LAB 4 “REPTILES”

As always, know the terms in **bold**

Station 1. Major groups of ectothermic amniotes (“reptiles” or reptilians).

Early tetrapods were, like early land plants, tied to the water by their reproductive mechanisms. Like most "fish" fertilization, egg-laying and development took place in water. The larvae then metamorphosed into land-living adults.

Sometime during the Carboniferous (354 to 290 million years ago during the late Paleozoic), one group of tetrapods developed the amniotic egg. In the ancestral condition, the amniotic egg has a shell hardened by calcium carbonate which is impermeable to water but allows gases to be transpired. The embryo lies floating in the amniotic fluid, which is formed by the embryo. The amniotic egg is a major synapomorphy for the Amniota that includes all of the vertebrates we will discuss from now on. Soon after the amniotes appeared, two distinct groups became recognizable - these are the **Synapsida** (which includes us) and the **Sauropsida**.

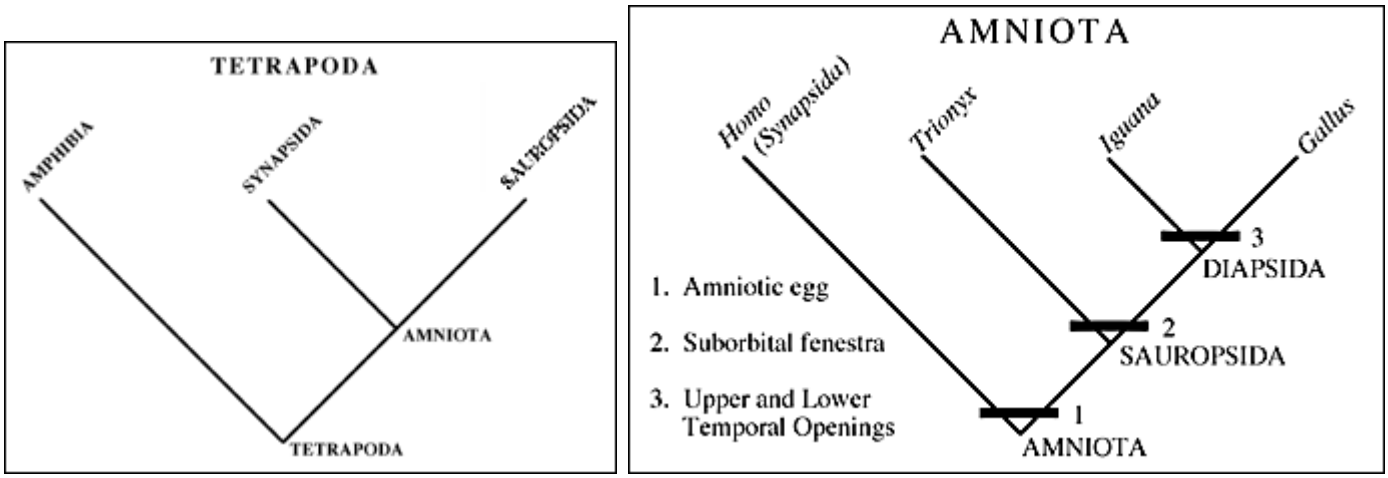


Figure 1. Tetrapod and Amniote relationships. Synapsida*: Homo*, mammals, Saurapsida contains two groups: 1. *Trionyx*: Chelonia (turtles, sometimes considered the “Anapsida) and 2. Diapsida: *Iguana* (Lepidosauria or the tuatara, lizards, snakes, amphisbaenians) and *Gallus*: birds. From http://www.ldeo.columbia.edu/edu/dees/courses/v1001/permtrias8.html

Within the **Sauropsida**, you find the “**Anapsida**” (the turtles) and the **Diapsida**, which includes the **Lepidosaurs** and the **Archosaurs**. The groups with the suffix “psida” above are all separated in terms of the configuration and number of the orbital fenestrae (windows) in the skull.

* You should be able to recognize any specimen to one of the major groups in **bold** below.

As you are probably aware, the traditional group Reptilia is paraphyletic because it includes a common ancestor and only some of its descendants (i. e., birds are not included in this traditional classification. The characteristics that link “reptiles” (e. g., scales and ectothermy) are ancestral traits. Therefore, we are studying this selected group of animals together in one lab has more due to human interest and perception rather than evolutionary history.

The order **Testudinata** (turtles or sometimes referred to as Chelonia) is a worldwide group of about 250 species. This group consists of two monophyletic lineages: the Cryptodira in which the neck is bent into a vertical S-shape for retracting the head, and the Pleurodira which retract the head by bending the neck in a horizontal S-shape. Most turtles are cryptodires.

The **Archosauria** consists of **Aves** (birds, a group we will discuss later), dinosaurs, pterosaurs (now extinct) and crocodilians. **Crocodylia** (order) is a primarily tropical and subtropical group of 23-25 species. All are relatively large, semi-aquatic carnivores. There are three monophyletic lineages (families): **Crocodylidae**, **Alligatoridae**, and Gavialidae. You are probably familiar with crocodiles and alligators. The third group, Gavialidae, consists of two species with extremely long and thin snouts.

The **Lepidosauria** consists of the orders **Rhynchocephalia** /Sphenodontia (tuatara) and **Squamata**. There are only two species of tuatara. They live on small islands off the coast of New Zealand in association with seabird colonies, feeding on arthropods attracted to the colonies as well as on nestling birds. Tuataras sort of look like a Mickey Mouse lizard (i. e., head looks large relative to body size). See Figure 5.1.

The order **Squamata** is the most diverse group of sauropsids (other than birds) with about 5700 species. Squamates are sometimes divided into lizards, snakes, and amphisbaenians (a group of burrowing, usually limbless animals). However, most phylogenetic studies of these taxa suggest that the group “lizards” is paraphyletic, with some lizards being more closely related to snakes or amphisbaenians than they are to other lizards.

Station 1B. The order Rhynchocephalia.
Examine the cast of the tuatara. Be able to identify it as one of the orders of Lepidosauria.

Station 2. External anatomy. Selected aspects.
1. Testudinata: The shell of a turtle is made up of an inner layer of dermal bone, and an outer layer of horny epidermal scutes. Are the divisions in the outer layer directly above the divisions in the inner layer? Why might they be arranged this way? Where are the ribs of a turtle? How does the position of the ribs with respect to the limb girdles compare to their position in other vertebrates? Identify these structures on the turtle: **carapace** and **plastron**.

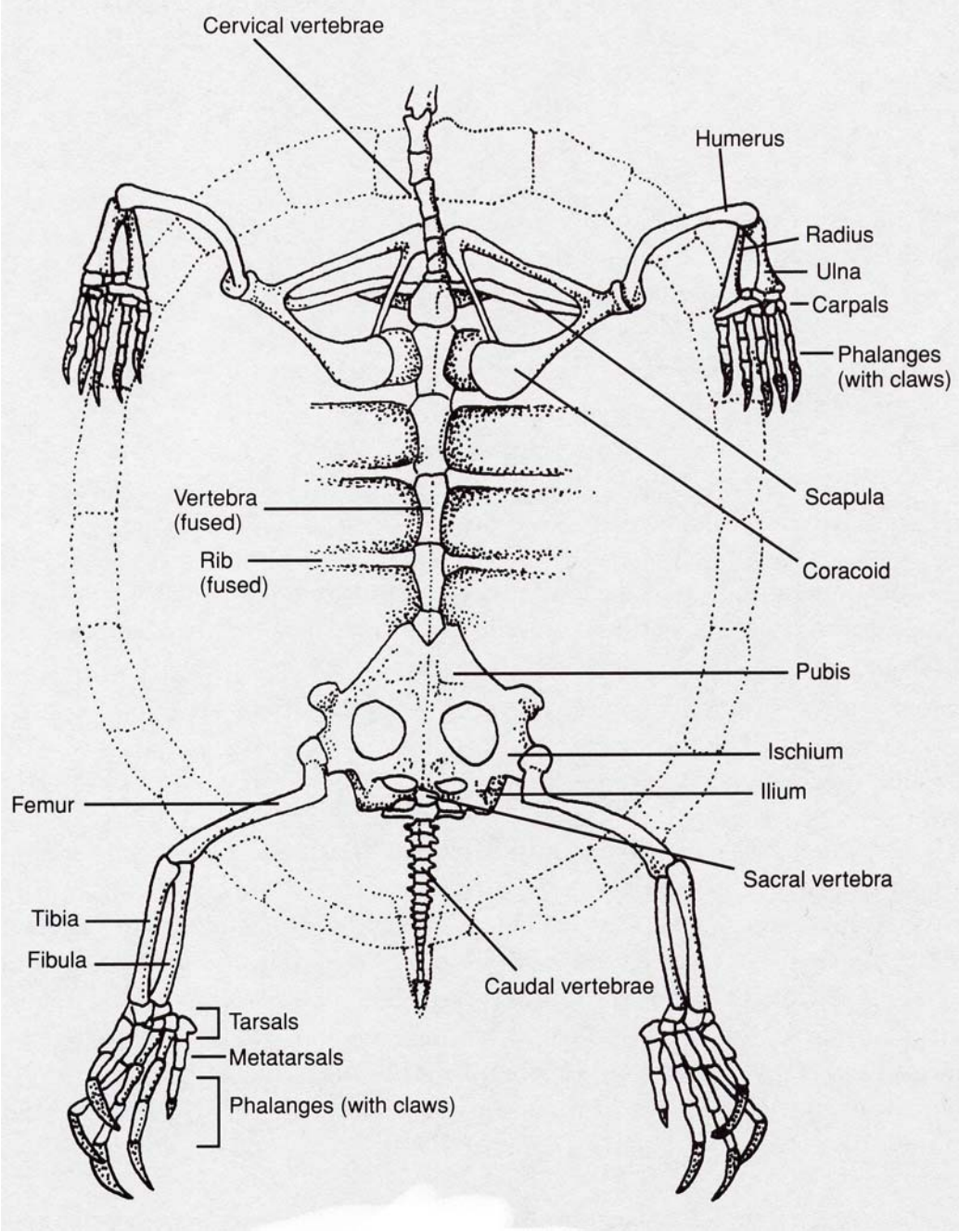


Figure 2.1. Testudinata: Ventral view of the carapace illustrating the skeletal system. From Gergus & Schuett 1997, Labs for Vertebrate Zoology: an Evolutionary Approach, Biological Sciences Press)

2. "Lizard": Locate the **femoral pores, cloaca / vent** and **gular fold**.

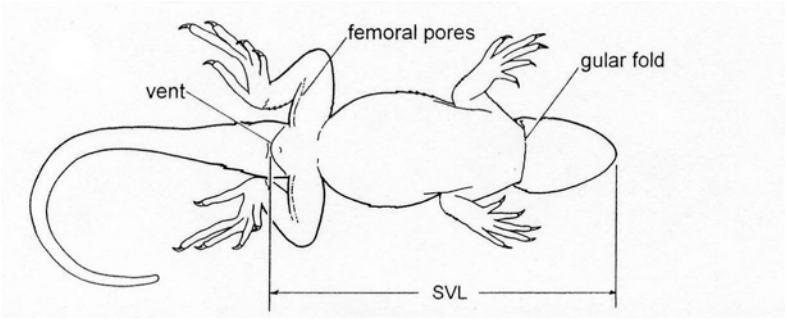


Figure 2.2. Ventral view of a lizard.

3. Snake: Locate the **loreal pit**. Only present in a particular group of snakes and located between the eyes and nostrils. These pits aid in sensing heat.

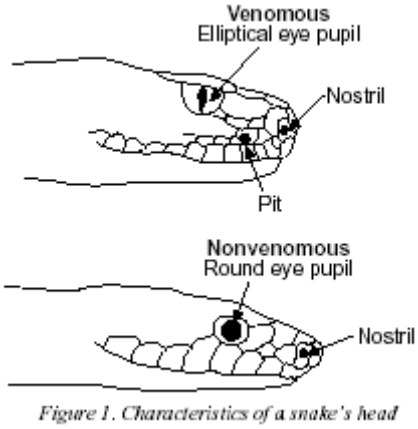


Figure 2.3. Lateral view of two snakes demonstrating different features. From the Missouri department of conservation.

4. Identify the scale types illustrated by the snakes and "lizard": **keeled** (*Crotalus*),**cycloid** (sometimes called smooth) (*Leptotyphlops*), and **granular** (*Holbrookia*)

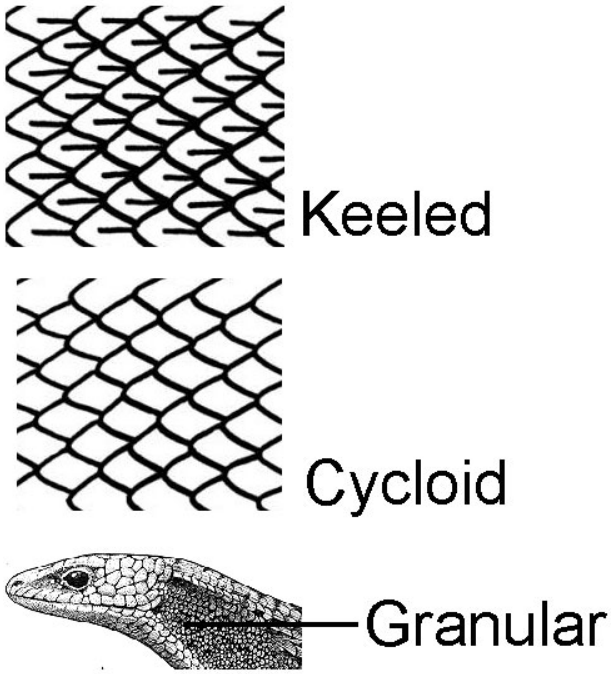


Figure 2.4. Scale types in lizards and snakes. Formulated with illustrations from Mike J. Pinder at (fwie.fw.vt.edu/) and from the Canadian Museum of Nature (www.nature.ca).

Station 3. North American families of the order Testudinata (turtles).
You should be able to identify any N. A. species of turtle to family. Remember, testudines are separated into two sub-orders (**Cryptodira** [hidden neck] and **Pleurodira** [side neck]) based on the manner in which the head retracts. Most turtles are **Cryptodires**. Use the associated key to help differentiate among families.

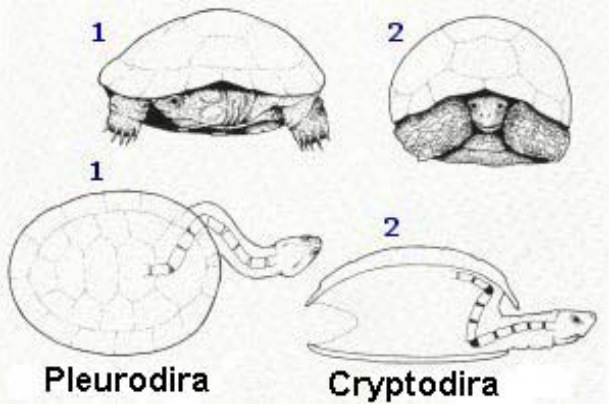


Figure 3.1. The two major groups of Testudines. From /www.czprima.cz.

Chelydridae (snapping turtles) rear edge of carapace saw-toothed, long tail with "spikes", very small plastron.

Emydidae (pond and box turtles) All of the turtles in this family have 6 pairs of shields on the plastron; top of head covered anteriorly with skin.

Kinosternidae (mud turtles) less that 12 plastron shields; rear of carapace smooth; have an oval, high-domed carapace.

Testudinidae (tortoises) elephant-like limbs; high, domed shell; 12 plastral shields but top of head covered entirely with shields.

Trionychidae (soft-shelled turtles) soft shell that is flat, leathery and almost circular in shape. They are very aquatic and have paddle-like feet and a long, tubular nose that they use as a snorkel.

Station 4. North American families of the order Squamata.
Identify any N. A. squamate to family. Most N. A. families are included. Use the associated key to help identify the families. To differentiate between amphisbaenians, snakes and "lizards" look for moveable eyelids ("lizards"), limbs (most "lizards") and scale rings (amphisbaenians).

4a. Sub- order: Amphisbaenidae (amphisbaenians) rings of scales around body, eyes covered with scales, no limbs or external ears (though the absence of the pelvic and pectoral girdles is variable). The head is strongly built to aid in digging. In most cases, the skin can move independently of the body.

4b. Sub-order: Sauria. Lizards

Family: **Iguanidae** (iguanas). Mid-dorsal scale row enlarged, or if not, rostral scale divided

Family: **Anguidae** (legless lizards, alligator lizards, glass lizards) lack legs but have moveable eyelids (snakes don't have moveable eyelids). All are heavily armored with scales (largely nonoverlapping) underlain by rectangular osteoderms. Commonly, a longitudinal ventrolateral fold separates the dorsal and ventral armor on each side, hence the name "lateral fold lizards".

Family: **Crotaphytidae** (collared lizards) large head, two black collars around neck, smooth dorsal scales.

Family: **Helodermatidae** (gila monster) the only venomous group of lizards (the bite is painful, but does not kill); heavy-bodied, short-tailed, marked with dark reticulations on a yellow or orange background, or vice versa (aposematic); the back and other surfaces of the limbs are covered with large bead-like scales.

Unlike those of the poisonous snakes, the venom glands of *Heloderma* are in the lower jaw; the teeth are grooved but not hollow. The venom empties into the mouth through several ducts that open between the teeth and the lips.

Family: **Phrynosomatidae** (e. g., horned and fence lizards) keeled scales (fence lizards), bony spines off back of head (horned lizards) or enlarged toe fringes (fringe toed lizards; *Uma*).

Family: **Scincidae** (skinks) typically scincids are slighly to markedly elongate lizards that have relatively long-snouted and somewhat flattened skulls. The head is usually covered with enlarged plates, termed head shields, and osteoderms are frequently present in some or all scales. These osteoderms are unusual because each is composed of a set of smaller ones in contrast to a single bone as in other lizards. Smooth, shiny cycloid scales (few exceptions, e.g. members of the genus *Tribolonotus*). Limbs are relatively small.

Family: **Teiidae** (whiptail lizards) body elongate, ventral scales rectangular

4c. Sub- Order: Serpentes

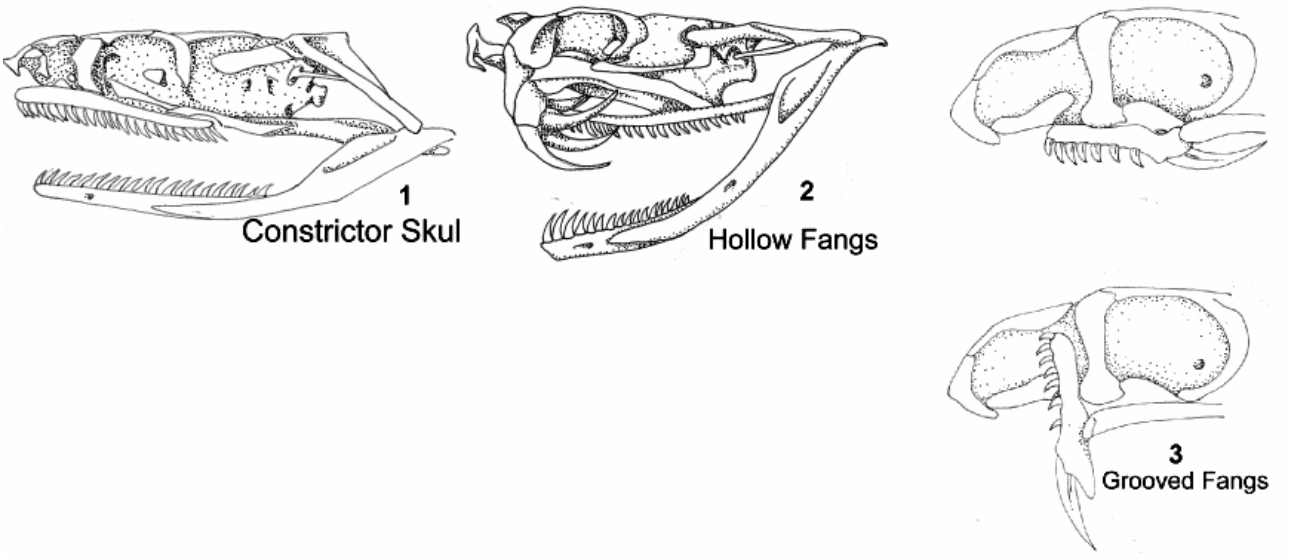
Family: **Boidae** (rubber/ rosy boas and pythons). Relatively large, stout snakes; anal spurs on males (vestigial hind legs); posterior head scales small; small chin shields.

Family: **Colubridae** (e. g., garter, king, hognose snakes) a group that is most likely paraphyletic made up of several distinct lineages and more than 1800 species. Most snakes fall into this classification. Because it is a paraphyletic group there are no good characters to identify snakes to this lineage, rather think of it as all the snakes that don't fall into the other groups.

The only decent character is that they either have undifferentiated teeth or enlarged rear fangs (you can't see this without the skull). Many species have glands that secrete venom, but lack hollow fangs to facilitate delivery and have a groove instead.

Family: **Elapidae** (coral snakes, cobras). Fixed, hollow front fangs (mostly); venomous; pattern red, yellow and black (in some cases).

Family: **Viperidae** (rattlesnakes, copperheads, cottonmouths) loreal pit (only in Asian and New World groups), triangular head, moveable front fangs in many groups (allows the fangs to rest horizontally when the mouth is closed).



1 CONSTRICTOR SNAKES e.g. boas (*Boidae*), phythons (*Pythonidae*), and rat snakes (*Colubridae*)	**2 HOLLOW-FANGED SNAKES** e.g. vipers (*Viperidae*), adders, mambas & cobras (*Elapidae*)	**3 GROOVE-FANGED SNAKES** e.g. boomslang (*Colubridae*).
Non-venomous snakes, kill their prey by suffocation Generally no fangs Numerous small backward curving teeth	Poisonous snakes Venomous fangs at anterior of jaw Most poisonous snakes Fangs are hollow and resemble hypodermic needles Each fang is connected to the venom gland by a narrow tube The two main types of hollow-fanged snakes, the vipers and elapids, differ in that vipers have long moveable front	Poisonous snakes Venomous fangs at posterior of the jaw Generally less dangerous as venom is released more slowly Fangs are grooved Venom runs down groove into bite wound

Figure 4.1. Snake dental morphology and adaptations.
Author: Chris, Gill and Justyn

Station 5. Shared characters of archosaurs.
Crocodilians, birds, and lepidosaurians (tuatara + squamates) are the living members of the **Diapsida**. The term diapsid refers to the two openings (fenestrae) in the temporal region of the skull. This condition is very obvious in the tuatara (Figure 5.1) and is visible in a crocodilian.

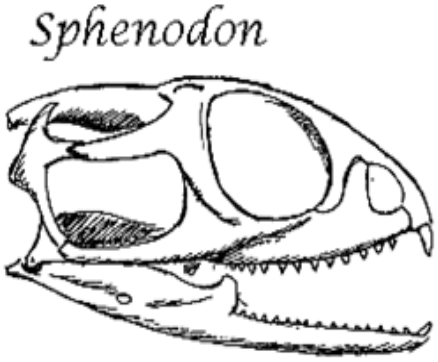


Figure 5.1. *Sphenodon* (Tuatara) demonstrating the double fenestrae of diapsids. Art by: Svend Palm (http://home13.inet.tele.dk/palm/)

1. Compare the crocodilian skull with the turtle skull. Turtles are anapsids (lack temporal fenestrae). In other living diapsids the skull is modified so that the diapsid condition is no longer obvious.

Crocodilians and birds are members of the **Archosauria**, which includes the extinct flying pterosaurs and non-avian dinosaurs. Crocodiles and birds share a number of derived traits such as vocal communication, parental care, a four-chambered heart, and a hard-shelled egg.

2. Compare the crocodilian egg to the much more flexible turtle egg. What does the sharing of these derived characters by birds and crocodilians suggest about non-avian dinosaurs?

3. Archosaur families: Know these two families of Archosaurs within the order **Crocodilia**.

Crocodylidae snout tapered and 4th lower tooth visible when mouth is closed

Alligatoridae snout rounded and broad; lower 4th tooth not visible when mouth closed

Station 6. Squamate diversity.

There are nearly half again as many species of squamates as there are mammals. This station gives a hint of the great diversity of squamate adaptations.

1. Aquatic. The sea snakes, represented here by *Pelamis platurus*, are an extreme example. Can you identify any characteristics of *Pelamis* that indicate it is aquatic lifestyle?
Most sea snakes spend their entire lives in the ocean (including all aspects of reproduction). How do you think they reproduce (i. e., internal vs. external fertilization; viviparous or oviparous)?

2. Sand. The fringe-toed lizards (*Uma*) are adapted to life on very fine sand. Compare the specimen of *Uma* with the closely related but non-sand dwelling *Holbrookia*. Can you identify characteristics of *Uma* indicating it is a sand-dweller?

3a. Venom. Certain groups of snakes are well known for being venomous (e. g., rattlesnakes, coral snakes) but **Helodermatidae**, represented here by the gila monster mount (*Heloderma suspectum*) is another squamate lineage that independently evolved venom.

3b. Venom. Venom has also arisen independently in several groups of colubrid snakes. Venomous colubrids have fangs in the rear of the mouth (rather than the front as in viperids and elapids) and are generally not harmful to humans (some deaths have occurred from colubrid bites*). Leptodeira* is a rear-fanged colubrid. This species is nocturnal, a common habit among snakes. Note its vertical pupil, a feature associated with nocturnality. Figure 4.1 should help you here.

4. Arboreality. Many species of squamates are arboreal. A gecko, chameleon, flying lizard (*Draco volans*) and an arboreal snake (*Imantodes*) all share the habit of living in trees. However, their adaptations for this lifestyle are quite different. Can you identify characteristics of each that suggest arboreality?

5. Fossoriality. Reduction or loss of limbs has occurred in many different squamate lineages. Three of those lineages are represented here: snakes (*Thamnophis*), amphisbaenians (*Zygaspis*, *Bipes*) and one group of limbless anguids represented by the skeleton (*Anguis fragilis*). The amphisbaenian *Bipes* is very unusual in retaining the forelimbs. An association exists between the loss of limbs and fossoriality (burrowing). For example, amphisbaenians and certain limbless skinks and anguids are fossorial and the first snakes were probably fossorial. Compare the skeleton of the snake and the limbless lizard. How do they differ?

Station 7. Reproduction.
All amniotes (mammals, reptilians and birds) produce a shell-bound egg and this character is tied to internal fertilization. Mammals, turtles, and squamates have independently evolved penis-like structures for internal fertilization.

1. Examine the hemipenes of the snake, a synapomorphy for squamates. Hemipenes are dual copulatory organs = two functional penises. There is some evidence that squamates alternate the use of each hemipene. During copulation, only one hemipene is everted and inserted into the female's cloaca. The name hemipenis (hemi = half) is actually a misnomer. Initially, it was thought that the each organ was half a penis and that both were necessary for copulation. This has since been proved false, but the name remains. The external morphology of hemipenes has frequently been used as a systematic character (usually at the species level). Can you think of a reason why hemipenes might be useful in discriminating among species?

2. Of interest: All turtles are oviparous, as are crocodilians and birds. In contrast, viviparity has evolved at least 100 times within squamates. In fact, some species of squamates have both viviparous and oviparous populations!

Several species of squamates reproduce by parthenogenesis. These species consist of all females and do not require sexual reproduction. In addition, some species that usually have sexual reproduction have been observed to reproduce parthenogenetically in captivity (e. g., timber rattlesnakes; however, this may be a product of captivity and may be very uncommon or not exist at all in natural populations). One of the best known groups with parthenogenetic species are the whiptail lizards (**Teiidae**; *Cnemidophorus*). There are about 65 species of whiptail lizards, about 1/3 of which are parthenogenetic. At this station are representatives of a couple of species of whiptail lizards. Interestingly, there are some species of *Cnemidophorus* that reproduce parthenogenetically, yet courtship must be performed to stimulate reproduction (even though copulation does not occur).

Appendix A: A Classification of the Amniotes. Note that not all groups fall into categories such as class, order, super order etc.

Kingdom: **Animalia**
Phylum: **Chrodata**
Subphylum: **Vertebrata**
Superclass: **Agnatha**
Superclass: **Gnathostomata**
Tetrapoda
Amniota
Synapsida
Therapsida
Class: Mammalia
Class: **Reptilia** (a paraphyletic group)
Anapsida (tortoises and turtles)
Order: **Testudinata**
Sub-order: **Pleurodira** (side-necked)
Sub-order: **Cryptorira** (hidden neck)
Family: **Chelydridae** (snapping turtles)
Family: **Emydidae** (pond & box turtles)
Famiy: **Kinosternidae** (mud turtles)
Family: **Testudinidae** (tortoises)
Family: **Trionychidae** (soft-shell turtles)
Diapsida (birds, crocodiles, lizards, snakes etc.)
Archosauria (birds, crocodiles and dinosaurs)
Class: **Aves**
Order: **Crocodilia**
Family: **Crocodylidae**
Family: **Alligatoridae**
Lepidosauria
Order: **Rhynchocephalia** (tuataras)
Order: **Squamata**
Sub-order: **Amphisbaenia**
Sub-order: **Sauria** (lizards)
Family: **Iguanidae** (iguanas)
Family: **Anguidae**
Family: **Crotaphytidae**
Family: **Helodermatidae**
Family: **Phrynosomatidae**
Family: **Scincidae**
Family: **Teiidae**
Sub-order: **Serpentes** (snakes)
Family: **Boidae**
Family: **Colubridae**
Family: **Elapidae**
Family: **Viperidae**