ZOOLOGY – EARLY TETRAPODS AND MODERN AMPHIBIANS

I. Classification

Phylum Chordata

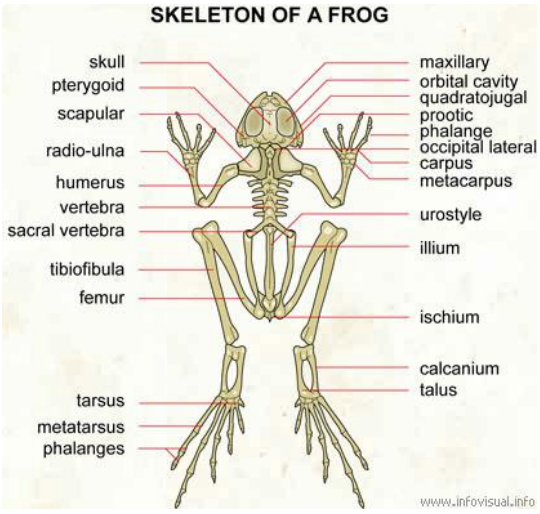
Class Amphibia

Order Gymnophiona "Caecilian Worms"	**Order Caudata** "Salamanders"	**Order Anura** "Frogs and Toads"
		

II. Movement Onto Land

A. Land represents a relatively dangerous habitat for animals. Adaptations must be made to the following challenges…

1. The danger of _____ – animals are made up mostly of water and are constantly at risk of dehydration and death.
2. Oxygen is _____ more abundant in air and diffuses much more rapidly through air than water.
    a. Animals would have to come up with a new solution to respiration to replace gills (which need to be constantly wet).
3. Air is _____ less dense and provides less buoyancy than water.



    a. Limbs and the skeleton must therefore support more weight.
    b. Terrestrial habitats selected for…
        1) stronger backbones
        2) muscles to support the body in air
        3) muscles to elevate the head
        4) stronger shoulder and hip girdles
        5) a more protective rib cage
        6) ear structure
        7) longer snout.
    c. Adaptations for life on land further included a skulls, teeth, pectoral girdles and jointed limbs.

4. Air fluctuates in temperature more rapidly than does water; animals must adjust to these extremes.

a. Animals must maintain a fairly narrow range of body temperature in order for the enzymes to carry out _____. This led to two solutions in tetrapods…

b. _____ – variable body temperature derived from heat acquired fro the environment.

1) This is found in _____ and _____.

c. _____ – a body temperature determined by heat derived from the animal's own oxidative metabolism.

1) This if found in _____ and _____.

5. Animals in water are exposed to much less UV radiation.
   a. UV radiation causes DNA damage and ultimately can lead to mutations and cancer.
   b. Terrestrial animals had to adapt their skin to this greater intensity of UV radiation.
6. Reproduction was about to become a lot more challenging.
   a. Animals in the water can simply squirt their gametes into the water.
   b. The sperm can then swim to the egg and fertilize it.
   c. The water can serve as the incubator for the young.
   d. Terrestrial reproduction would involve some means to ensure fertilization and a way to keep the embryos wet during development.

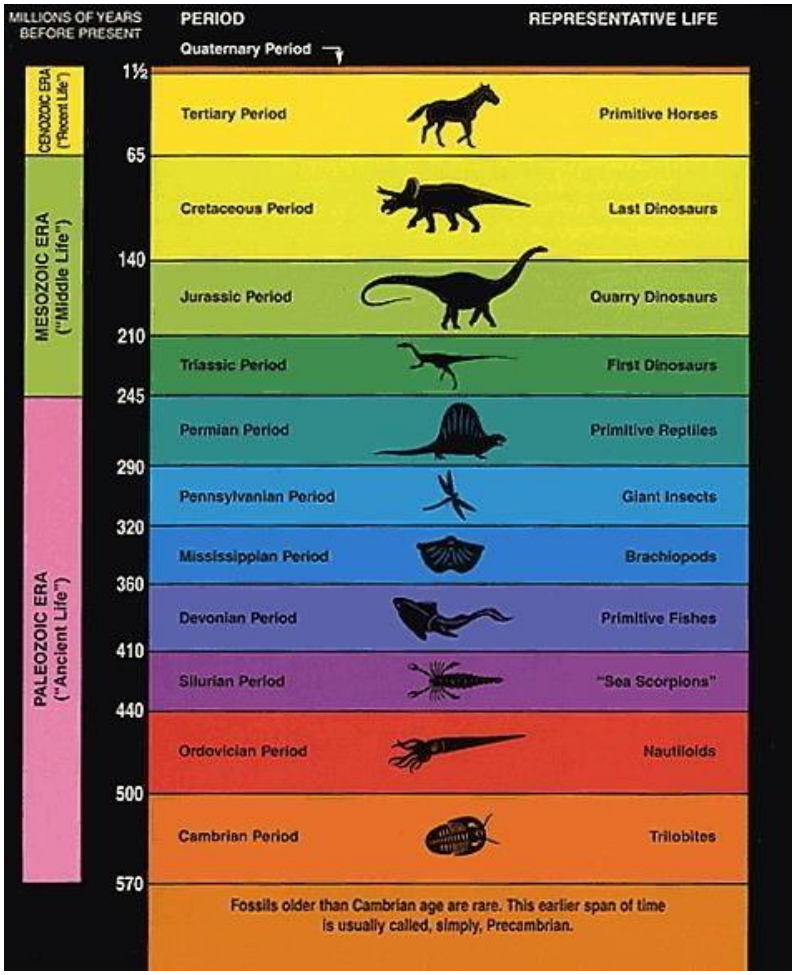
B. _____, _____ and _____ all made the transition to terrestrial life earlier.

1. Recall that arthropods made the transition thanks to their _____ which was waterproof, UV resistant, and was hard enough to provide protection from the pull of gravity.

C. Amphibians are the animals that are most like the first vertebrates to make this transition.

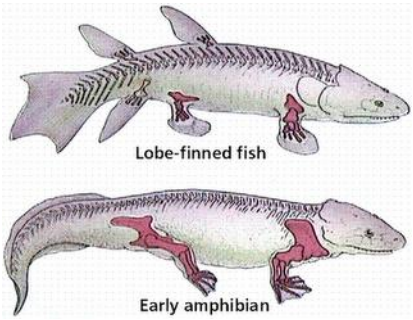
D. Why would they leave the water?

1. The water was already crowded with life.
   a. They faced _____ for resources from similar animals.
   b. They faced heavy _____ pressures in the water.
2. However, the land was inhabited only by plants, snails, and arthropods.
3. Further, the variety of terrestrial habitats allows dramatically greater opportunities for adaptation.



E. What might have been the driving force for this transition?

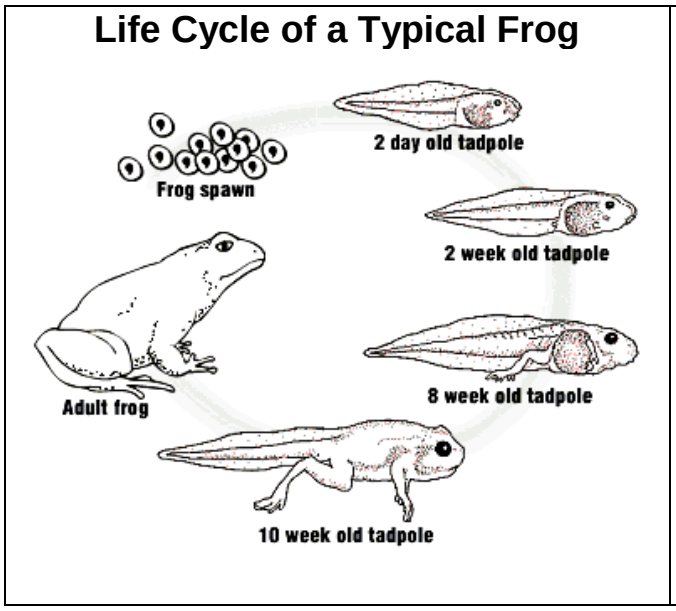
1. Tetrapods evolved from _____ during the _____, 400 million years ago.
    a. This period was a time of mild temperatures, floods and droughts.
2. The Devonian freshwater environment was unstable.
    a. As pools evaporated, water fouled and _____ levels declined, only fish with some kind of lung could survive.

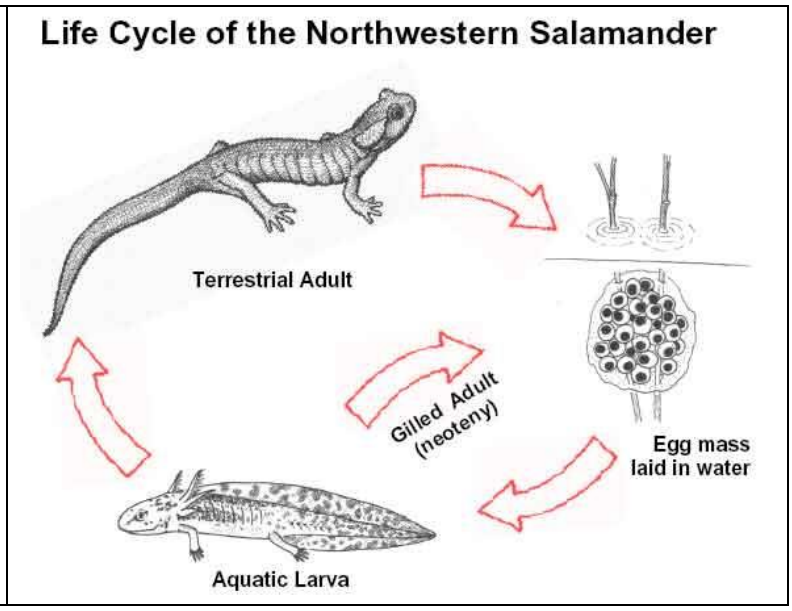


3. Alfred Romer proposed a **seasonal drought hypothesis** where amphibian ancestors developed legs from selection for migrating across land to new ponds.
    a. The bony elements of the fins of lobe-finned fishes resemble the limbs of amphibians.
4. A more active lifestyle on land caused these ancestral amphibians made the following adjustments…
    a. More capillaries and arterial blood from the last aortic arch were directed to the air-filled cavity.
        1) This cavity resulted from an _____ of the _____ tract.
        2) This pouch became filled with air.
        3) It would eventually become _____.
    b. Oxygenated blood returned directly to the heart by a pulmonary vein to form a _____.

F. So, why are amphibians considered to be _____?

1. In contrast to the varied climate of the Devonian, the _____ **Period** was uniformly warm and wet.
2. Tetrapods radiated into the swampy moss and fern landscape.
    a. They ate insects, insect larvae and aquatic invertebrates.
3. During the Carboniferous, amphibians developed additional adaptations for living in water.
    a. Bodies became flatter for moving in water.
    b. Early salamanders developed weaker legs and the tail became better developed.
    c. Anurans developed webbing on hindlimbs for better swimming.
4. Today, amphibians are largely confined to wet habitats. They rely upon water for…
    a. Exchange of oxygen and carbon dioxide.
        1) Some salamanders have gills.
        2) Some amphibians diffuse gases across their skin.
            a) This requires that their skin remain moist.
        3) Some amphibians diffuse gases across moist mucous membranes in their mouth.
    b. Temperature regulation – water loses and gains heat much more slowly than air.
    c. Reproduction
        1) Most amphibians deposit eggs and sperm directly in water.
        2) The eggs have no shell and would dehydrate on land. (The eggs are aquatic.)
        2) The larvae (e.g. tadpoles) depend on gills for respiration.





III. Modern Amphibians

A. Amphibian Characteristics

1. Over _____ living species are known in the three amphibian orders.
2. The olfactory epithelium and the ear are redesigned to improve sensitivity to airborne sound.
3. They remain tied to water; eggs are aquatic, and the larvae depend on gills for respiration.
4. The thin skin loses water rapidly; this restricts even terrestrial forms to moist habitats.
5. Being ectothermic, their body temperature depends on the environment and restricts their range.
6. Eggs easily dessicate and must be shed into water or kept moist.
    a. A few amphibians brood their young.

B. Caecilians: Order _____ (Apoda) "Caecilian worms"

1. About 160 living species of elongate, _____, burrowing caecilians are known.
2. They live in tropical forests in South America, Africa and Southeast Asia.
3. They eat primarily _____ and small underground invertebrates.

C. Salamanders: Order _____ (Urodela)

1. About 360 species of living salamanders are found mostly in northern temperate regions.

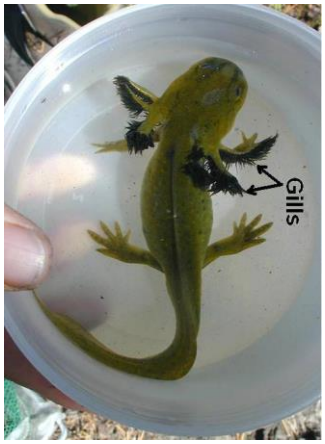
2. Most are small, under 15 centimeters long, but the Japanese giant salamander is 1.5 meters long.

3. Usually their limbs are at right angles to the body; forelimbs and hindlimbs are about equal in length.
    a. Burrowing species and some aquatic forms may have lost their limbs.

4. Salamanders are _____ as both larvae and adults, eating worms, small arthropods and molluscs

5. They are ectotherms with a low metabolic rate.

6. Respiration - Salamanders have a wide array of respiratory mechanisms.
    a. They have extensive vascular nets in their skin that exchange both oxygen and carbon dioxide.
        1) Many species in the terrestrial family Plethodontidae lack lungs and use only _____ respiration.



    b. Respiratory gases may also be exchanged across the vascularized lining of the mouth cavity.
    c. At various stages, they may also have external gills, lungs, both gills and lungs, or neither.
    d. Salamanders with an aquatic stage hatch with gills and lose them at metamorphosis.
        1) Where present, lungs are present from birth and become functional following metamorphosis.
        2) Aquatic amphibumas lose their gills and respire by lungs, holding nostrils above the water surface.
    e. Several diverse lineages fail to undergo metamorphosis and retain gills and a fin-like tail.
        1) _____ - the preservation of pre-adult features into adulthood.

D. Frogs and Toads: Order _____ (Salientia)
1. Over 3450 species of frogs and toads compose the order Anura.
2. This group is known from the Jurassic period, 150 million years ago.
3. Tied to an aquatic mode of reproduction and a water-permeable skin, they must be near water.
4. Ectothermy keeps anurans from inhabiting polar and subarctic habitats.
5. All pass through a tailed larval stage to become tailless, jumping adults.
6. Eggs hatch into _____ with a long, finned tail, no legs, internal and external gills and specialized mouthparts for (usually) herbivorous feeding.
7. There are 21 families of frogs and toads.
    a. Family _____ contains the common larger frogs in North America.
    b. Family _____ includes the tree frogs.
    c. Family _____ contains toads with thicker skins and prominent warts.
8. Anurans are declining worldwide and becoming patchy in distribution; a potential culprit is an ancient fungus .

Read more about this: http://www.sciencedaily.com/releases/2008/10/081014111403.htm
9. Life Cycle
    a. Most larger frogs are _____ until breeding season.
    b. During the breeding season, males are especially noisy when trying to attract a female.

Check out these frog calls: http://animaldiversity.org/collections/frog_calls/

c. During winter in temperate climates, they _____ in soft mud in the bottom of pools.

d. Frost-tolerant frogs prepare for freezing by accumulating _____ and _____ in body fluids; this protects them from the otherwise damaging effects of ice-crystal formation.

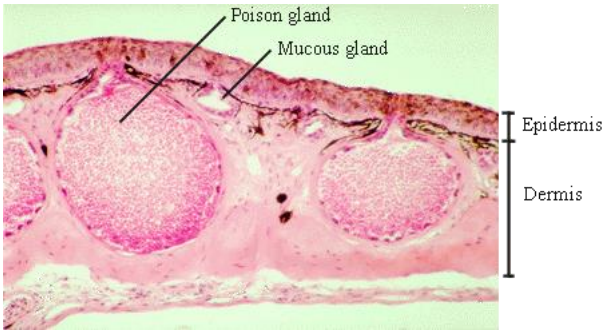
Watch this video on frozen frogs: http://youtu.be/hIGtLKxoFeA

e. Many are easy prey; they defend themselves by aggression, concealment, and poison glands.

10. Integument and Coloration

a. Frog skin is thin, moist and attached loosely to the body at a few points.

b. The inner layer of epidermis has two types of integumentary glands…



1) _____ glands produce a protective, waterproofing secretion.

2) large _____ glands produce a whitish, watery poison.

c. Specialized pigment cells, _____, produce skin color in frogs.

d. Many frogs can adjust their color to blend with their background and thus camouflage themselves.

11. Skeletal and Muscular Systems

a. A well-developed _____ of bone and cartilage provides protection and muscle anchorage.

b. Anurans show dramatic changes in the musculoskeletal system for jumping and swimming.

c. The vertebral column lost much of its flexibility in order to transmit force from limbs to the body.

d. The front of the frog skull, containing the brain, eyes, and nose is lightweight and flattened; the back of the skull, which contained the gill apparatus in fishes, is reduced.

e. The foot generally has five rays and the hand is four-rayed; both have several joints in the digits.

1) This system is derived from the pattern in rhipidistian lobe-finned fish.

12. Respiration and Vocalization

a. Amphibians use three respiratory surfaces for gas exchange in air.

1) The skin provides cutaneous breathing.

2) The mouth provides _____ breathing.

3) Lungs are usually present in adults.

b. Frogs and toads depend on lung breathing more than salamanders.

c. Unlike reptiles, birds, and mammals, frogs & toads don't suck air into their lungs.

1) Air is forced into the lungs by the mouth muscles.

d. Carbon dioxide is mostly lost across the _____ while oxygen is absorbed across the _____.

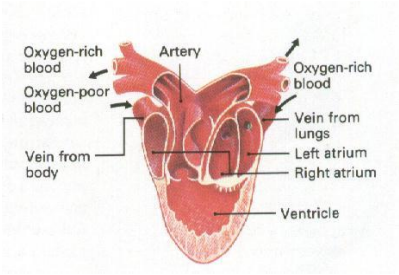
e. The absorptive surface in a frog lung is 20 cm^2 per cc of air compared to 300 cm^2 for humans.

13. Circulation

a. The circulatory system is _____, with a pumping _____.

b. Separating the oxygenated blood from the deoxygenated blood circuit is not completed.

c. Frog Heart



1) The frog heart has a single undivided _____ and two separate _____.

2) Blood from the body enters through the sinus venosus and right atrium.

3) Blood from the lung enters the left atrium.

4) Both atria contract at the same time, driving blood into the ventricle.

5) When the ventricle contracts, blood moves to the lungs or body.

6) Although there is no septum, deoxygenated blood goes primarily to the lungs and oxygenated blood goes mostly to the body due to separation by a spiral valve in the conus arteriosus.

14. Feeding and Digestion

a. Most adult amphibians are carnivorous, feeding on insects, spiders, worms, slugs, etc.

b. They catch prey with a tongue that is attached at the front of the mouth.

c. The free end of the tongue is glandular; a sticky secretion adheres to prey.

d. Any teeth that are present function to hold prey; they do not bite or chew.

e. Larval stages or tadpoles are usually _____; their digestive tract is relatively long.

15. Nervous System and Special Senses

a. The brain has three fundamental parts.

1) The forebrain or _____ interprets the sense of smell.

2) The midbrain or _____ perceives vision.

3) The hindbrain or _____ perceives hearing and balance.

b. The brain is gradually assuming more information processing ability independent of the spine.

c. However, a headless frog still has highly

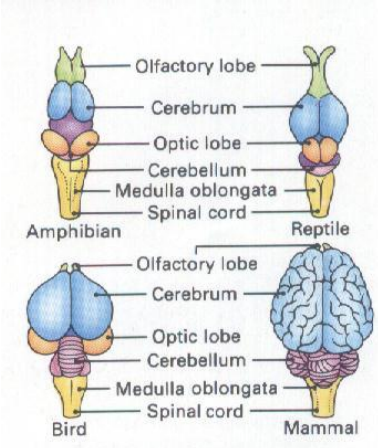


Figure 39–3. The cerebrum controls intelligence. The more complex the vertebrate, the larger its cerebrum.

coordinated behavior based on spinal cord alone.

d. The ear becomes specialized for detecting airborne sounds.

1) A large tympanic membrane or eardrum passes vibrations to the inner ear via the columella.

2) The inner ear has a utricle with three semicircular canals and a saccule with a lagena.

3) A lagena is covered with a tectorial membrane that is similar to the mammalian cochlea.

e. Except for blind caecilians, _____ is the dominant sense in many amphibians.

f. Lachrymal glands and eyelids evolved to keep the eye moist, free of dust, and protected.

1) The upper eyelid is fixed.

2) the lower is folded into a transparent nictitating membrane.

g. The amphibian retina contains both rods and cones; the cones provide frogs with color vision.

16. Reproduction and Development

a. Frogs and toads are ectothermic; therefore they breed, feed, and grow during the warm seasons.

b. In the spring, males call to attract females.

c. When the eggs are mature, females enter the water and the males clasp them in _____.

d. As the female lays eggs, the male discharges sperm over them.

e. The jelly layers absorb water and swell; the eggs are usually laid in large masses.

f. Development begins immediately; a tadpole may hatch in 6-9 days.

g. Three pairs of external gills soon develop into internal gills covered with a flap of skin.

h. Metamorphosis

1) Hindlegs are first to appear; the forelegs are temporarily hidden in folds of the operculum.

2) The tail is resorbed.

3) The intestine becomes shorter.

4) The mouth transforms to the adult condition.

5) Lungs develop and the gills are resorbed.