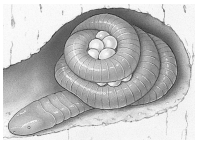
Chapter 17: Early Tetrapods & Modern Amphibians

Phylum: Chordata

Subphylum: Vertebrata

Class Amphibia (~5500 spp.)

Order Gymnophiona: caecilians
elongate body, no limbs, tail short or absent



Order Urodela: salamanders

Order Anura: frogs/toads

semi-aquatic

millions of years evolve from aquatic to terrestrial habitats

monophyletic group known as **tetrapods** four limbs

amphibians

amniotes (reptiles, birds, mammals)

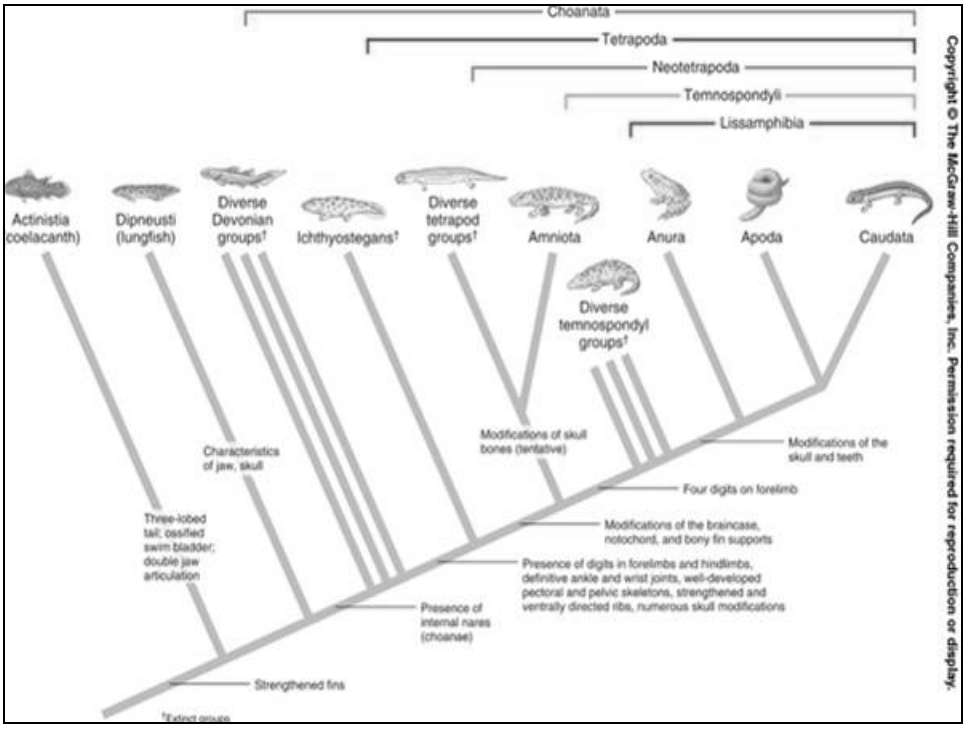
- Four classes are land-dwelling tetrapods
  - Amphibia - amphibians
  - Reptilia - reptiles
  - Aves - birds
  - Mammalia - mammals

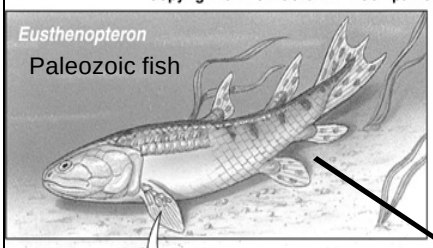
Amphibia

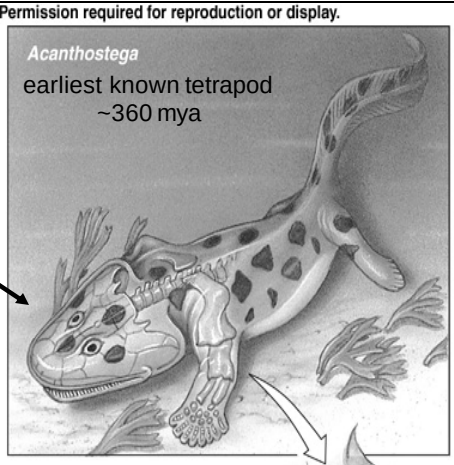
- First vertebrates to walk on land
- Characteristics
  - legs
  - cutaneous respiration
  - lungs
  - pulmonary veins
  - partially divided heart

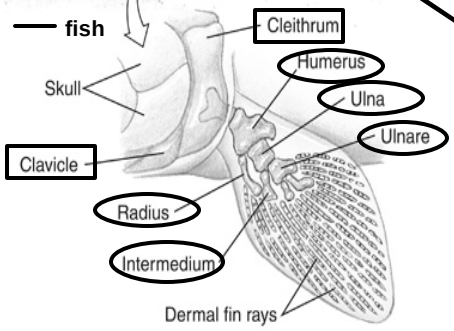
History of the Amphibians

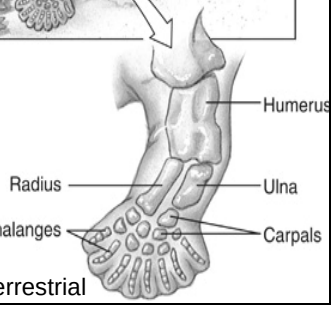
- Adaptations for the invasion of land
  - legs to support body's weight
  - lung to extract oxygen from the air
  - redesigned heart to drive new respiratory system
  - reproduction in water to prevent egg desiccation
  - system to prevent body desiccation





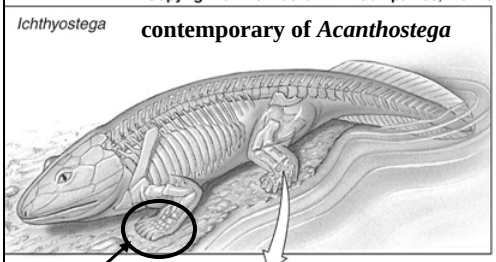






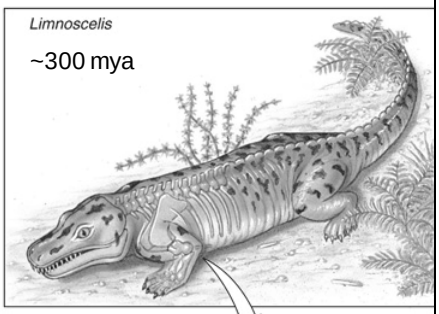
upper arm
forearm
wrist bones

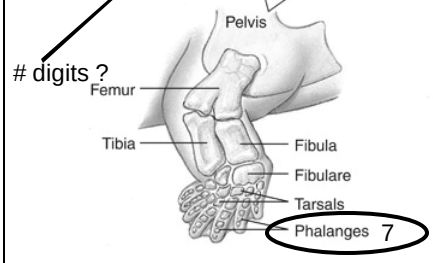
exclusively aquatic-weak limbs for terrestrial



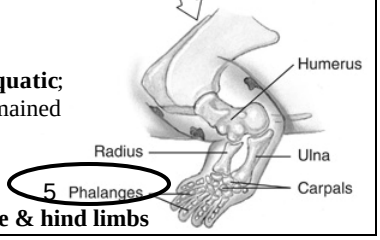
contemporary of *Acanthostega*

Seasonal drought hypothesis: amphibian ancestors developed legs from selection for migrating across land to new ponds





Recent fossil of ***Acanthostega*** with tetrapod legs **fully aquatic**; suggests that legs completely developed while animal remained a fully aquatic animal



both fore & hind limbs

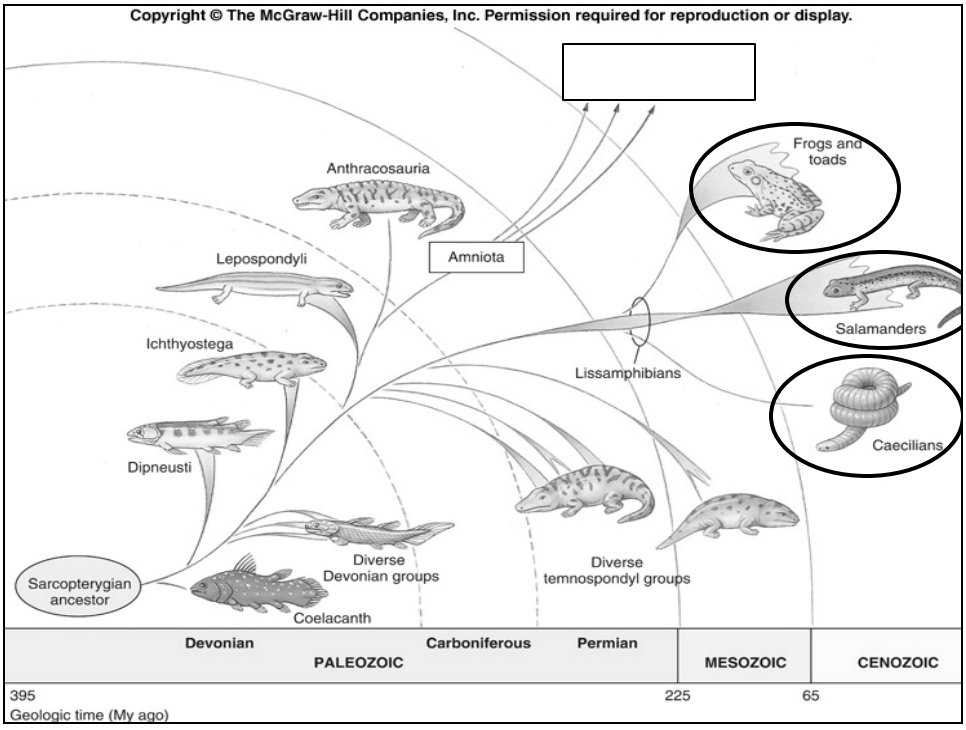
Adaptations for land

a. skull, teeth, pectoral girdle & jointed limbs.
b. stronger backbone, muscles to support body in air
c. muscles to elevate head, stronger shoulder & hip girdles
d. more protective rib cage, ear structure & longer snout

During the Carboniferous

developed additional adaptations for living in water

a. bodies became flatter for moving in water
b. early salamanders developed weak legs; tail became better developed
c. anurans developed webbing on hind-limbs for better swimming
d. swampy forests→ porous skin as an accessory breathing organ

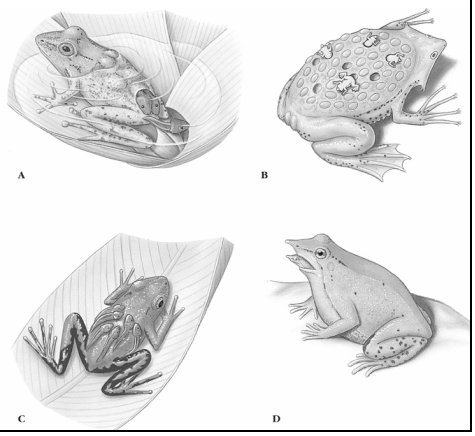


Modern Amphibians

1. olfactory epithelium & ear redesigned to improve sensitivity to airborne sound
2. **remain tied to water**; eggs aquatic & larvae depend on **gills** for respiration
3. some salamanders retained aquatic morphology throughout life;
   others lack larval phase
4. generally, gills are lost & lungs are activated when salamanders breathe air
5. **respiration also occurs across skin** especially in terrestrial salamanders
6. thin skin loses water rapidly; this restricts even terrestrial forms to moist habitats
7. **ectothermic**: body temperature depends on environment & restricts their range
8. eggs easily desiccate; must be shed into water or kept moist; few brood their young

Variety of unique anuran reproductive strategies

1) Eggs may float on surface foam masses or be deposited on leaves overhanging ponds
2) Some lay eggs in burrows, tree cavities, on in water-filled chambers on plants
3) Most frogs abandon their eggs but some tend their eggs & carry tadpoles on backs
4) Marsupial frogs carry eggs in a dorsal pouch
5) Many tropical frogs have direct development



Caecilians: Order Gymnophiona (Apoda)

~160 living species



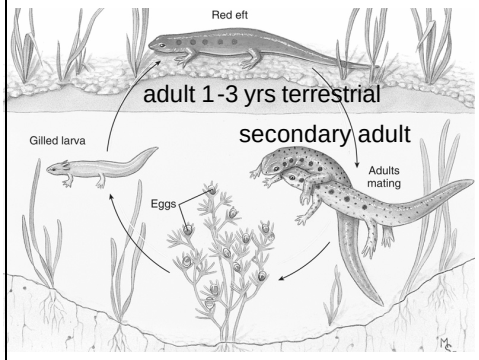
1. elongate, **secondarily limbless**, burrowing
2. live in tropical forests in South America, Africa & Southeast Asia
3. long bodies many vertebrae, long ribs, no limbs & a terminal anus
4. eat primarily worms & small underground invertebrates
5. fertilization internal & male has a protrusible copulatory organ
6. eggs deposited in moist ground near water
7. some species, eggs guarded & develop in folds of body
8. other species, **viviparity** allows embryos to obtain nourishment by eating wall of oviduct
9. unlike adults, hatchling has a tail fin, open gill slit & external gills in some species

Salamanders: Order Urodela

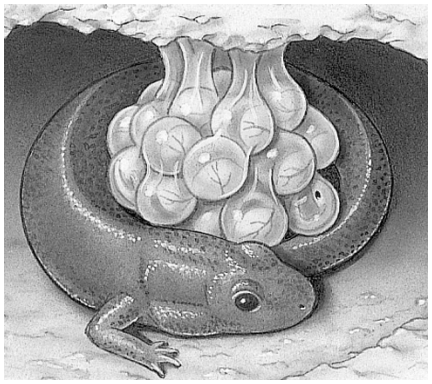
~500 species mostly in northern temperate regions

1. most small, under 15 cm long, but the Japanese giant salamander 1.5 m long
2. usually limbs at right angles to body; forelimbs & hind-limbs about equal in length
3. burrowing species & some aquatic forms may secondarily lost their limbs
4. carnivorous as both larvae & adults, eating worms, small arthropods & molluscs
5. **ectotherms** with a low metabolic rate
6. **Breeding Behavior**
   a. some aquatic throughout their life cycle; most aquatic larvae & terrestrial adults
   b. most fertilize eggs internally
   c. female picks up a **spermatophore** that has been deposited on a leaf or stick
   d. aquatic species lay eggs in clusters or stringy masses that hatch into larvae with external gills & a finlike tail
   e. completely terrestrial species deposit eggs in small, grape-like clusters under logs or in soft earth
   f. terrestrial species undergo direct development, hatching as miniature adults
   g. some North American newts have aquatic larvae that metamorphose into terrestrial juveniles that again metamorphose into secondarily aquatic, breeding adults

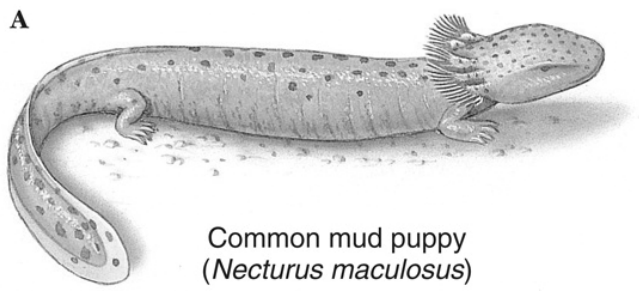
courtship & sperm transfer
in pygmy salamander



red-spotted newt

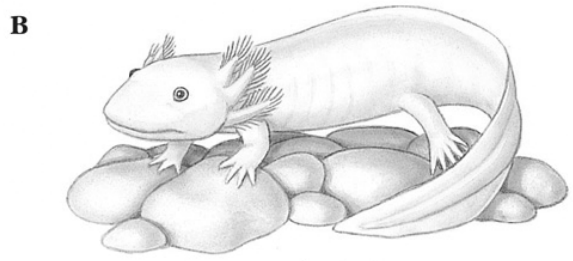


dusky salamander: providing maternal care/protection from predators



Common mud puppy
(*Necturus maculosus*)

Paedomorphosis: some adults reach sexual maturity
but retain gills (larval structures)



Axolotl
(*Ambystoma mexicanum*)

Frogs & Toads: Order Anura
>4840 species

1. group known from Jurassic period, 150 mya
2. tied to aquatic mode of reproduction & water-permeable skin, near water
3. **ecothermic** prevents anurans from inhabiting polar & subarctic habitats
4. all pass through a tailed larval stage to become tailless, jumping adults
5. eggs hatch into **tadpoles** with a long, finned tail, no legs, internal & external gills & specialized mouthparts for (usually) herbivorous feeding
6. look & act different from adult frogs; permanent gills never occur in frogs & toads
7. 21 families of frogs & toads
   a. Family Ranidae contains common larger frogs in North America
   b. Family Hylidae includes tree frogs
   c. Family Bufonidae contains toads with thicker skins & prominent warts
   d. West African ***Conraua goliath*** may weigh 3.3 kg (7.5 lbs)
   e. Cuban ***Phyllobates limbatus*** 1 cm long, the smallest frog recorded

African clawed frog

bullfrog pillow talk

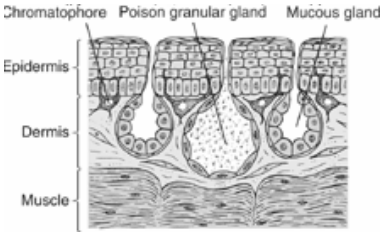
green tree frog

green tree frog sex

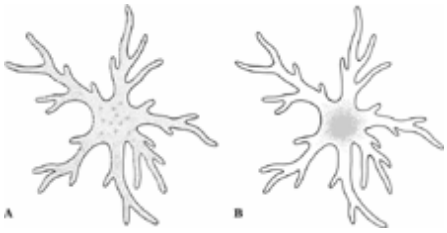
American toad

Conraua goliath
(West Africa) 3.3 kg

Figure 25.16



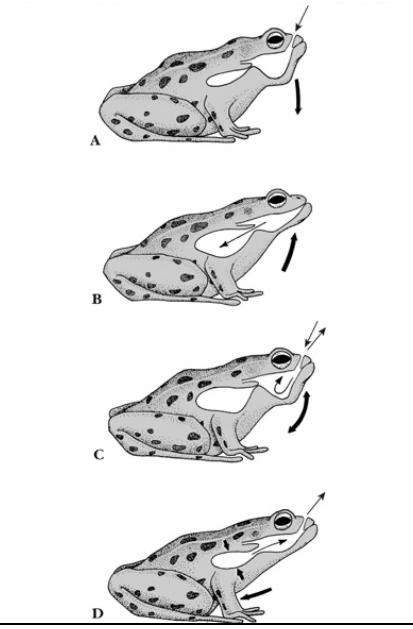
section through frog skin



pigment cells (chromatophores)

cryptic gray tree frog

Positive-pressure breathing in frog



floor lowered
air drawn
through nostrils

nostrils close
glottis opens

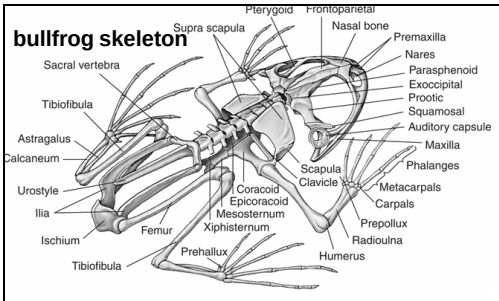
floor elevated

air forced to lungs

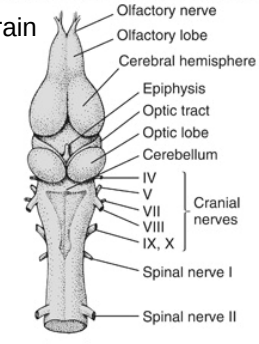
mouth cavity
rhythmic ventilates
for a period

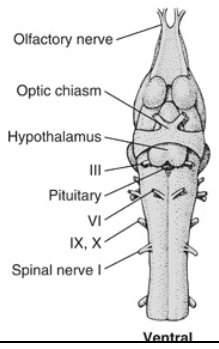
lung emptied by
muscular contraction
& elastic lung recoil

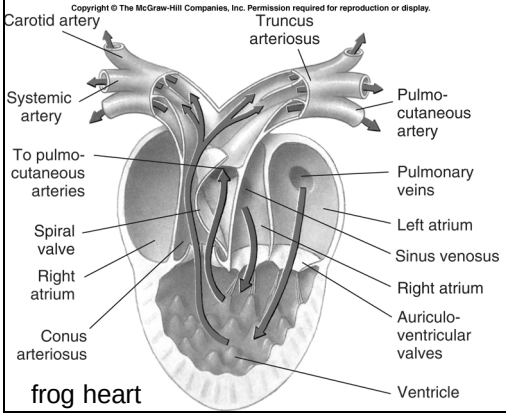
bullfrog skeleton



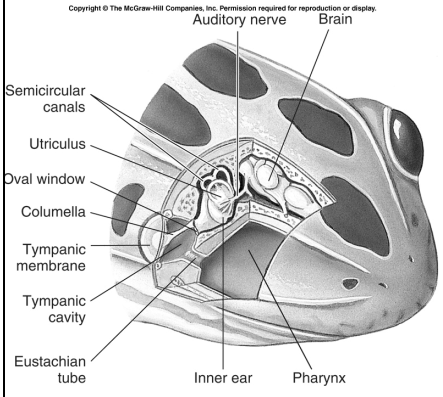
frog brain

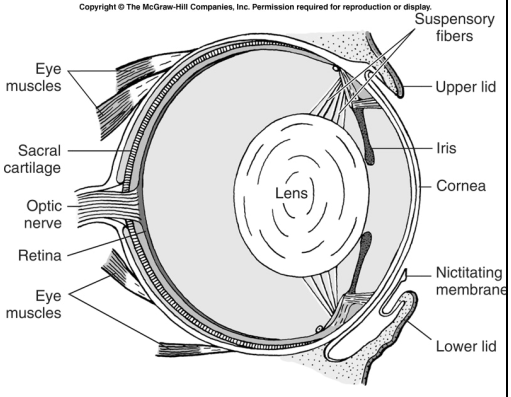


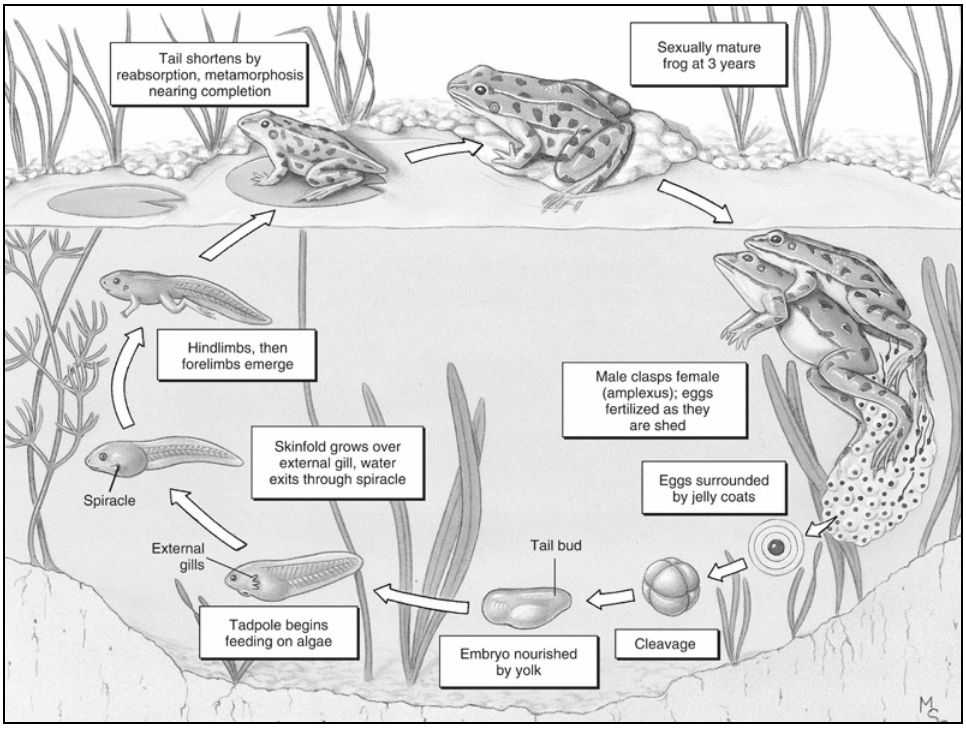




frog heart







Overview of the Evolution of Vertebrates

- 1st vertebrates evolved in oceans ~470 mya
  - hinged-jaw ~410 mya
  - amphibians on land ~300 mya
  - reptiles take over ~248 mya
  - split into birds & mammals

History of the Amphibians

- **Rise & fall of amphibians**
  - became common during Carboniferous period 360-280 mya
  - began to leave marshes for dry uplands during early Permian period ~280 mya
    - large size and complete body covering indicate skin was not used as respiratory system

History of the Amphibians

- **By the end of Permian (~248 mya)**, therapsid (reptile) ousted amphibians from their niche on land
  - by the end of the Triassic (~213 mya), only 15 amphibian families left
    - almost all were aquatic
    - only 2 groups from Jurassic period (213-144 mya)
    - **Anura** - frogs & toads
    - **Urodela** - salamanders & newts