are some species of amphibians that are strictly aquatic throughout their lives and others that are strictly terrestrial. Taxonomically, amphibians are considered to be an intermediate form between fish and reptiles, exemplified by the presence of gills in the larval stage and lungs in the adult stage. There is no single, broad defining characteristic that sets amphibians apart from other animals, but the following paragraphs will explore some of the characteristics shared by most amphibians. The fact that there are exceptions to every "rule" used to define amphibians is a testament to their diversity and to how they have adapted to survive in many different habitats. Amphibians are considered to be the first vertebrates to have colonized land. This occurred during the late Devonian period, approximately 360 million years ago, and over the subsequent 140 million years amphibians became a very diverse group. During those years, amphibians had little competition on land and were the dominant terrestrial life form. Currently there are approximately 4,550 species of amphibians inhabiting the earth (Stebbins and Cohen, 1995).



Ornate horned frog WPZ

Life Cycle

As implied by the name "amphibian" the life stages of these animals differ significantly from each other, both in appearance and mode of living. Most amphibians hatch from eggs laid in water or in moist areas. Amphibian eggs, unlike reptile and bird eggs, lack protective shells to retain moisture. Thus, amphibian eggs must remain in water or in very moist areas so that they do not dry out. The eggs do, however, include a large yolk that serves to nourish the embryo and a gelatinous coating which supports the eggs, can stick the eggs to substrates such as plants, and protects the eggs


salamander

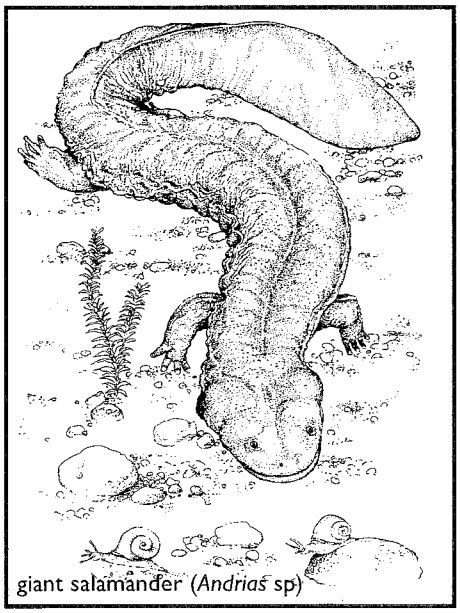
from damage. Amphibian eggs may be clear or pigmented. Generally, eggs that are pigmented are laid in open areas exposed to the sun. The pigment, which is often only present on the upper surface of the eggs, may help to protect the eggs from ultraviolet radiation. Eggs lacking pigment are usually laid in protected places out of direct sun.

In the case of most species, larval amphibians hatch from the eggs. In the larval stage, most amphibians inhabit water and breathe oxygen by way of gills. Frog and toad larvae, commonly called tadpoles, have tails but do not have legs, while the larvae of salamanders and newts have tails but also have four legs. Before reaching adulthood (sexual maturity), most amphibians go through **metamorphosis**, a process of abrupt development. Frog and toad larvae lose their gills and tails and develop legs. Salamanders and newts, which already have legs as larvae, also lose their gills, but they retain their tails. Most species of amphibians develop lungs as they lose their gills. When metamorphosis is complete, amphibians are sexually mature and most species leave the water to live terrestrial adult lives. In caecilians, a group of legless amphibians, the aquatic larvae of some species have gills, functioning eyes and a finned tail. Through metamorphosis the gills are lost, the eyes degenerate, and in some species the tail is also lost.

Many amphibians undergo processes of development different than the usual cycle of egg, aquatic larva, metamorphosis to terrestrial adult. Descriptions of these processes are given in the paragraphs on the three orders of amphibians in this packet.

In species of salamanders that do not undergo complete metamorphosis, the larvae develop into sexually mature adults with legs but retain their gills and continue to live in the water. This is an example of **neoteny**, when larval characteristics are retained into adulthood. One example is the Cope's giant salamander (*Dicamptodon copei*) of western Washington, in which the larvae almost never metamorphose completely but rather live as neotenic adults. In some salamander species, such as Pacific giant salamanders (*Dicamptodon tenebrosus*), tiger salamanders (*Ambystoma tigrinum*) and Northwestern salamanders (*Ambystoma gracile*) in the Pacific Northwest, the larvae may or may not fully metamorphose into terrestrial adults depending on conditions.

The feeding habits of amphibians vary between the types of amphibians and also between the different life stages. Frogs and toads are generally **herbivorous**, or plant-eating, during their larval stages but are **carnivorous**, or animal-eating, during their adult stages. Frog and toad tadpoles eat mainly bacteria and algae, but may also scavenge material from dead animals such as earthworms, fish and other amphibians. Some species of frogs, such as spadefoot toads (*Scaphiopus* spp.) in North America, are carnivorous in the larval stage. As adults, frogs and toads eat a range of animals from small insects to other amphibians. Salamanders, on the other hand, are generally carnivorous in both larval and adult stages. Like tadpoles, salamander larvae have yolk reserves from their eggs that they survive on before they begin to forage for food. Salamander larvae and adults eat mainly invertebrates, such as insects, snails, and worms but can also eat larger prey such as crawfish and small invertebrates, including other salamanders. The Pacific giant salamander, which can reach a length of 13 inches (33 cm) from nose to tip of tail, is large enough to eat frogs and mice. Giant salamanders (*Andrias japonicus* and *A. davidianus*) of Japan and China, which are strictly aquatic, can


giant salamander (*Andrias* sp)

grow to 5 feet (1.5 m) long and eat a variety of aquatic animals, including crabs and other crustaceans, fish and frogs. Caecilians are also believed to be mainly carnivorous throughout their lives, eating such animals as insects, insect larvae and earthworms.

PHYSICAL CHARACTERISTICS and ADAPTATIONS

The class Amphibia is divided into three different orders, however all species in this class have several physical characteristics in common. One characteristic, which is also true of reptiles, is that amphibians are ectothermic. Animals that are ectothermic are commonly referred to as "cold-blooded." While it is true that ectothermic animals do not have internal mechanisms to keep their blood warm (as do endothermic animals such as birds and mammals), this does not necessarily mean that their blood is cold. Ectothermic animals rely on their external ("ecto") environment to control their body temperature. So the air, water, substrate or sunlight that an amphibian is exposed to will greatly affect the animal's internal temperature. Amphibians do have limited control over their body temperature, in that they can move short distances to different microclimates, such as sun or shade. Few amphibians (or reptiles) live in extremely cold environments such as the arctic tundra or mountaintops and amphibians living in regions with significant seasonal changes may hibernate during the winter. There are more species of frogs and toads (order Anura) than there are any other amphibians and tropical regions host the greatest diversity of anurans.

waxy tree frog Gerry Ellis

Most amphibians have smooth skin, composed of an inner dermal layer and outer epidermal layer of dead cells, that does not grow scales, hairs or feathers. Amphibians have very permeable skin, meaning liquids and gases can easily pass across the skin cells into the body. The skin is an important organ for amphibians. Adult amphibians breathe through their skin in addition to, and in some lungless species of amphibians, in place of, their lungs. Amphibians do not have diaphragm muscles to expand and contract their lungs, but use movements of their mouths for the intake and exhalation of air. Gas exchange through the skin supplements this shallow breathing. Gland cells in the skin of amphibians produce mucus which helps to keep the skin moist, enabling the passage of gases across the skin. Other gland cells in the skin produce poisons, ranging from mild to deadly (in only a few species), that provide defense against predators. Amphibians also rely on their skin to absorb water, as they do not usually drink water through their mouths. Because their skin is so permeable, amphibians are particularly vulnerable to environmental toxins.

Another characteristic of amphibians is that they do not have claws or nails on their toes, although one group of amphibians, the caecilians, are legless (and therefore toeless) and the clawed frogs (*Xenoporus* spp.) of sub-Saharan Africa have small claws on the three inner toes of their back feet. Most amphibians have four toes on each front foot and five toes on each back foot, though some species of salamanders have fewer toes. Most species of frogs and toads have webbed feet. Some kinds of amphibians, such as tree frogs, have glands on their toes that exude a sticky substance which helps them to climb. Some toads, such as spadefoot toads, have hard growths on the skin of their hind feet which help them to dig themselves into the ground. A similarity between reptiles and amphibians is that they both shed their outer skin periodically. Amphibians, however, generally eat their shed skin, which is why amphibian sheds are not commonly found.

Like fish, amphibians usually lay their eggs in water in order to prevent the eggs from drying out. Some amphibians lay their eggs on land in moist areas. Most frog and toad eggs are fertilized externally. In this process, the female releases the eggs and then the male, who is on the female's back clasping her, releases sperm over the eggs. In amphibians, the clasping of the female by the male during fertilization is termed **amplexus**. One species of frog in the Pacific Northwest, the tailed frog (*Ascaphus truei*), employs internal fertilization by way of a modified **cloaca** (hence the name "tailed" frog) which the male uses to deposit sperm in the female.

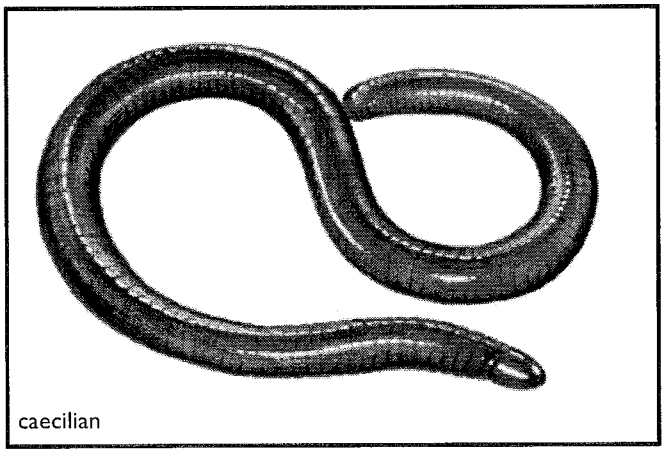
In most salamanders, fertilization is internal. The male deposits a small packet of sperm, called a **spermatophore**, on the ground and the female salamander picks it up with her cloaca. In a few families of salamanders, the eggs are externally fertilized by the male as they are being laid by the female. Fertilization is also internal for the caecilians. Male caecilians possess an organ, called the **phallodeum**, which is used to deposit sperm inside the female.

THREE ORDERS OF AMPHIBIANS

Order Gymnophiona: Caecilians

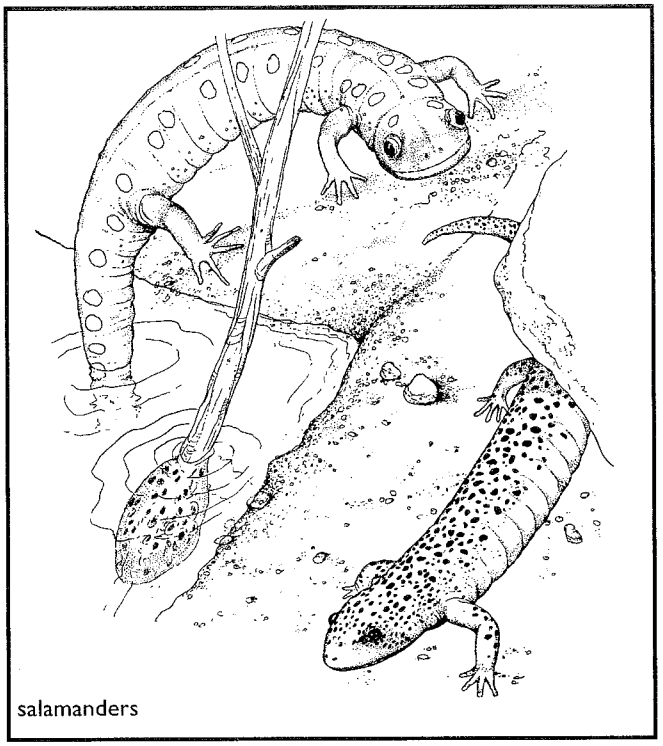
Caecilians are the least known of the three orders of amphibians, most likely due to their burrowing, nocturnal habits. There are approximately 163 known species of caecilians. Caecilians are legless amphibians that resemble worms, mainly due to the rings along their bodies that look like segments. These animals range in length from approximately 5 inches (12.5 cm) to approximately 4.5 feet (1.4 m). Caecilians usually lack tails, though some species have very short tails, and, in most species, the eyes are covered with skin or with bone and skin, thus rendering them useless for vision. Caecilians do, however, have a unique sensory organ: a tentacle located between the eye and the nostril on either side of the head. These tentacles are used as olfactory (smell) and tactile (touch) receptors. The skin of some caecilians, unlike any other amphibians, has small scales embedded within the dermal layers.

Caecilians generally live underground, though some species are aquatic, in tropical areas of Mexico, Central and South America, sub-Saharan Africa, India and southeast Asia. Because of their burrowing lifestyle, little is truly known about the diet and reproduction of caecilians. Most caecilians are thought to be predators, feeding on animals such as earthworms and, in some regions, small burrowing snakes. Of the species that have been studied, most species of caecilians give birth to young that have metamorphosed to adulthood



caecilian

within the mother's body nourished by secretions from her oviducts (these species are **viviparous**). Species in which the larvae develop within eggs that are laid by the mother prior to significant development of the embryos are **oviparous**. In some species, the eggs hatch into aquatic larvae that eventually metamorphose into adults, while in other species, the larvae metamorphose within the egg and hatch as fully-formed, small adults (this is **direct development**).



salamanders

Order Caudata: Newts and salamanders

The order Caudata consists of 10 families of newts, salamanders and related amphibians. Newts all belong to the Salamandridae family within the order Caudata, though this family also includes salamanders. The order Caudata consists of roughly 390 species in approximately 60 genera, which are collectively referred to as salamanders. Salamanders are set apart from other amphibians by the presence of a tail in all life stages and by two pairs of limbs of approximately equal size, with the exception of the Sirenidae family, which lacks hind limbs. Salamanders range from 1.5 inches (4 cm) to over 5 feet (1.5 m) from nose to tail.

These amphibians mainly inhabit northern temperate regions of the earth; in the Americas north of tropical Mexico, Europe, extreme northwestern Africa, and Asia north of the Himalayas; though one family, the Plethodontidae extends into Central and South America. The greatest diversity of salamander species occurs in North America, with the Pacific Northwest hosting a large number of species, some found

nowhere else in the world. In some areas of the Pacific Northwest, up to 11 different species of salamanders may coexist (Leonard et. al., 1993). Salamanders are adapted to cool, moist climates with many species being primarily nocturnal. Terrestrial species are commonly found under rocks, logs or leaves and aquatic species generally rest at the bottoms of streams or ponds under stones or in other protected areas. The activity level of these amphibians varies with the seasons, usually with one period of high activity, but this depends on the species. Salamanders generally prey on **arthropods** and other invertebrates, from small to large ones depending on the size of the salamander, but may also feed on small snakes or on other amphibians.

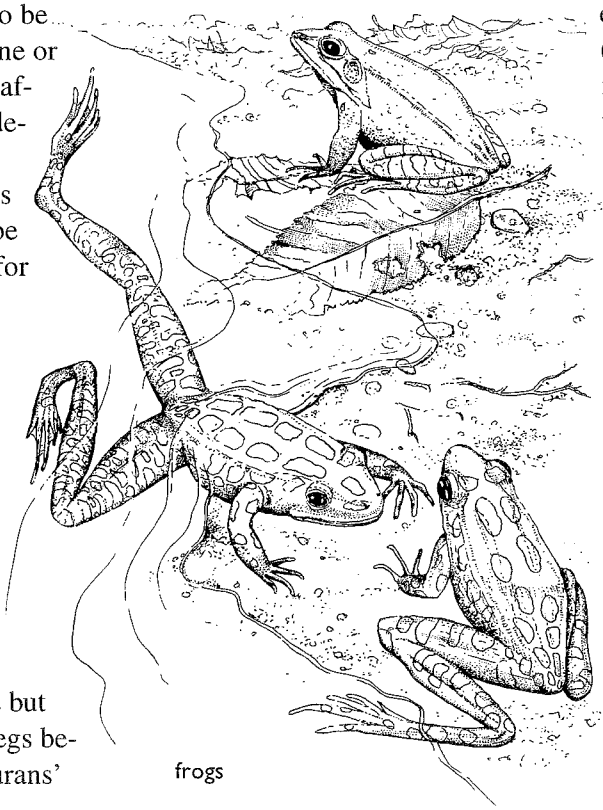
Most salamanders lay eggs (these species are oviparous) which in some species hatch into aquatic larvae and in other species, undergo direct development and hatch as small adults. Species in the Plethodontidae family, the largest salamander family with 250 identified species many of which inhabit the Pacific Northwest, lay their eggs in moist places on land and the females rub secretions from their skin glands over the eggs to keep them moist. Plethodontids undergo direct development, completing their larval stage within the egg and hatching out as small adults. Some salamanders are **ovoviviparous**. These species carry the developing eggs inside their bodies and, in most cases, the young undergo direct development, emerging from the female fully metamorphosed. Only one species of salamander, the alpine salamander (*Salamandra atra*) of the Alps in Europe, is known to be viviparous, giving birth to only one or two fully metamorphosed young after a three to five year period of development (Stebbins and Cohen, 1995). A few other related species of salamanders are suspected to be viviparous but this is not known for sure.

Order Anura: Frogs and toads

The order Anura comprises the largest order of amphibians, with approximately 4,000 species in 335 genera. Members of the order Anura are often collectively referred to as frogs. In these amphibians, the larvae are tailed but legless, and the adults are tailless but have two pairs of legs, the hind legs being longer than the fore legs. Anurans' modes of locomotion, hopping or leaping, and the physical adaptations to do these actions, are characteristics that set this order of amphibians apart from the other two orders. Although there is no scientific distinction between frogs and toads, frogs generally have smooth skin, live in water and have very long hind limbs adapted for leaping; toads usually have drier, warty skin, live on land and have shorter hind limbs that are better adapted for hopping (Haliday and Adler, 1986). Frogs range in length from 3/8 inches (1 cm) to 12 inches (30 cm).

Most frogs lay eggs in water or in moist places on land — these are the oviparous species. In most species, these eggs hatch into tadpoles, aquatic larvae that eventually metamorphose into adults. Tadpoles are usually herbivorous, but some species are carnivorous, eating a variety of small invertebrates and sometimes eggs or larvae of other amphibians. A very few species of frogs, including two species of poison dart frogs (*Dendrobates* spp.) are known to lay unfertilized eggs for their larvae to consume.

In some species of anurans, the larvae metamorphose inside the eggs and hatch out as small adults, sometimes called froglets (this is direct development). Some species of frogs, the ovoviviparous species, carry their eggs inside the reproductive tract or in other parts of the body, such as the stomach, vocal pouch or skin pouches. The young may hatch at any point of development, depending on the species. For example, female Surinam toads (*Pipa pipa*) carry their eggs in individual pockets of skin on their backs that form over the eggs as they are deposited there. Fully metamorphosed toadlets hatch from the eggs. Only two species in the order Anura are known to be viviparous. These African toads, *Nectophrynoides occidentalis* and *N. liberiensis*, live at high altitudes in southwestern Africa and give birth to their young after a nine-month gestation period.



frogs

Frogs, unlike caecilians and salamanders, possess vocal cords and are able to produce a variety of sounds. Given that, it is not surprising that frogs also possess eardrums and have

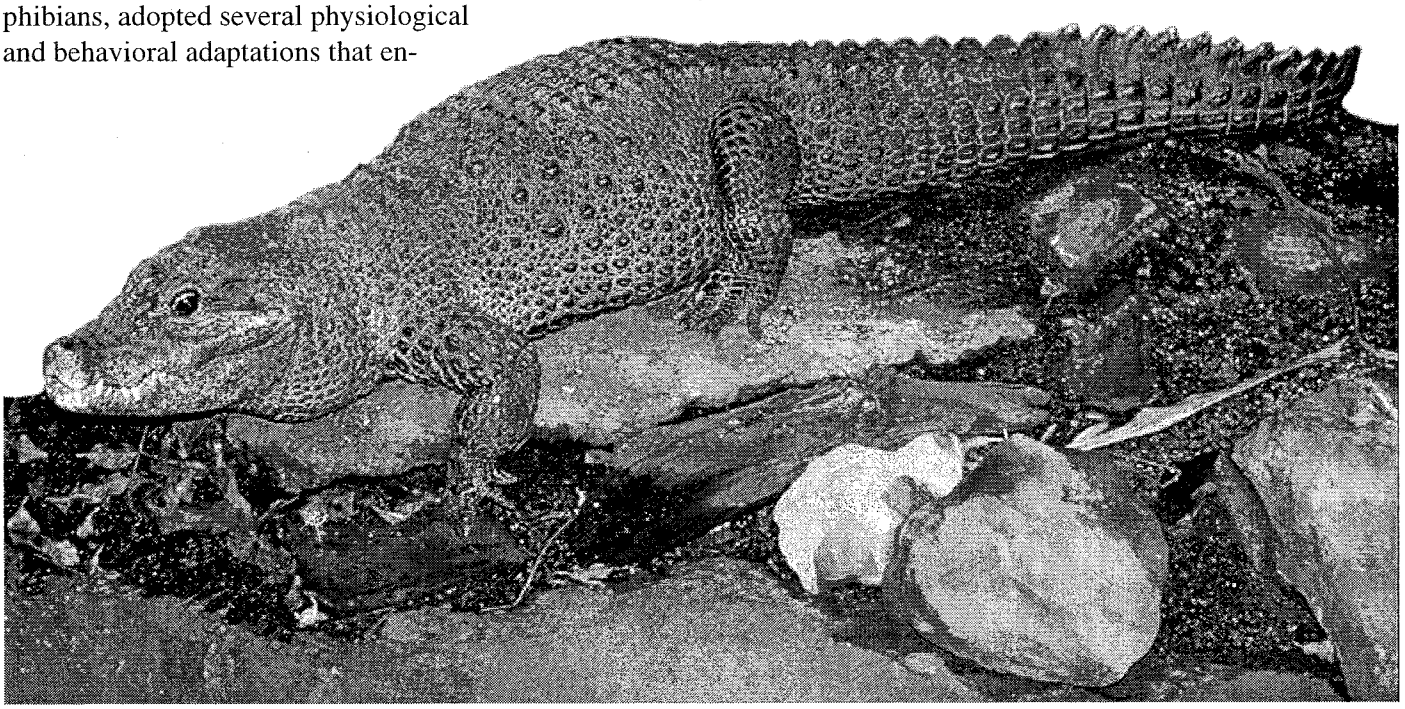
much better auditory perception than caecilians or salamanders, which make only quiet clicking and squeaking sounds and lack eardrums. Male frogs often attract mates by calling and also warn other males to stay away with territorial calls. In some species, both males and females may emit distress calls when a predator apprehends them. Frogs produce mating and territorial calls by passing air back and forth over the vocal cords with their mouths closed. Distress calls are usually made with an open mouth. Some male frogs have sacs near their mouths or necks that can be inflated to resonate the sound created by the vocal cords.

Some species of frogs that inhabit more arid regions have skin that is less permeable to water. These species may exude a thick mucus to keep themselves cool by evaporation, or may spend time underground to prevent moisture loss. Some tree frogs in the genus *Phyllomedusa* are capable of secreting a waxy substance that covers the skin and prevents moisture loss. These frogs are adapted to warm, dry conditions. Some frogs that spend long, dry periods of time underground in a state called **estivation** actually create cocoons around their bodies that hold in moisture. These cocoons are formed by layers of skin secretions or of shed skin with skin secretions in between the layers. Sirens, a group of salamanders found in the southeastern United States, also estivate in cocoons.

REPTILES

Although amphibians were the first vertebrates to colonize land, reptiles, which are descended from amphibians, adopted several physiological and behavioral adaptations that enabled them to become fully terrestrial, reach larger sizes, and, eventually, to become the dominate vertebrates on land for a long period of time. The first early reptiles inhabited the earth roughly 300 million years ago, after which time they diversified greatly, becoming the most prominent terrestrial vertebrates during the Mesozoic era, 265 to 65 million years ago. One group of ancient reptile-like animals familiar to most people is the dinosaurs. Most dinosaurs went extinct at the end of the Mesozoic era. Birds are related to dinosaurs, as are **crocodilians**. The first birds coexisted with dinosaurs but birds have survived into present times. Modern crocodilians have existed from the latter part of the Mesozoic era until the present times and are considered to be the nearest living relatives of birds. Other reptiles that inhabit the earth today are descended from reptile species that survived the extinction at the end of the Mesozoic era.

Currently there are approximately 7,883 species of reptiles in four orders (Uetz, 1995). Like amphibians, reptiles do not have one major defining feature that sets them apart from all other classes of animals. "They must therefore be distinguished on the basis of a combination of characters, none of which are unique possessions but which add up together to give a picture of reptilian organization." (Bellairs, 1970, p. 17) The combination of characteristics that separate reptiles from other vertebrates include skin covered in scales (no feathers or hair and few skin glands), ectothermic body temperature regulation (like amphibians), and amniotic eggs with leathery or hard shells.



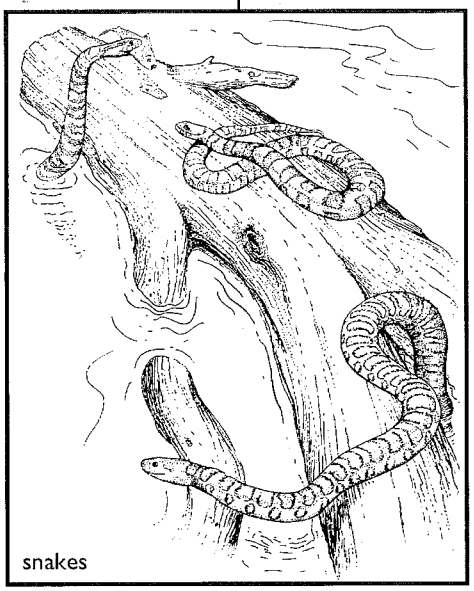
dwarf crocodile

Lee Schroeder

LIFE CYCLE

As reptiles adapted to terrestrial life, the laying of shelled eggs necessitated the development of internal fertilization. The eggs must be fertilized before the shell is laid down, and thus, internally. This means that the eggs must be fertilized while inside the female's body. Fertilization is internal in all reptiles, and male reptiles, excluding tuataras, have special organs used to accomplish this. Most reptiles mate on land, but crocodilians and aquatic species of turtles mate in the water.

Some reptiles exhibit an interesting mode of reproduction in which eggs develop normally without ever being fertilized. This is called **parthenogenesis** and is not uncommon among arthropods (such as insects) but is only known to occur among several species of reptiles, primarily whiptail lizards of the genus *Cnemidophorus*. There are no males in these species of lizards. According to hormonal cycles, female whiptail lizards participate in courtship behaviors with other females of the species, with the lizard having the highest estrogen levels exhibiting female behaviors and the female with the lowest estrogen levels exhibiting male behaviors (mounting the other female). This courtship behavior actually increases the number of eggs produced by the ovulating (high estrogen) females as compared to females that produce eggs without going through the motions of mating (Campbell, 1996). Eggs of these whiptails that are produced through parthenogenesis develop into normal, adult female lizards.


snakes

Not all reptiles lay eggs. Some species are viviparous, giving birth to live young that are nourished inside the mother's body, and other species are ovoviviparous, retaining the eggs inside the body but not directly nourishing the embryos. Generally, reptiles that are viviparous or ovoviviparous live in habitats where temperatures are not reliable, such as high elevations or extreme latitudes. The mother reptile can move around to ensure optimal temperatures for the young developing inside of her. Many reptiles that lay eggs take measures that ensure proper temperatures and moisture levels for the development of their young. For example, female American alligators (*Alligator mississippiensis*) build elaborate nests prior to laying their eggs. The female picks a suitable location, near the water but situated in such a way that the eggs will lie above the high water mark. After clearing vegetation from the area, the alligator piles up the plants she just cleared and makes a depression in the center of the mound. She fills the depression with mud and more plant debris and then creates another depression in the same area in which she deposits her eggs. She then covers the eggs with plant materials from the nest, mud and plant materials from the water. By the time it is finished, the whole mound can be up to 3 feet (1 m) high and 6 feet (1.8 m) wide. As the vegetation used to make the nest decays, heat is produced and serves to incubate the eggs.

Many reptiles lay their eggs buried underground in sand, dirt or leaves or in crevices under rocks or stones. In a sense, sea turtles have requirements for breeding that are opposite those of some terrestrial amphibians. Whereas some species of terrestrial amphibians return to water to lay eggs, sea turtles, which spend the majority of their lives in water, return to land to lay their eggs in nests under the sand. Some snakes coil around their eggs until they hatch. Female Indian pythons (*Python molorus molorus*) actually quiver their muscles as they are coiled around their eggs which helps to keep the eggs warm. Sea snakes of the family Hydrophiinae inhabit tropical waters in various parts of the world. These snakes are truly aquatic and, unlike other reptiles, produce their young in the water. Sea snakes do not lay eggs, but are viviparous, giving live birth. Most sea snakes remain in coastal waters, but the yellow bellied sea snake (*Pelamis platurus*) inhabits the open ocean, drifting at the surface and feeding by day and resting at the ocean bottom during the night, occasionally rising to the surface to breathe.

For some reptiles, including crocodilians, most turtles, and some lizards, the temperature at which the eggs are kept during the first stages of development determines the gender of the developing young. For American alligators, if the eggs are kept below 85°F (29°C) females will be produced. If the eggs are kept above 91°F (33°C) males will be produced. Temperatures somewhere in between will produce both male and female young. Currently, no snakes are known to exhibit temperature-dependent gender determination in developing young.

When reptiles hatch or are born, they are essentially small, sexually immature adults. Unlike amphibians, they do not exhibit a larval stage nor go through metamorphosis. Most young reptiles are on their own after birth or hatching. Some reptiles continue to grow throughout their lives, though the rate of growth is often dependent on temperature and light conditions and the availability of water and food.

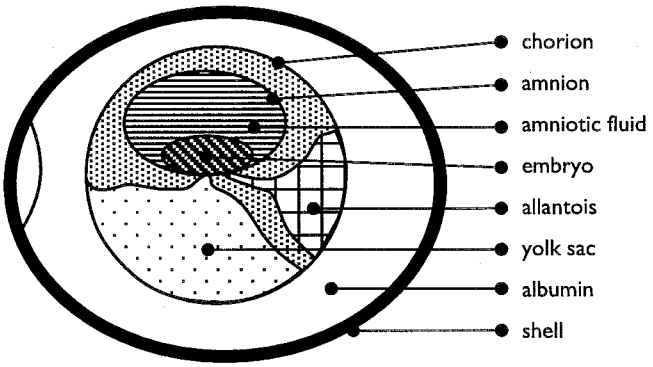
The vast majority of reptiles, both as young and as adults, are carnivorous. A prime exception are the tortoises which are mainly herbivorous but may occasionally scavenge meat from dead animals or eat fresh meat. Freshwater turtles may eat some plant material along with their diet of small animals. Sea turtles can be considered to be omnivorous, as they eat seaweed and other marine plants along with jellyfish, mollusks, fish and crustaceans. Tuataras and most lizards feed on a variety of invertebrates, while the larger lizards may take vertebrates such as small mammals and birds. Some lizards, such as some species of iguana, primarily eat plants. Snakes and crocodiles are almost exclusively carnivorous. Crocodiles will scavenge meat from dead animals, while snakes do not commonly scavenge but consume live prey.

PHYSICAL CHARACTERISTICS and ADAPTATIONS

Reptile eggs represent a significant advancement in the development of terrestrial animals. Although amphibians have several adaptations which allowed them to be the first vertebrates to colonize the land, the nature of their eggs and, in many species, fertilization (external) requires most species of amphibians to live in water or return to water in order to reproduce. The amniotic eggs of reptiles, with their hard or leathery shells that prevent the embryos from drying out, permitted reptiles to make a break from water. Not only can reptiles live on land, they can live quite independently of water. Thus, reptiles are capable of inhabiting very arid regions where few amphibians are found. Reptiles have a wide distribution across the globe, living on every continent except Antarctica, though they are still limited by freezing temperatures in polar regions and on high mountains.

Amniotic eggs, laid by reptiles, birds, and monotremes (a group of mammals which includes platypuses), consist of a series of four membranes covered by a hard shell. The shell is an important factor as far as adaptation to terrestrial life is concerned. The shell, while allowing the exchange of gases, prevents amniotic eggs from drying out. Thus, these animals are not dependent on water in which to lay their eggs. In fact, most amniotic, shelled eggs would "drown" if laid in water. The membranes immediately surrounding the embryo are the amnion, the allantois and the yolk sac.

The amnion is filled with amniotic fluid which cushions the embryo and helps to prevent moisture loss. The allantois removes wastes produced by the embryo and, by pressing against the chorion, allows for gas exchange by the embryo. The yolk sac contains an abundance of nutrients and is slowly digested by the embryo as it develops. The chorion is yet another membrane and encloses the embryo, amnion, allantois and yolk sac. Between the chorion and the shell is the albumin (the "white" of the egg) which stores additional nutrients.



The scaly skin of reptiles is another feature that has allowed reptiles to live on land and independently of water. Although the scales of reptiles appear to be little plates attached to the skin, they are actually formed by folds and thickenings of the skin, which is a continuous sheet. The skin is thinner in the areas between the scales. The scales are thickened by a covering of keratin, a fibrous protein found mainly in hair, horns and claws or nails of other animals, which helps to prevent moisture loss. With little gas exchange taking place across their scaly skin, most reptiles have well-developed lungs that they rely upon for breathing. Some snakes and turtles that are more or less aquatic respire to some extent through their skin. Reptiles that have legs usually have five toes on each foot with a claw (made of keratin) on each toe. Claws serve a number of purposes in reptiles, but mainly aid them in burrowing to escape temperature extremes. Claws are also useful for climbing and many lizards are accomplished climbers.

Although reptiles are ectothermic, meaning that their body temperature is determined by their external environment, most reptiles have behavioral means of

influencing their body temperature. For reptiles, the optimal body temperature for activity is between 60°F to 100°F (15.5°-37.8°C), but this varies depending on the type of reptile. To prevent overheating, reptiles can retreat underground or to the shade, or if there are long periods of high temperatures, some reptiles estivate. Estivation is much like hibernation, in that the animal becomes inactive and the animal's metabolism slows down dramatically. However, estivation is a state of dormancy during hot weather, whereas hibernation is a state of dormancy during cold weather. To avoid becoming too cold, reptiles can move so that they are basking in the sun or absorbing heat from the substrate on which they are resting. If there are long periods of cold weather, some reptiles can hibernate. A few kinds of reptiles have physiological ways that help to raise or lower their body temperature. Some species can regulate the distribution of pigments in the skin, making areas darker or lighter in color and therefore increasing or decreasing absorption of solar radiation. One example of a lizard with this ability is the western fence lizard (*Sceloporus occidentalis*) which inhabits Washington state.

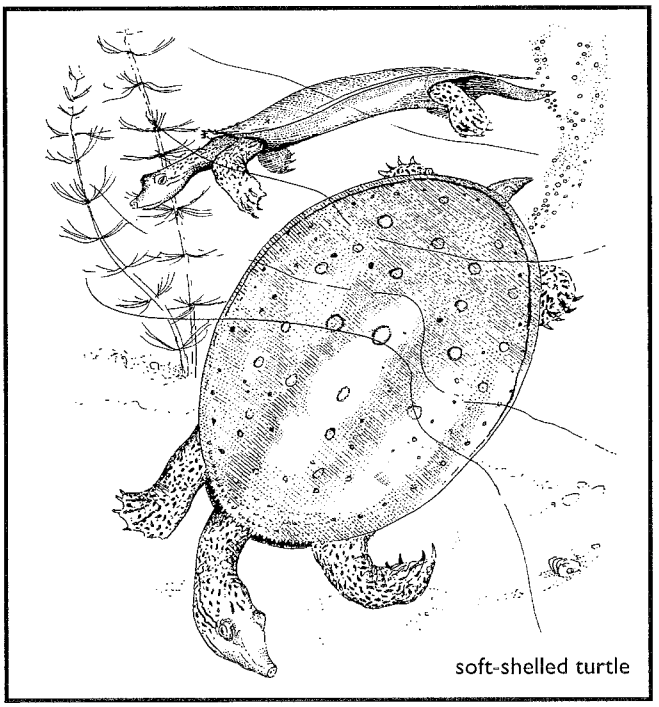
Snakes and lizards have a pair of particularly well-developed olfactory organs called the **Jacobson's organs**, also called the **vomeronasal organs**. Amphibians and mammals also possess these organs but they are not as sensitive as those of snakes, lizards and amphisbaenians (see the section on "Squamata" in this packet). Crocodiles and birds do not have Jacobson's organs, while turtles have a small chamber within their nasal region that can be considered to be a poorly developed Jacobson's organ. In most lizard and snake species, the Jacobson's organs, two separate sacs located within either side of the snout, are relatively large. These organs are chemosensory, meaning that they respond to chemicals, primarily scent particles. Snakes and lizards use their tongues to bring scent particles in proximity to the openings of the ducts to the Jacobson's organs. Thus, forked tongues that are common in snakes and lizards are well constructed to work in conjunction with the paired Jacobson's organs. The particles are conducted through the ducts into the organs where special sensory cells are located. It is thought that the Jacobson's organs help these reptiles to recognize others (including mates) of their species, recognize their enemies, and locate food or follow the trails of prey. Both the nose and the Jacobson's organs work together in the processes of initiating courtship and determining the precise location of prey.

FOUR ORDERS OF REPTILES

Without delving too deeply into the ancient history of reptiles, it is simply stated that over geological time, turtles were the first of the modern reptiles to take on their present form. Crocodiles were the next to appear and are considered by some scientists to be more closely related to birds than to other reptiles. Crocodiles and birds are the only living types of animals that are closely related to dinosaurs. Following crocodiles, tuataras, lizards and then snakes took their places among the earth's kingdom of animals.

Order Testudines: Turtles and their relatives

It would not be difficult for most people to pick a turtle out of a crowd of reptiles. The distinctive characteristic of species in the Testudines order, a hard shell, is a unique and recognizable trait. Not all, but the majority of the approximately 300 species of Testudines do have hard shells; some species have soft shells. Turtles' shells are formed of horny plates made of keratin, called **scutes**, that form the **carapace** (top half of shell) and **plastron** (bottom half of shell). Underlying the scutes are plates of bone which are fused with the vertebrae and the ribs of the turtle. Thus, turtles are firmly joined with their shells and cannot crawl out of them, as some cartoons might lead one to believe. The plastron and carapace are joined at the sides by a bridge and some species, such as box turtles, are able to squeeze the plastron and carapace tightly together for greater protection from predators. Those turtles that do not have hard shells, such as soft-shelled turtles (*Trionyx* spp.), have bony plates like other turtles do, but they are covered with skin, not

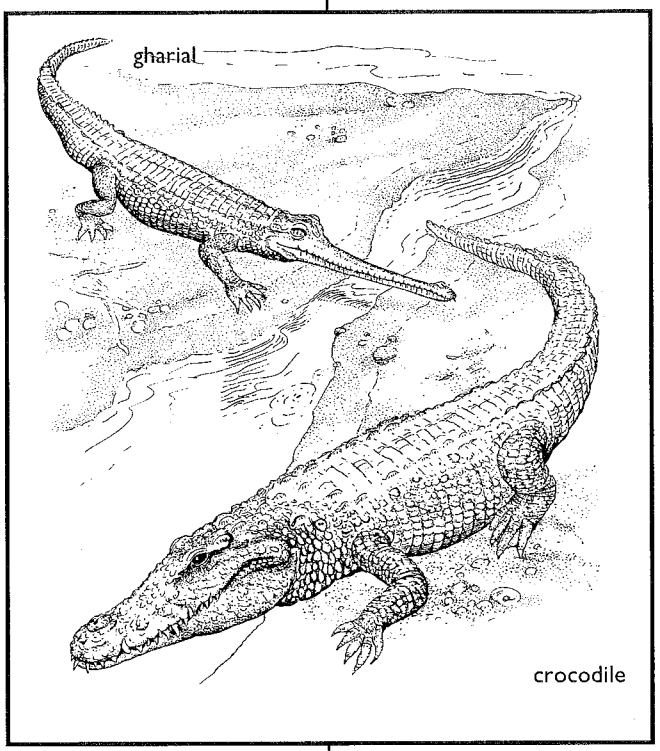

soft-shelled turtle

with scutes. Leatherback turtles have neither scutes nor bony plates, but do have thick, leathery skin covering a mosaic of little bones that are not connected to the turtle's skeleton.

Some turtles are predatory carnivores and other species are herbivores. Turtles do not have teeth, but their mouths, called beaks, are strong and adapted for the feeding habits of the species. Some turtles have beaks that are hooked, notched or serrated. Tortoises, land-dwelling turtles, are primarily herbivorous and eat a wide variety of plants. Freshwater turtles eat both plant and animal material, including worms, arthropods, amphibian larvae and fish. Sea turtles are omnivorous, eating seaweed, fish, crustaceans, mollusks and jellyfish. Some sea turtles are more carnivorous, while other species are more herbivorous. Most turtles have four legs with clawed toes, however some species have modified legs. Sea turtles rely on their flipper-like legs to propel them through the water.

Order Crocodylia: Crocodiles and their relatives

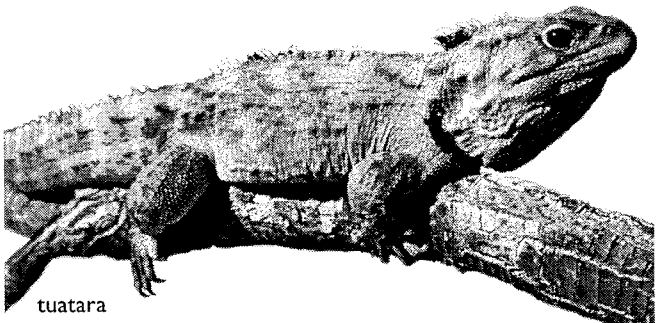
The long-snouted, well-toothed members of the order Crocodylia are an impressive group of reptiles. The 23 species of living crocodilians are classified in the family Crocodylidae which includes alligators and caimans, crocodiles and the gharial. In many members of this family, the large scales are underlain by bony plates that reinforce the scales. Crocodilians are extremely aquatic and have special adaptations for this mode of life. The eyes, nostrils, and ears are all located on the upper side of the long head and snout so that the crocodile can remain virtually underwater but still see, smell and hear. Crocodilians are the only reptiles that have outer ear flaps. These flaps remain closed most of the time, though a small slit opens up when the ears are above water, allowing crocodilians to hear airborne sounds. Crocodilians use a variety of sounds to communicate, though they do not possess vocal cords. Crocodilians have different calls to communicate threat, distress, hatching and contact. Some male crocodilians produce bellows to attract mates during courtship.



The order Crocodylia includes the largest living species of reptile, the saltwater crocodile (*Crocodylus porosus*). Although some snakes can grow longer, if you take both length and body weight into account, these crocodiles reach the largest overall size of any living reptile. Large adult males can grow up to 20 to 23 feet (6-7 m) in length, though males over 16.5 feet (5 m) are rare. Large males can weigh up to 3,300 pounds (1,485 kg). Crocodiles can be distinguished from alligators by the shape of the snout and the placement of the teeth. Crocodiles generally have snouts that are more pointed than those of alligators, which are usually broad and rounded. A more distinguishing characteristic is that in alligators the upper jaw is larger than the lower jaw, such that when an alligator's mouth is closed only the upper teeth project and are visible. On the other hand, crocodiles' jaws are approximately the same size, so when the mouth is closed the teeth interlock and both the upper and lower teeth are visible along the outer edges of the jaw. The fourth tooth is particularly prominent in crocodiles and is easily seen projecting upward from the lower jaw.

Crocodiles are the most widespread of the crocodilians. Species of crocodiles are found in the southern United States, Central and South America, Africa, India, southeast Asia and northern Australia. There are only two species of alligator worldwide: the American alligator (*Alligator mississippiensis*) in the southeastern United States, and the Chinese alligator (*Alligator sinensis*) in the Yangtze River basin of China. Caimans are grouped together with alligators and these two types of crocodilians are very similar in many ways. However, caimans differ from both crocodiles and alligators in that they have bony plates underneath the skin on their ventral (stomach) side. Caimans are mainly found in South America. Caimans and alligators can be visually distinguished by their heads and tails. Alligators generally have broader, more rounded snouts and caimans have more pointed snouts. Caimans' tails are usually shorter than alligators' tails.

The last group of crocodilians includes only one species, the Indian gharial *(Gavialis gangeticus)* which is found mainly in rivers of India but extends into river systems of surrounding countries. Gharials have long, slender snouts which are adapted for catching fish, their main prey. Adult male gharials have bulbous growths on the tips of their snouts which help to resonate sound and serve as a visual signal to female gharials. Gharials are named after these growths which resemble a type of Indian pot called a "ghara." The scientific name *Gavialis* is actually a misspelling of the word "ghara."



tuatara

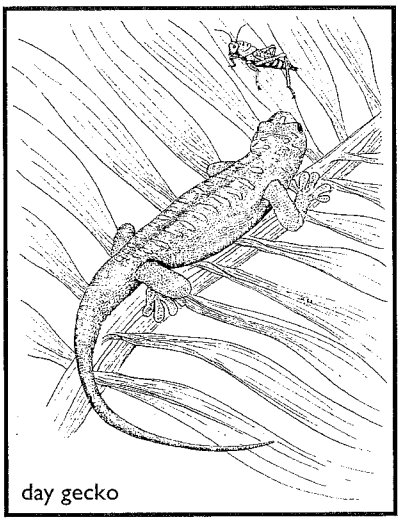
Chuck Dressner

Order Rhyncocephalia: Tuatara

The order Rhynchocepahlia contains only two species, both in the genus *Sphenodon*. These two species of tuatara, *Sphenodon punctatus* (tuatara) and *Sphenodon guntheri* (Gunther's tuatara), are found only on small islands off the two main islands of New Zealand. "Tuatara" is a Maori (the language of the indigenous Maori people of New Zealand) word that translates to "spiny back" or "peaks on back" and refers to the ridges of spines along the heads and backs of tuataras. Tuataras were once found throughout New Zealand, but introduced rats, which prey on the eggs and young of tuataras, have affected their populations. Tuataras are similar in outward appearance to lizards. Unlike lizards, however, tuataras lack a special scale over the external ear opening. Tuataras differ from all other reptiles in that internal fertilization is accomplished through contact of the cloacas of the male and female; in other reptiles, the males possess organs that are inserted for internal fertilization. Tuataras also possess other specific physical characteristics that separate them from other reptiles, such as small differences in the ribs, teeth, skull structure, vertebrae and the oviducts of females.

Tuataras are burrowers and are active nocturnally. They are mainly carnivorous and eat such animals as worms, insects, lizards, millipedes and even small seabirds. The habitat where tuataras live is relatively cold and damp, with the temperature rarely exceeding 70°F (21°C). Tuataras have a much slower metabolism than other reptiles and are capable of being active at these low temperatures. The ideal body temperature range for tuataras is from 60°F to 70°F (15.5°C to 21°C) and they have even been observed moving about at temperatures near freezing. With such low metabolisms, tuataras do not eat as often as other reptiles and have an extended life span. Tuataras do not reach sexually maturity until sometime between the 10th and 20th year of life, depending on climatic conditions and food availability. Once they begin reproducing, female tuataras only lay one clutch of eggs, usually around a dozen, every four years. Tuataras are long-lived and do not even reach full adult size until around 60 years of age. Tuataras have lived over 70 years in captivity and are believed to live as long as 100 years.

Order Squamata: Lizards, snakes and amphisbaenians



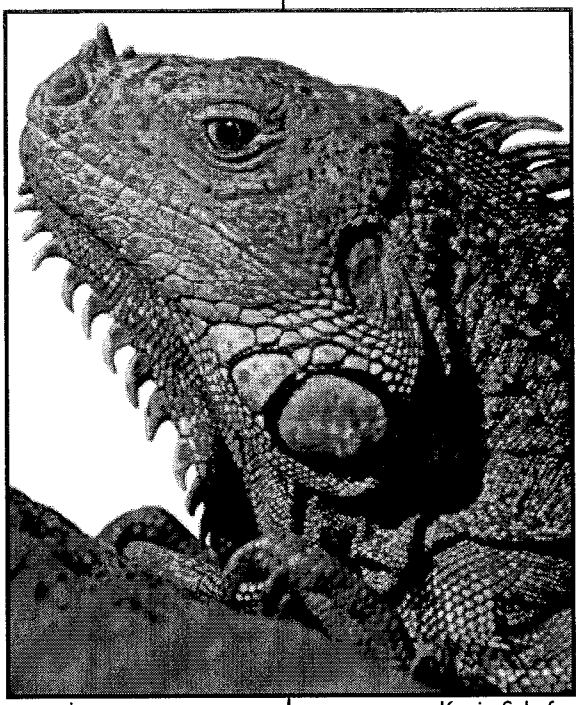
day gecko

The order Squamata is the largest order of reptiles and contains, according to many taxonomists, three suborders that are rather distinct from one another: Sauria (lizards), Serpentes (snakes), and Amphisbaenia (amphisbaenians or worm-lizards). Lizards, snakes and worm-lizards have very well-developed Jacobson's organs which greatly improve their sense of smell. Another characteristic of this group is the paired male organs used to accomplish internal fertilization. These **hemipenes** differ from the single organs of turtles and crocodiles, while the tuataras lack such organs. In most lizards and snakes, the scales of the skin overlap one another, providing extra protection and reducing the loss of moisture. Scientists have identified 4,479 species of lizards, 2,926 species of snakes and 157 species of amphisbaenians that currently inhabit the earth (Uetz, 1995).

Several physical characteristics separate lizards from snakes and amphisbaenians, including two pairs of limbs, sharp claws on the fingers and toes, external ear openings, and a pair of well-developed lungs. In several families of lizards, including the Anguidae and

Pygopodidae, some species have reduced limbs or no limbs at all. These legless lizards, however, retain the other physical characteristics specific to lizards. The amphisbaenians, legless reptiles in the order Squamata, have physical characteristics different enough from lizards and snakes to be considered in their own group (see the paragraph on amphisbaenians in this section).

Some lizards, but no snakes or amphisbaenians, have moveable eyelids with a third membrane, called a nictitating membrane, that sweeps across the eye surface and keeps it clear of debris. Like snakes and amphisbaenians, geckoes and a few other types of lizards have transparent eyelids that are fused over the eyeball, protecting it from debris. Geckoes can sometimes be seen cleaning their eyelids with their tongues!



green iguana Kevin Schafer

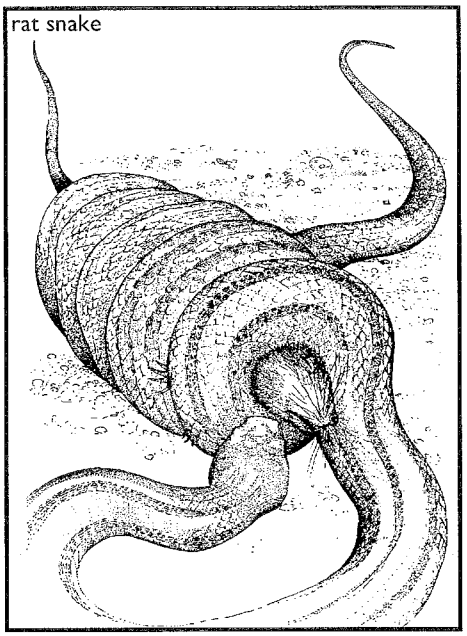
Many lizards have good color vision. This can aid them in distinguishing distasteful arthropods, which are often brightly colored, from tasty ones. In lizards that are diurnal, active during the day, the retinas of the eye possess only cone cells. These visual cells are important for seeing in bright light, while rod cells are the visual cells responsible for nocturnal vision. Most vertebrate animals, including most reptiles, possess some combination of rod and cone cells. Chameleons have distinctive sight capabilities. Their eyes are set in turret-like structures that project from the sides of the head and have a wide range of movement. If the "turrets" are pointed in different directions, the chameleon has monocular vision from each eye. If the eyes are focused on the same point, the chameleon has binocular vision with the eyes functioning together. If a chameleon is hungry, it will search with both eyes, each eye searching in different directions than the other eye. When it locates food, the chameleon focuses on the item with both eyes and moves closer until it is able to catch the prey with its tongue. The binocular vision enables the chameleon to judge distance in order to aim its tongue properly.

Lizards feed on invertebrates of many different types, though larger species may prey on vertebrates, and most species are not highly selective in their choice of prey. Some species, however, do have specialized diets, such as the short-horned lizard (*Phrynosoma douglassii*) of eastern Washington which feeds primarily on ants, and Gila monsters (*Heloderma suspectum*) which eat mainly eggs of other reptiles and birds, and baby birds, mice and rats. There are some species of lizards that are quite large, particularly Komodo dragons, which are capable of catching and eating large animals such as small deer and pigs. Some lizards, particularly iguanas, are herbivorous. Only two species of lizards are known to be venomous: the Gila monster (*Heloderma suspectum*) and the Mexican beaded lizard (*Heloderma horridum*). The venom of these lizards could be fatal to humans but only small amounts are usually released, so bites from these lizards are not normally deadly. These species do not have hollow fangs, like some snakes, but have grooved teeth that direct the venom from where it is released by the venom gland into the bite wound. In order to direct enough venom into the wound, these lizards usually bite their prey repeatedly in the same spot using a chewing motion. The venom can immobilize and partially predigest prey.

Many lizards can shed the latter portion of their tails, which may occur if the lizard is being attacked by a predator. When the tail separates, muscles in the remaining part of the tail contract to prevent the loss of blood and, eventually, a new tail regenerates. Snakes do not possess the ability to shed and regenerate their tails. Lizards range in size from a small gecko at 1.4 inches (3.5 cm) long to 9 feet (2.7 m) long and can weigh up to 300 pounds (135 kg), the largest being male Komodo dragons, a species of monitor lizard.

Snakes are recognized as reptiles that do not have legs. There are, however, several other characteristics used by scientists to set snakes apart from other reptiles. Snakes do not have external ear openings or bladders and both halves of their lower jaws are able to move independently of one another, they are not fused together as in lizards. In snakes, the eyelid scales, called **brilles**, are fused together over the eye but are transparent, creating a permanent protective shield over the eye. This

shield may be scratched, but is shed periodically along with the skin, so any damage is only temporary. It is this combination of characteristics that makes a snake a snake; there are other reptiles in the order Squamata that do not have legs but that do not possess other characteristics of snakes and are thus classified in their respective suborders. Although a snake might look like one long tail, the head and body are usually the longest part of a snake. The body ends and the tail begins at the cloacal opening of the snake.


rat snake

No snakes are known to be solely herbivorous, and most snakes rarely, if ever, eat plant matter. The majority of snakes are carnivorous predators, ambushing live prey and then consuming the animal, usually after it has been killed. They will, however, take animals that have recently been killed or even animals that have been frozen and thawed, and this is how many snakes in captivity are fed. Some snakes specialize in eating bird eggs. Snakes swallow their prey whole and have the ability to swallow animals that are much larger in diameter than their own bodies. The structure of snakes' skulls and other parts of their bodies are specially adapted for swallowing large prey. In 1999, a researcher from Woodland Park Zoo who was working together with sun bear researchers in Borneo discovered that a surprising thing had happened to one of the sun bears the team had radio-collared and was tracking. The bear's radio signal had stopped moving and was transmitting weakly. When the team finally located the source of the signal, they discovered a large python with a sun bear-sized lump in it!

The longest snakes in the world are the green anaconda (*Eunectes murinus*) of South America and the reticulated python (*Python reticulatus*) of southeast Asia. Both of these snakes can grow up to 20 feet (6 m) with some individuals reaching 30 feet (9 m). Green anacondas are the heavier of these two species; a green anaconda will outweigh a reticulated python of equal length. The smallest snakes are the thread snakes, also called slender blind snakes, in the family Leptotyphlopidae, the smallest of which grow to about 5 inches (13 cm) long and are very thin.

The amphisbaenians, or worm-lizards, are closely related to both lizards and snakes. These species lack limbs and have adopted a burrowing lifestyle. Because of this secretive lifestyle, less is know about amphisbaenians than lizards and snakes and they are unfamiliar to many people. The heads of amphisbaenians are well-adapted for burrowing and, due to their reliance on other senses, amphisbaenians have poorly developed eyes with transparent, fused eyelids protecting the eyeballs. Amphisbaenians range in length from approximately 3 inches (8 cm) to 2.6 feet (80 cm). Nearly all amphisbaenians, with the exception of a few species which possess front legs, are legless. In amphisbaenians, the right lung has been reduced and the left lung has taken over the job (this is opposite of snakes in which the left lung has been reduced). Amphisbaenians, which are found in Africa, southern parts of North America (south from California and Florida), Central and South America, western Europe (Portugal and Spain), and the Middle East, eat mostly insects and other invertebrates. The small scales of these animals are arranged in rings around the body, helping amphisbaenians to move through their tunnels by muscular contractions, with the scales grasping by friction as the muscles pull the rest of the body forward. Amphisbaenians have the ability to reverse these contractions, thus allowing the animals to also move backwards in their tunnels, hence the name "amphisbaenian," which is derived from the Greek words "amphis" meaning "both ways" and "bainein" meaning "to go."

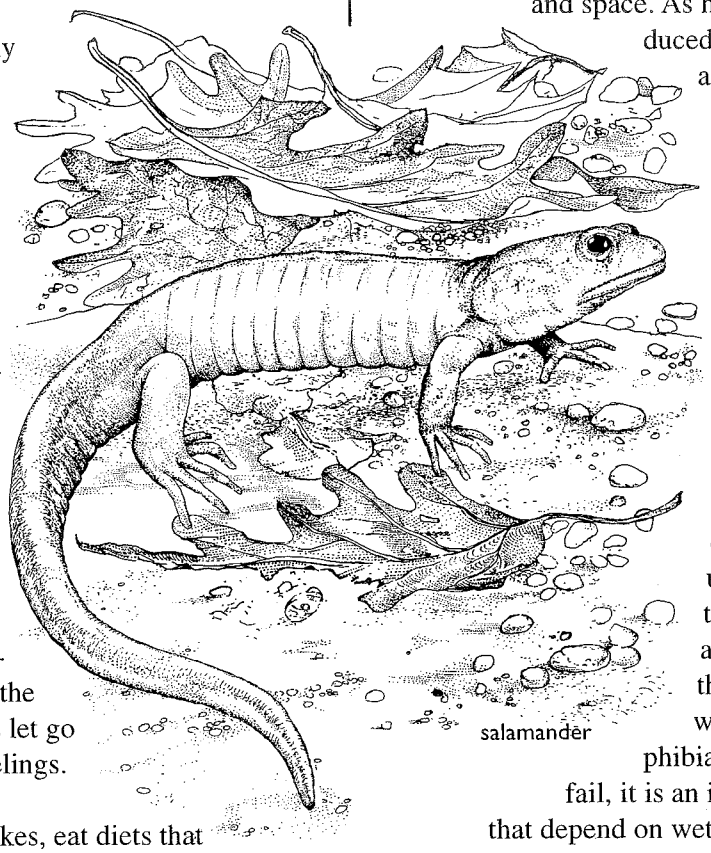
The Importance of Reptiles and Amphibians

Humans have differing attitudes towards reptiles and amphibians, as we do towards other aspects of the natural world. Reptiles and amphibians have appeared as revered cultural icons throughout history. The Huron of mideastern Canada (a confederation of four tribes with a common language called Wyandot) included a toad and a tortoise as key figures in their creation myth. The story goes that, in the beginning, the world was made of water. A divine woman fell from the sky and was caught by loons. The loons tired of carrying her, so she needed earth upon which to stand. Several animals attempted to dive to the bottom of the

water and bring up earth, but they failed. Only the toad succeeded in returning with some earth.

> On searching [the toad's] mouth, the tortoise found in it some earth, which he gave to the woman. She took it and placed it carefully around the edge of the tortoise's shell. When thus placed, it became the beginning of dry land. The land grew and extended on every side, forming at last a great country fit for vegetation. All was sustained by the tortoise, which still supports the earth. (Sproul, 1979)

This myth is only one of many examples of how reptiles and amphibians have been important figures in human culture. On the other hand, some people associate reptiles and amphibians with danger and disgust. It is true that some reptiles, and some amphibians, can be very dangerous to humans. The vast majority, however, are not dangerous. As we expand our knowledge of reptiles and amphibians, we can better understand the ways in which these animals have adapted to survive and appreciate their important roles in the world's ecosystems, and thus let go of some of those negative feelings.


salamander

Many reptiles, especially snakes, eat diets that consist largely of small mammals, such as rodents. In this way, reptiles play an important role in maintaining the natural balance of species in an environment. This can be especially helpful to farmers because rodents, if their populations get out of balance, can damage crops and consume stored grain. Similarly, the majority of amphibians, and many lizards, prey on invertebrates, such as insects, and help to control their population numbers. In turn, amphibians provide a high protein food source for animals such as snakes, birds and some mammals. Many of these larger animals do not themselves feed on invertebrates, and thus the amphibians serve as a necessary step in the transfer of energy up the food chain.

Amphibian larvae, by feeding on organic debris, aid in the decomposition of organic matter. Some larvae also feed on algae, controlling the growth and spread of the algae. Although they might not be commonly observed, amphibians are major players in many ecosystems. In the forests of the Pacific Northwest salamanders can be very densely distributed on the forest floor, in some cases having a total biomass greater than that of many other vertebrate animals in the forests. All of these salamanders consume a huge number of invertebrates.

Many species of amphibians depend on wetlands to provide for their basic needs: food, water, air, shelter and space. As human activities have reduced and degraded wetlands, amphibians have become environmental indicators of just how much wetlands habitat and the living organisms that depend on them can handle. As described earlier, amphibians are particularly vulnerable to environmental toxins because their skin is so permeable. Amphibian eggs can dry out if water levels drop and the developing embryos can be affected by ultraviolet radiation. Due to these and other sensitivities, amphibians are often among the first species to suffer if wetlands are altered. If amphibian populations in wetlands fail, it is an indicator that other animals that depend on wetlands may also be at risk if action is not taken to protect these habitats.

Threats to Survival

Although reptiles and amphibians have existed on earth for millions of years, there are current factors threatening the survival of many species of these animals. For the most part, these threats are caused to varying degrees by human impacts on the earth's ecosystems. Today's extinctions are occurring at an unprecedented rate over a much shorter period of time than other known extinctions in earth's history. Many human activities have impacted the environment; these activities can collectively have consequences for all living things around us. It is generally agreed by conservation scientists that the four major current threats to the survival of animals and plants as we know them are, in order of severity, habitat destruction, intro-

duced species, pollution and overexploitation (e.g. hunting, collecting). These threats are all compounded by the currently rapid rate of human population growth.

HABITAT DESTRUCTION

As human demands on resources increase, and as human populations grow, our pressures on the land also increase. Land may be turned over to agriculture or human habitation, mined, logged, or otherwise altered in ways that make the land useful for humans but may not allow for the survival of all the species that once lived there. In cases where the value of the land as habitat for animals and plants is significantly decreased, these changes are referred to as habitat destruction. When habitat is destroyed, living organisms are deprived of some or all of their basic needs for survival: food, water, air, shelter and space.

In some cases, the alteration of habitat can have beneficial effects for some species of plants and animals and can actually provide for basic needs that were not previously represented in the habitat. For example, the establishment of irrigation canals and other permanent water sources for agricultural needs has resulted in aquatic habitats for amphibians that may not otherwise have found sufficient water in the area. Animals have also adapted to other human developments, such as shelters and lights. Some reptiles are known to seek out the shelter and warmth of buildings and the bright lights outside many human dwellings are prime hunting grounds for some insect-eating reptiles, such as geckos. On the other hand, these same lights when located near ocean shores may confuse newly hatched sea turtles trying to reach the ocean. Purposeful efforts at habitat restoration, such as the improvement of wetlands, can benefit local species. While habitat alteration can provide some benefits for some species, the changes can, at the same time, eliminate resources used by other species, throwing off the balance of nature.

INTRODUCED SPECIES

The second major impact on the survival of species are the effects, direct and indirect, of introduced species. Introduced species are species of plants and animals that have been transplanted from their native habitats to new habitats. This transplanting, whether it occurs accidentally or on purpose, is mainly due to human activities. Once introduced, a species may thrive and establish itself in the new habitat. When this happens, the species can have negative effects on the local plants and animals. These effects can be direct when an introduced animal preys on native animals, such as introduced fish eating the eggs and larvae of native amphibians. Indirect effects are often changes in the habitat itself, or changes in the resource use of the native species, caused by the introduced species. These changes mainly result from resource competition between the introduced species and the native species. Introduced species often have characteristics that give them advantages over native species, such as being very prolific (producing many offspring or seeds), and are often able to "outcompete" native species for resources such as food and water. Because the native animals are best adapted to coexist with the native plants, changes in the plant composition of a habitat from native to introduced species can have drastic effects on the local animals.

There are many examples of amphibians, and also of reptiles, that have been threatened by introduced species. Often, once introduced species have established themselves, it is very difficult to right the situation. All over the world, habitats are currently under the influence of numerous introduced species. In Australia, the pygmy blue-tongue lizard (*Tiliqua adelaidensis*) was once thought to have disappeared altogether, but a small breeding population was rediscovered in the early 1990s. Although this species was rediscovered, there is no doubt that it has suffered from the influence of introduced species, in this case plants (Newsletter of the Commonwealth of Australia Endangered Species Program, 1993). The habitat of this lizard in South Australia has been affected by grazing and introduced pasture grasses have come to dominate the vegetation along the banks of the streams. Very little of the native vegetation community, upon which this lizard depends remains, and where it does, it occurs in fragmented patches.

There are also many examples of amphibians and reptiles that have been introduced to different parts of the world and have had negative effects. A good (or bad) example is the brown tree snake (*Boiga irregularis*), which was accidentally introduced from its native range of northern Australia, Indonesia, New Guinea and Solomon Islands to the island of Guam after World War II. The brown tree snake, an adept predator of birds and their eggs, has caused the drastic decline of nine of the 12 species of birds native to Guam. Now dense on Guam, up to 12,000 snakes per square mile in some areas, scientists are concerned about the further spread of the snake, especially to other islands such as the Hawaiian Islands which are home to 41 percent of all endangered birds in the United States (Rillero, 1998). The brown tree snake has already been intercepted at least six times in association with

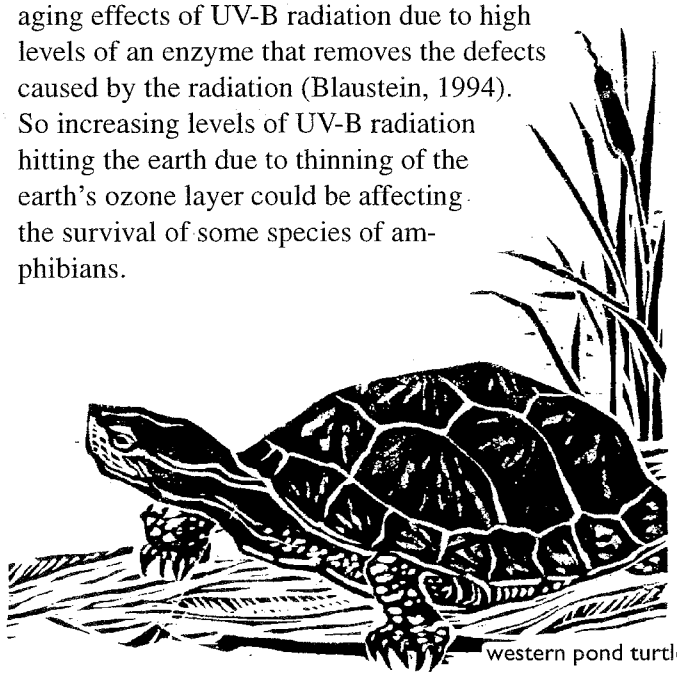
aircraft coming from Guam to Hawaii, but has not yet established itself on the Hawaiian islands. It is hoped that it never will, or Hawaii's native bird life may become even more endangered. In Washington state, and in other western states, a major culprit is the bullfrog (*Rana catesbeiana*), which was introduced from the eastern United States in the early 1900s. Bullfrogs are large frogs, up to 7 inches (17.5 cm) long or even longer, and are voracious predators, eating the young of other amphibians, reptiles and even waterfowl. It is widely believed that in Washington state, bullfrogs have been a factor in the decline of western pond turtles (*Clemmys marmorata*), Oregon spotted frogs (*Rana pretiosa*) and possibly even northern leopard frogs (*Rana pipiens*).

POLLUTION

Over the years, the creation and disposal of poisonous chemicals and other environmental toxins has polluted all of earth's ecosystems to varying degrees. Noise, light and thermal (heated water) pollution are also factors in our environment. The introduction of CFCs (chloroflourocarbons), from products such as air conditioners and plastic foam, into the atmosphere has resulted in a depletion of the atmosphere's ozone layer. The ozone layer serves to protect the earth from harmful ultraviolet radiation. Pollution can affect species in many ways. Certain chemicals disrupt the hormone levels in some animals, resulting in abnormal reproductive systems or developmental processes. In Florida, alligator eggs were examined for effects of chemicals found in high levels in certain lakes. The affected young alligators were found to have abnormal internal and external reproductive organs and skewed hormone levels. Garbage, especially plastics, that is discarded carelessly can be harmful to many species of reptiles and amphibians. For example, sea turtles sometimes mistake floating plastic for jellyfish and eat it. This can cause the turtles to become sick and even die.

In 1989, amphibian scientists from across the globe came together for a meeting, the First World Congress of Herpetology, and realized that amphibian populations were in serious decline in many parts of the world. In 1995, elementary school students in Minnesota brought the problem of deformed frogs to the attention of the scientific community and to the world as a whole. The worldwide phenomena of deformation and decline of frogs is still an environmental mystery. Scientists have conducted many studies on the various factors that may be contributing to these problems, but not one factor has been singled out. It is most likely that some combination of these factors has mounted to an overall environmental problem for frogs and other amphibians. Factors that pose major threats to amphibian survival in some areas may not be present in other areas. So it is difficult to determine with certainty exactly what is causing so many frogs to be deformed and why amphibian populations have been declining worldwide. The fact that amphibians are suffering is an indicator of possible environmental problems that could affect other species, including humans.

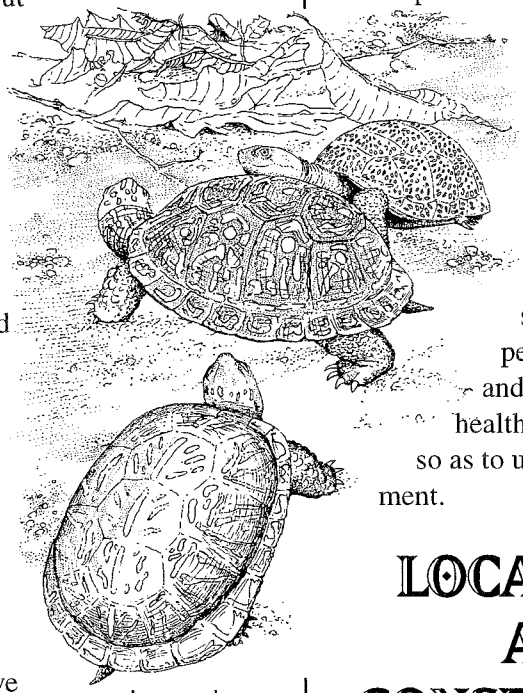
Many scientists are actively researching this topic and attempting to understand what kinds of global changes could be resulting in the disappearance of so many species of amphibians. Some of the contributing factors that have been identified include exotic pathogens (such as viruses), fungal infections, environmental contaminants such as pesticides, introduced species and ultraviolet radiation. In the Minnesota deformed frogs, the presence of certain pesticides has been linked to abnormal function of the thyroid gland which produces hormones critical to physical development (Raloff, 1999). It has also been suggested that some combination of environmental factors and changes has resulted in a decrease in function of amphibian immune systems, making them more vulnerable to disease caused by such things as exotic viral and fungal infections (Lips, 1998). In the Pacific Northwest, UV-B radiation has been shown to affect the survival of embryos of several species, such as the western toad (*Bufo boreas*) and Cascades frogs (*Rana cascadae*). Other species, most notably the Pacific tree frog (*Hyla regilla*), proved to be resistant to the damaging effects of UV-B radiation due to high levels of an enzyme that removes the defects caused by the radiation (Blaustein, 1994). So increasing levels of UV-B radiation hitting the earth due to thinning of the earth's ozone layer could be affecting the survival of some species of amphibians.



western pond turtle

PET/PRODUCT TRADE

The demand for live amphibians and reptiles to be kept as pets, as well as for products produced from their bodies, is a modern threat facing these species. Populations faced by other threats, such as those described in the previous paragraphs, can be put over the edge by the impact of harvesting for the pet or product trade.



box turtle

Amphibians and reptiles are popular as pets, especially in classrooms. Some species, such as leopard geckos, corn snakes, horned frogs, boa constrictors and bearded dragons, which are bred very successfully in captivity, are relatively easily cared for and can be handled. Other species, however, are difficult to breed in captivity and thus, many animals that are available for purchase are taken from the wild. There are many cases where species of reptiles or amphibians have become endangered due to collection for the pet trade. In Egypt, the Egyptian tortoise (*Testudo kleinmanni*) was driven to extinction in its native range within a matter of years due to rapid collection for the pet trade. Egyptian tortoises are now found in the wild only in national parks in Israel. On a local level, it is important that native reptiles and amphibians be left in the wild and not removed to become classroom or house pets. These species may be difficult to care for, or those who capture them may not have proper care information, and most do not survive for long out of their wild habitats. Collecting native species from the wild only puts more pressure on populations already facing habitat destruction, pollution and other threats to their survival.

Some species, primarily reptiles, are harvested for the valuable products that can be produced from their skin and other body parts. Although trade in threatened and endangered species is restricted by international treaties (Convention on International Trade in Endangered Species of Wild Fauna and Flora — CITES) and national legislation (Endangered Species Act), illegal wildlife trade continues to threaten many species. As consumers, we can be sure to avoid purchasing products made from reptiles and amphibians, particularly from endangered species. Everything we do as individuals can make a difference.

Another problem related to reptiles and amphibians in the pet trade is that of exotic species being released into local habitats. As explained in previous sections, if these introduced species are able to survive where they are released, they can alter the native habitat and impact native species. Furthermore, releasing exotic pets, or even dumping water from tanks that have housed exotic species, can introduce diseases into local habitats. Native species may have few defenses against these diseases and can be impacted significantly. It is important that pet amphibians and reptiles are taken care of properly and not released into the wild. In making a decision to keep amphibians or reptiles as pets, it is important to understand the care and responsibility involved in keeping the pet healthy, as well as the life expectancy of the pet so as to understand the duration of your commitment.

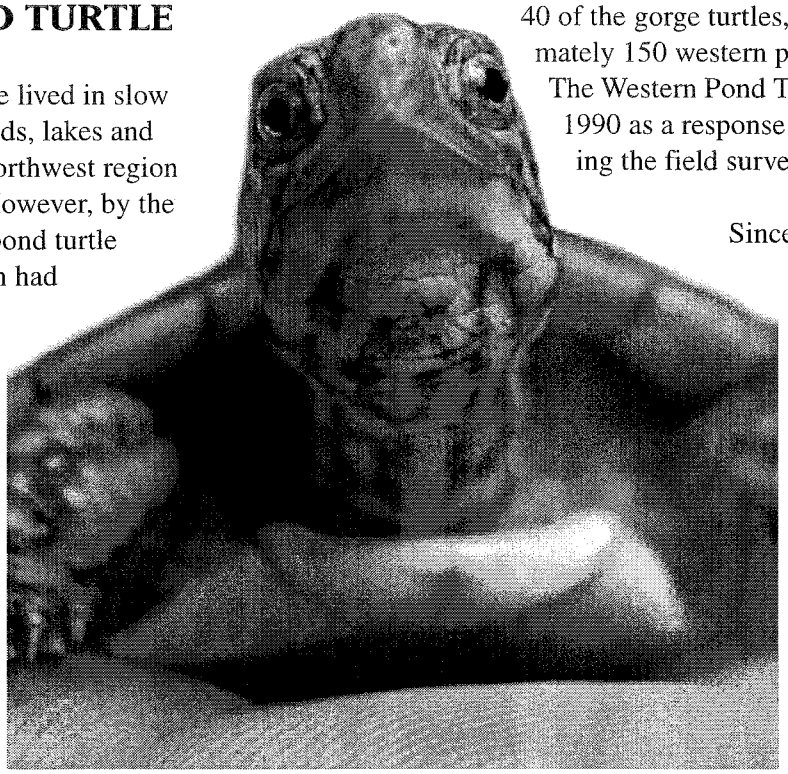
LOCAL REPTILES AND AMPHIBIANS: CONSERVATION EFFORTS

Washington state encompasses a diversity of habitats and thus, a rich biodiversity of plants and animals. The region west of the Cascades crest, where the land is mainly cloaked in temperate forests, receives a significant amount of precipitation each year, ranging from 35 to 120 inches (300 to 350 cm). The Olympic and Cascade mountain ranges together create a barrier to moist air as it travels inland from west to east. Thus, the eastern portion of Washington state is significantly drier, with an average annual precipitation ranging from 10 to 15 inches (25 to 38 cm) in the Columbia Basin region. The vegetation of eastern Washington includes dry temperate forests and sagebrush steppe, which consists of sagebrush and other shrubs mixed with grasses and wildflowers. Due to these climatic conditions and the adaptations of reptiles and amphibians, there are more species of reptiles inhabiting eastern Washington than there are western Washington, but the opposite is true of amphibians, with more species of amphibians, particularly salamanders, inhabiting the wetter west side. The following paragraphs will examine just a few species of Washington's reptiles and amphibians, focusing on those that are on the Washington Department of Fish and Wildlife's Species of Concern list. (For more information on species of reptiles and amphibians throughout Washington state, see the zoo's "Washington Wildlife" teacher packet.)

WESTERN POND TURTLE

(*Clemmys marmorata*)

Western pond turtles have lived in slow backwaters of rivers, ponds, lakes and marshes of the Pacific Northwest region for thousands of years. However, by the mid-1980s, the western pond turtle population in Washington had been drastically reduced. In 1993, the western pond turtle was listed as endangered by the Washington Department of Fish and Wildlife (WDFW). This species is also listed as a species of concern under the Endangered Species Act (ESA) of the United States Fish and Wildlife Service (USFWS).



western pond turtle hatchling Fred Housel

What happened to Washington's native pond turtles? Several factors have come into play over the history of western pond turtles. Humans have long considered wetlands to be land of little value. For this reason, more often than not, wetlands have been drained or filled so that the land could be paved over and developed. These actions significantly reduced the healthy habitat available for animals such as pond turtles. Western pond turtles have also suffered from the introduction of bullfrogs (*Rana catesbeiana*) and largemouth bass (*Micropterus salmoides*) into the region. Bullfrogs were introduced to the western United States from the eastern United States in the early 1900s. Bullfrog legs were sought after for food and the introduced bullfrogs were hunted as game. Bullfrogs are large (adult males can be longer than 7 inches (17.5 cm)) and eat a variety of animals from small insects to birds as large as robins. Predation by bullfrogs and largemouth bass has had a significant effect on the survival of baby pond turtles. Other factors affecting pond turtle populations include disease and environmental pollution, such as oil spills.

Biologists conducted field surveys of western pond turtles between 1985 and 1990. These field surveys determined that western pond turtles, which had been common throughout Puget Sound, were now virtually extinct in the Puget Sound area and only two small populations remained in the Columbia River gorge area. Then in 1990, a disease outbreak killed at least 40 of the gorge turtles, leaving only approximately 150 western pond turtles in the state. The Western Pond Turtle Project began in 1990 as a response to discoveries made during the field surveys.

Since the start of the project, biologists from Woodland Park Zoo and the WDFW have been working to protect baby western pond turtles from introduced predators and to increase the size of the pond turtle population. This has been accomplished by taking newly hatched pond turtles from the wild and raising them in captivity for a year before releasing them back into the wild, thus giving them a "head-start" on life. Each spring wild turtles are trapped to be identified, weighed and measured. Transmitters are put on the backs of the captured adult females. From May 15 to July 15 of each year, these females are monitored with telemetry every two hours to discover when they come out of the water to nest. Once a female has finished laying her eggs, biologists cover the nest with wire mesh "exclosures" to protect the eggs from predators such as raccoons and skunks. After approximately 100 days of incubation, the eggs hatch and the hatchling turtles are collected and brought to an off-view holding area at Woodland Park Zoo for the head-start program. After a year of growth, the pond turtles are large enough to avoid being eaten by bullfrogs and largemouth bass. Since the inception of the head-start program, 332 hatchlings have been raised at the zoo and released. An additional 77 hatchlings are at the zoo at the time of this writing. These animals will be released in the summer of 2000.

At the beginning of the head-start program, field evaluations were conducted to assess the progress of turtles that had been through the program and it was determined that this was the best course of action for restoring the species to Washington state. Biologists also work to control the population of bullfrogs. One way they accomplish this is by removing bullfrog egg masses (which may contain over 10,000 eggs) from the ponds where pond turtles are released. The Western Pond Turtle Project has also involved captive

breeding of the few wild turtles found in the Puget Sound area. These turtles, which are housed and bred at Woodland Park Zoo, represent some of the last individuals of a former western Washington population and will be the foundation for any new populations established in western Washington.

A recovery plan for the western pond turtle has been developed by the WDFW. Recovery plans for endangered species take several years to write and publish, as it is imperative to study each species and determine what elements of the species' habitat are necessary for survival. For many local species, little literature exists and little previous research has been conducted about their life histories and habitat needs. Therefore, learning as much as possible about the natural history of each species will help identify what has caused the species to decline in numbers and will point to specific activities that can help restore those numbers.

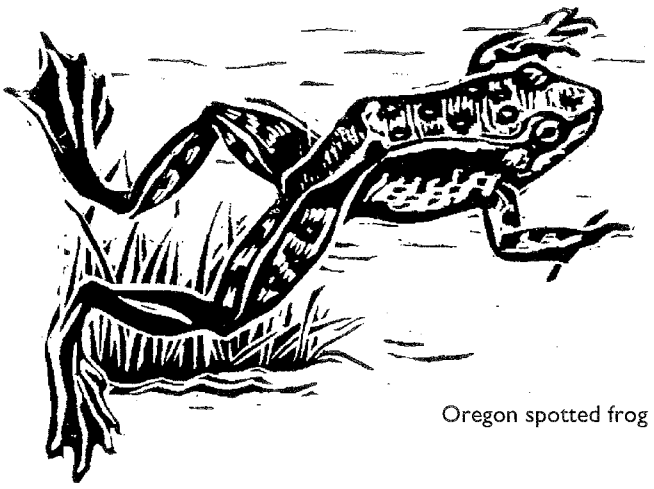
The Western Pond Turtle Project recovery efforts will continue until the goals of the "Washington State Recovery Plan for the Western Pond Turtle" have been accomplished. These goals include the establishment of three populations in the Columbia River gorge and one population in the Puget Sound area with at least 200 turtles each, of which 70 percent are adults.

As we examine the case of the western pond turtle, it is not difficult to see that the factors which caused western pond turtles to become endangered have also caused many other species worldwide to face extinction. As described previously, major factors affecting the continued survival of species, such as western pond turtles, are habitat loss, introduced species, pollution, hunting and harvesting, all of which are directly related to human activity and human population growth. For most species, a combination of factors has resulted in declining populations. But as we become more aware of these common factors, we can make efforts in our own lives to have as little impact as possible.

OREGON SPOTTED FROG

(Rana pretiosa)

The Oregon spotted frog, a highly aquatic amphibian found in western Washington, was listed as endangered by the Washington Fish and Wildlife Commission in 1997 and is a candidate for listing under the Endangered Species Act of the United States Fish and Wildlife Service. This species was recently taxonomically distinguished from its close relative, the Columbia spotted frog (*Rana luteiventris*) of eastern Washington wetlands, whose populations have not declined as drastically. In Washington state, only three populations of Oregon spotted frogs are known to exist, but, fortunately, these populations seem to be healthy and are breeding successfully.



Oregon spotted frog

Oregon spotted frogs spend the majority of their lives in water, whereas other frogs may spend significant periods of time out of water at certain times of year. Oregon spotted frogs lay their egg masses in exposed shallows at the margins of wetlands. This exposure ensures that the eggs will remain at temperatures sufficient for normal development. However, because they are laid in such shallow water, the eggs are vulnerable to freezing or drying out if water levels change. Oregon spotted frog tadpoles eat algae, decaying vegetation and other **detritus**. Adult frogs eat insects, such as beetles, flies, ants and water striders, and other arthropods, such as spiders.

Several factors have been indicated as being possible contributors to the decline of Oregon spotted frogs. In many wetlands inhabited, either currently or historically, by spotted frogs, nonnative fish, including largemouth bass, black crappie, brown bullhead, pumpkinseed, yellow perch and bluegill, have been introduced along with bullfrogs. Bullfrogs and introduced fish may prey on spotted frog eggs, tadpoles or adults. Another introduced species, reed canary grass (*Phalaris arundinacea*), has also played a part in the decline of spotted frogs. Reed canary grass grows densely and takes over shallow, emergent wetlands, creating thick stands of vegetation in areas that were previously suitable egg-laying sites for spotted frogs.

Wetlands were once abundant within the range of Oregon spotted frogs. However, many of these wetlands have been significantly altered or destroyed. These wetlands played an important role in moderating the fluctuation of water levels by absorbing and then

slowly releasing run-off water. In the absence of these wetlands, spotted frog eggs are subject to freezing or desiccation (drying out) when water levels fluctuate significantly. Of course, the loss of the wetlands themselves decreased the amount of land suitable for spotted frogs to live and breed.

Whatever the cause, or combination of causes, that have resulted in the decline in Oregon spotted frog populations, their continued survival is at risk. "Although theories about the factors which caused these population losses are many, conclusive evidence of the importance of any one factor is lacking. Therefore, each potential threat must be taken as though it is equally serious." (McAllister and Leonard, 1997)

Without a clear understanding of the specific factors that have resulted in the disappearance of spotted frogs, it is difficult to determine how the recovery of the species should be accomplished. Currently, biologists with the Washington Department of Fish and Wildlife are undertaking research in an attempt to better understand this species and its needs. Field studies are being conducted to identify more clearly the habitat needs of spotted frogs at different times of the year and in different life stages. For example, one study has been designed to determine whether or not spotted frogs will lay their eggs in wetlands where dense growths of nonnative vegetation have been cut back. If they will, and if the embryos survive and develop normally, then this may be one method of aiding the reproduction of spotted frogs. Some preliminary trials in captive breeding and reintroduction of spotted frogs have been conducted. If biologists can obtain a full understanding of the habitat requirements of this species, reintroduction might be a viable option for recovering spotted frog populations.

Essentially, the key to survival of spotted frogs in Washington state is more scientific research that will shed light on this species' habitat requirements in order to identify the factors that have resulted in declining populations of spotted frogs. Only with a thorough understanding of what has caused the frogs' disappearance will scientists be able to take significant steps towards ensuring the survival of this species.

LARCH MOUNTAIN SALAMANDER

(*Plethodon larselli*)

The larch mountain salamander is listed as sensitive by the Washington Fish and Wildlife Commission and as a Species of Concern under the Endangered Species Act. This species makes its niche in unique habitats of southern Washington. Larch mountain salamanders have adapted to life in talus (rock fall) slopes and rocky cave entrances in damp, forested areas of the southern Cascade Mountains and the Columbia Gorge. These salamanders eat invertebrates that live in accumulated organic debris among the rocks.

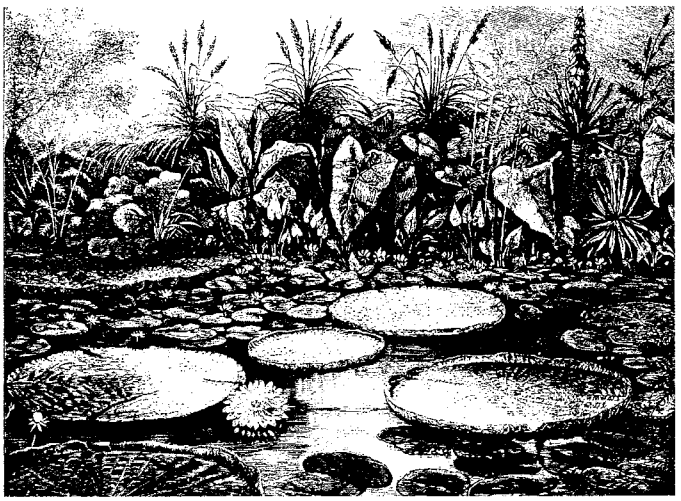
Talus slopes are often the source of rocks used in road building. The removal of rocks from these slopes, in addition to logging in adjacent areas, can alter the habitat to the degree that larch mountain salamanders can no longer survive there. There is still much to be learned about the life history of these salamanders and the specific effects of activities, such as logging and road- or trail-building, on these salamanders are not yet fully understood. On federal lands, such as national forests, in Washington where trails, timber sales or other human impacts are imminent, surveys are conducted to determine whether larch mountain salamanders are present. Management recommendations are made based on the findings of these surveys.

NORTHERN LEOPARD FROG

(*Rana pipiens*)

Northern leopard frogs, although widespread in North America, have been declining throughout their range in recent years. In February of 2000, this species was listed as endangered in Washington state, however it is currently not listed by the USFWS. These frogs breed in the spring when the males attract mates with their calls. Females lay egg masses that are usually attached to vegetation growing in shallow water, such as sedges and rushes, in places exposed to sunlight for warmth. In the summer, after breeding, adults disperse far and wide from the ponds, into a variety of habitats where there is dense vegetation in which to hide. After the tadpoles have hatched and metamorphosed into adults, they also disperse from the ponds to larger bodies of water such as lakes and streams. Northern leopard frogs do not hibernate, but do spend a period of decreased activity in deep water that does not freeze.

In the tadpole stage, northern leopard frogs are preyed upon by large aquatic insects, fish, bullfrogs and waterfowl. Predation by bullfrogs, an introduced species in Washington state, is considered to be one of the factors that has caused northern leopard frog populations to decline in our region. Northern leopard frogs move long distances at different times of year, from breeding pond to meadow to overwintering sites. Adult leopard frogs may move up to a mile away from their breeding ponds during the summer season. Because of these movements, leopard frogs are prone to being killed by vehicle traffic on roads. Other threatening factors include rapid changes in water level due to irrigation and other human developments that alter the movement of water in a region. Rotenone, a chemical used to control fish, has been shown to kill leopard frog tadpoles. This chemical is used to control introduced fish species and is used in areas where leopard frogs currently occur. Applying rotenone during a time of year when there are no tadpoles in the water would reduce the impact of this chemical on northern leopard frog populations.



In 1992, scientists conducted surveys attempting to locate northern leopard frogs at sites the frogs have historically inhabited, but populations of these frogs were found in only two areas, both located in the Crab Creek drainage in Grant County. Due to concern over the survival of this species, a status report was prepared and the northern leopard frog was subsequently listed as an endangered species in Washington. According to the status report, in order to ensure the survival of this species further field surveys need to be carried out and more research must be done to gain a better understanding of the factors that have caused the decline of this species. Northern leopard frogs, along with larch mountain salamanders and Oregon spotted frogs, are still in the process of being surveyed and studied in order to construct plans for their recovery. Listing by the WDFW gives these species protection from any further habitat destruction or collection. Preservation of habitat will be a very important part of the recovery plans for these species, but the habitats also need more intense study.

WHAT YOU CAN DO

As we learn about reptiles and amphibians, their characteristics and their roles in the environment, we also become more aware of our own roles in the environment. What is the global decline of amphibians really telling us? What can we do about it? What choices can we make that will lessen our negative impacts on reptiles and amphibians and the environment as a whole? The following list provides some suggestions of ways teachers, students, individuals and/or groups can promote and be involved in conservation of reptiles and amphibians. Some of these suggestions are simple daily choices, other suggestions involve more time and commitment, but any of these choices or actions will help to ensure that the diversity of reptiles and amphibians on our earth will survive into the future. Every effort counts!

- Educate yourself about the characteristics and habitat needs of local species of reptiles and amphibians. By doing so, you can better understand how to lessen your own impact on these species.
- Step lightly in wetlands and other natural areas. Disturbance of soils and vegetation can be detrimental to the health and survival of reptiles and amphibians.
- Participate in, or initiate, a community or school project to restore a wetland or other natural habitat for wildlife. Contact your county public utilities department for information on grants available for habitat restoration projects or see the "Resources" section in this packet for information on habitat restoration funding.
- Learn how to take photographs or practice naturalistic drawing or painting so you can "capture" images of the reptiles and amphibians that you see in your explorations of natural places.
- Do not release pets into the wild. These animals may affect native species by preying on them or by outcompeting them for resources. Introduced species can also spread diseases into local populations.
- Do not capture or disturb wild amphibians and reptiles. If you do "borrow" something from the wild to study it, return it to where you found it as soon as possible.

- If you keep pet animals, such as fish, in an aquarium, when you clean the aquarium, dump the water down the sink and not outside. Diseases can spread from aquarium animals to wild fish and amphibians if the water is dumped outside and gets into local water systems.
- If you want to keep a reptile or amphibian as a pet, research the care requirements of different species and determine your level of commitment. Also, be sure that the species you choose has been bred in captivity and not taken from the wild.
- Reduce your and your family's use of harmful chemicals. Natural products, such as vinegar and baking soda, can accomplish many household or classroom clean-up jobs just as well as chemical-based products. By reducing our use of harmful products, we can reduce the amount of environmental toxins that get into ecosystems and can harm reptiles and amphibians.
- Be sure you dispose of hazardous materials (pesticides, weed killers, paints, solvents, automotive fluids, cleaning chemicals, etc.) properly. Contact your county hazardous waste management program (see the "Resources" list in this packet for a partial listing) to learn how to dispose of leftover or used chemicals or other harmful materials, such as motor oil and paint.
- Avoid buying products made from parts of reptiles and amphibians. Although some of these products are produced sustainably, such as alligator skin from alligator farms, many products found in the United States and abroad are produced from threatened and endangered species.
- Using field guides and other resources, you can learn how to identify native and nonnative species of turtles common to Washington state. As a group, you can conduct turtle surveys of local wetlands. *Note: Students should be careful to tread lightly around the edges of wetlands, causing as little disturbance as possible to these fragile habitats.* If you believe you have spotted a western pond turtle, you can report your sighting to Woodland Park Zoo's Turtle Hotline at (206) 615-1334. Be sure to include:
  1) A photograph or detailed description
  2) The exact location of the turtle
  3) Date of the observation
  4) Observer's name, address and phone number
  5) Any other details about the observation
- Become involved in local wildlife monitoring programs, such as NatureMapping or the King County Amphibian Monitoring Program (see the "Resources" list in this packet for contact information), to help determine what native and nonnative species inhabit your neighborhood or town. *Note: Amphibian monitoring is most appropriate for small groups, such as families, due to the sensitive nature of wetlands. Teachers can recommend this activity to interested students and their families, but it is inadvisable to involve large groups of students in amphibian monitoring projects.*