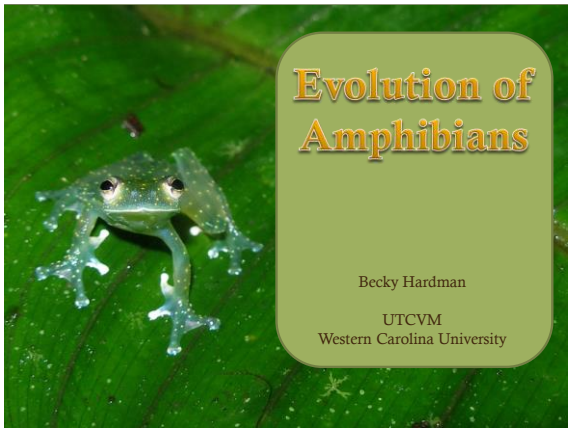
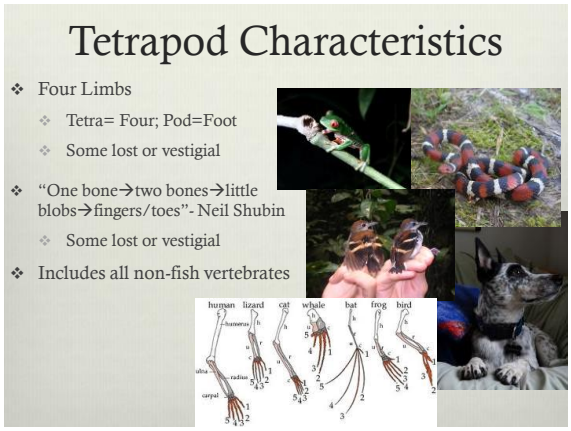

Evolution of Amphibians
Becky Hardman
UTCVM
Western Carolina University

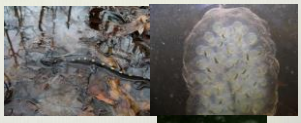

Paleozoic
Devonian
Carboniferous
Permian
Mesozoic
Triassic
Jurassic
Cretaceous
Cenozoic
416
360
300
250
200
146
65
Objectives
Define Tetrapod/Amphibian
Origin of Tetrapods
Tetrapod Advantages
Split of Amphibians
First Modern Amphibians
Extant Families
Simplification

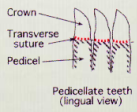

Tetrapod Characteristics
Four Limbs
Tetra= Four; Pod=Foot
Some lost or vestigial
"One bone→two bones→little blobs→fingers/toes"- Neil Shubin
Some lost or vestigial
Includes all non-fish vertebrates
human
lizard
cat
whale
bat
frog
bird

Amphibian Characteristics

"Tetrapod vertebrates that pass through a larval state and undergo metamorphosis into terrestrial adults."

- **Anamniotes**
  - Eggs need moist environment
- **Larval**; metamorphosis
- **Permeable Skin**
  - Cutaneous respiration
- **Two Gland Types**
  - Mucous
  - Poison
- **Pedicellate Teeth**
- **Amphibian papillae/Opercular bone**
  - Can Hear Vibrations
- **Fat Bodies**
- **Green Rods-** fxn unknown
- **Singular Sacrum**
  - Lost in caecilians



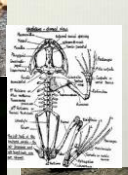


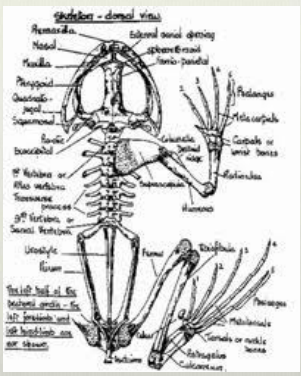
Pedicellate teeth (lingual view)

Amphibian Characteristics

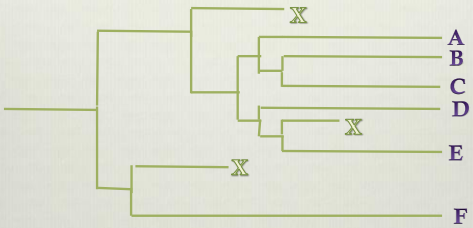
As a Fossil…

- Articular surface of axis convex
- Exoccipital Bone articulates with dermal roofing
- Hand (Manus) 4 digits
- Foot (Pes) 5 digits
- Some Secondarily Lost

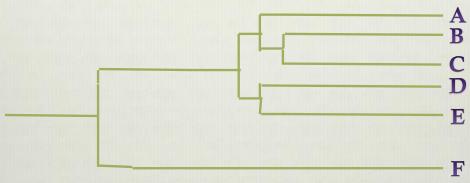




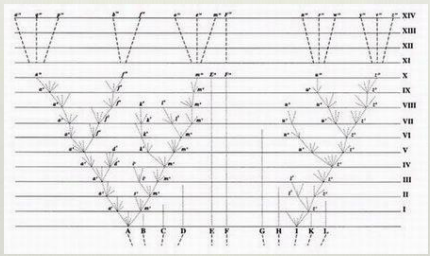
Phylogenetic Trees



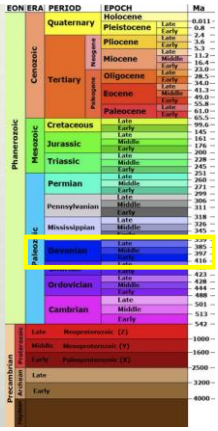
Phylogenetic Trees

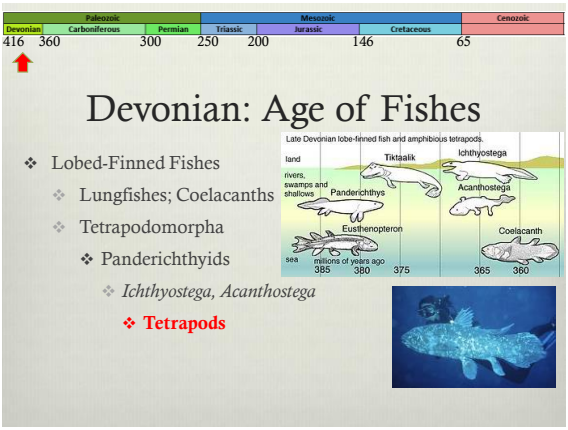


Darwin's Tree



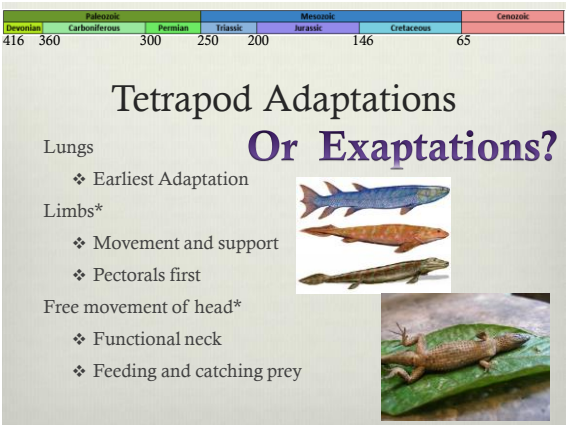
Geologic Time Scale





Devonian: Age of Fishes

- Lobed-Finned Fishes
  - Lungfishes; Coelacanths
  - Tetrapodomorpha
    - Panderichthyids
      - *Ichthyostega, Acanthostega*
        - **Tetrapods**



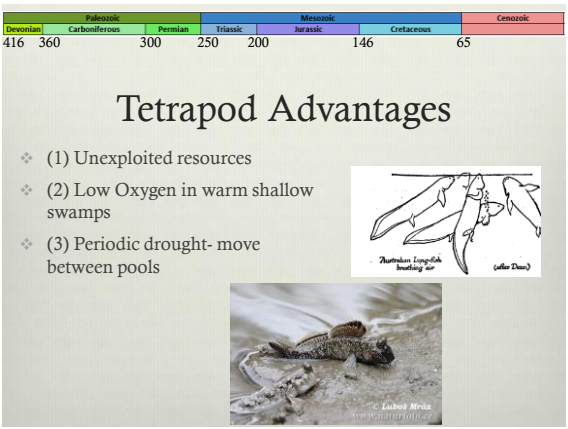
Tetrapod Adaptations

Or Exaptations?

Lungs
- Earliest Adaptation

Limbs*
- Movement and support
- Pectorals first

Free movement of head*
- Functional neck
- Feeding and catching prey



Tetrapod Advantages

- (1) Unexploited resources
- (2) Low Oxygen in warm shallow swamps
- (3) Periodic drought- move between pools

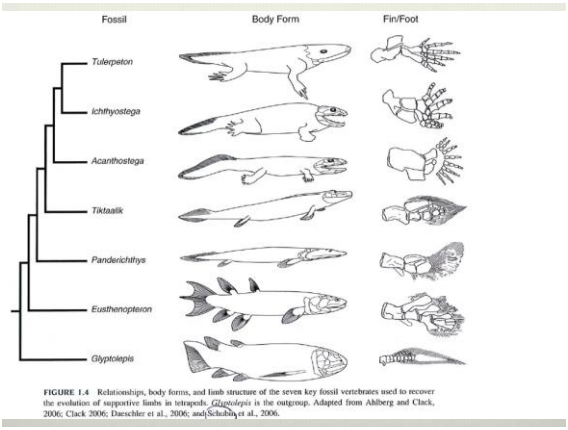
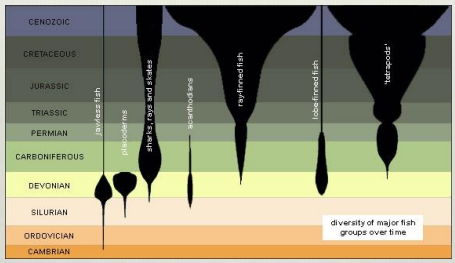
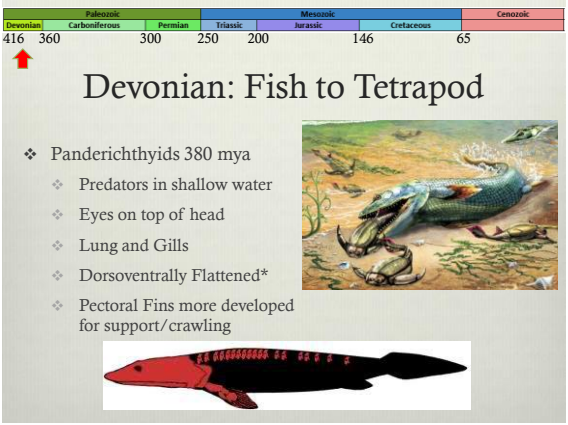


FIGURE 1.4 Relationships, body forms, and limb structure of the seven key fossil vertebrates used to recover the evolution of supportive limbs in tetrapods. *Glyptolepis* is the outgroup. Adapted from Ahlberg and Clack, 2006; Clack 2006; Daeschler et al., 2006; and Schubin et al., 2006.





Devonian: Fish to Tetrapod

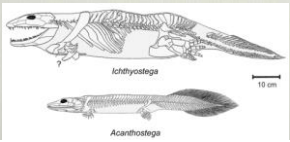
- Panderichthyids 380 mya
  - Predators in shallow water
  - Eyes on top of head
  - Lung and Gills
  - Dorsoventrally Flattened*
  - Pectoral Fins more developed for support/crawling

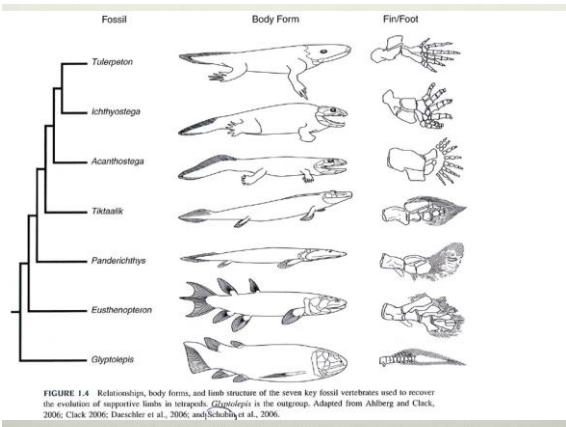
Missing Link or "Fishpod": Tiktaalik 375 mya

Devonian: Fish to Tetrapod

- Ichthyostega/Acanthostega 365 mya
  - First tetrapods
  - Still aquatic
  - Ichthyostega maybe seal-like on land

Ichthyostega as pictured in *Scientific American*





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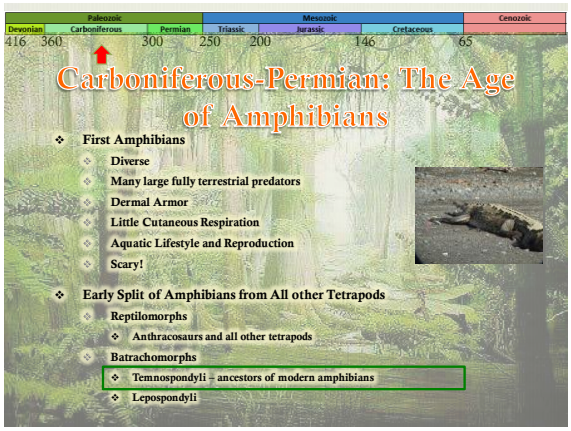


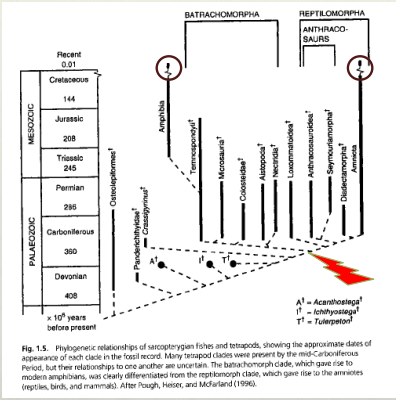
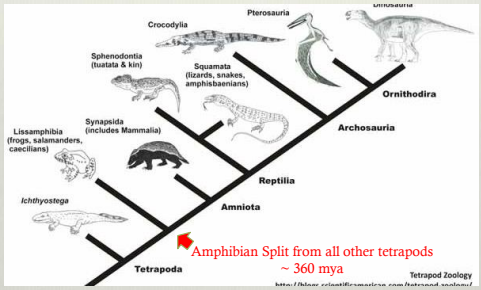
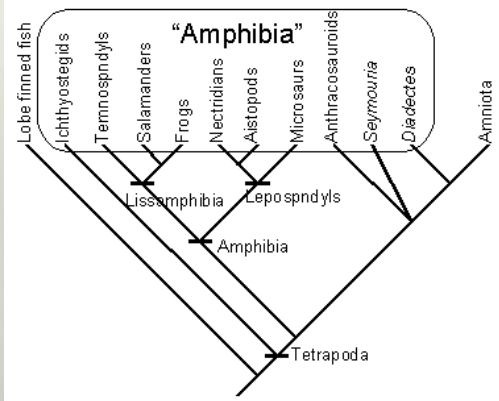


Fig. 1.5. Phylogenetic relationships of sarcopterygian fishes and tetrapods, showing the approximate dates of appearance of each clade in the fossil record. Many tetrapod clades were present by the mid-Carboniferous Period, but their relationships to one another are uncertain. The batrachomorph clade, which gave rise to modern amphibians, was clearly differentiated from the reptilomorph clade, which gave rise to the amniotes (reptiles, birds, and mammals). After Pough, Heiser, and McFarland (1996).

"cleaned-up" Tetrapod Phylogeny





Lepospondyli ~300 mya

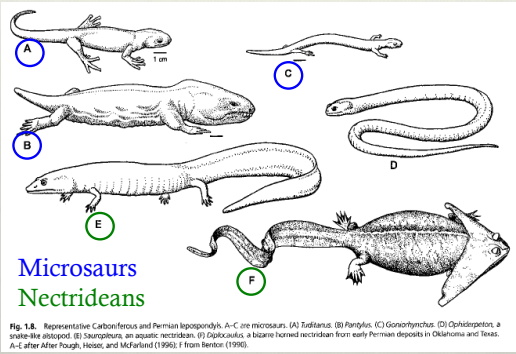


Fig. 1.8. Representative Carboniferous and Permian lepospondyls. A–C are microsaurs. (A) *Tuditanus*. (B) *Pantylus*. (C) *Goniorhynchus*. (D) *Ophiderpeton*, a snake-like aistopod. (E) *Sauropleura*, an aquatic nectridean. (F) *Diplocaulus*, a bizarre horned nectridean from early Permian deposits in Oklahoma and Texas. A–E after After Pough, Heiser, and McFarland (1996); F from Benton (1990).

Temnospondyli 330-120 mya

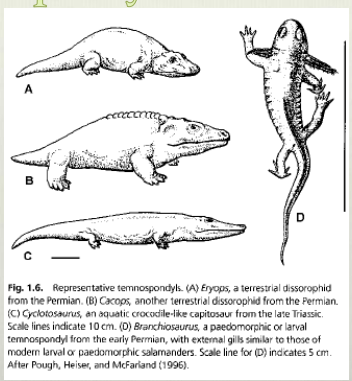
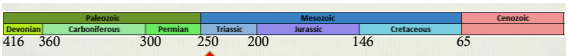


Fig. 1.6. Representative temnospondyls. (A) *Eryops*, a terrestrial dissorophid from the Permian. (B) *Cacops*, another terrestrial dissorophid from the Permian. (C) *Cyclotosaurus*, an aquatic crocodile-like capitosaur from the late Triassic. Scale lines indicate 10 cm. (D) *Branchiosaurus*, a paedomorphic or larval temnospondyl from the early Permian, with external gills similar to those of modern larval or paedomorphic salamanders. Scale line for (D) indicates 5 cm. After Pough, Heiser, and McFarland (1996).

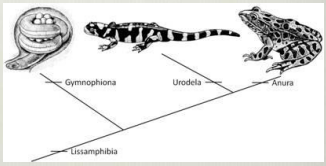


Triassic- Aquatic Shift 245mya

- Temnopsondyli: **Stereospondyli***
  - Only remaining Temnospondyls
  - All mostly aquatic
  - Terrestrial Reptiles dominated
  - Miniaturization through progenesis
  - Scales and Dermal Armor
  - Still much Diversity
  - One group marine

Lissamphibia: Modern Amphibians*

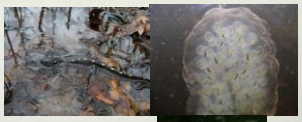
- Class: Amphibia
  - Monophyletic (most likely)
  - Caecilians
  - Frogs
  - Salamanders
- First Appearance
  - *Triadobatrachus* (Frog) 245mya
  - Triassic

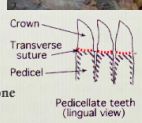


Amphibian Characteristics -again

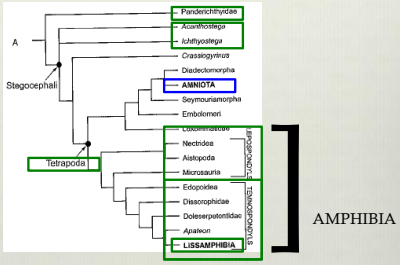
"Tetrapod vertebrates that pass through a larval state and undergo metamorphosis into terrestrial adults."

- **Anamniotes**
  - Eggs need moist environment
- **Larval**; metamorphosis
- **Permeable Skin**
  - Cutaneous respiration
- **Two Gland Types**
  - Mucous
  - Poison
- **Pedicellate Teeth**
- **Amphibian papillae/ Opercular bone**
  - Can hear low frequencies
- **Fat Bodies**
- **Green Rods-** fxn unknown
- **Singular Sacrum**
  - Lost in caecilians





Amphibia Evolution: Recap



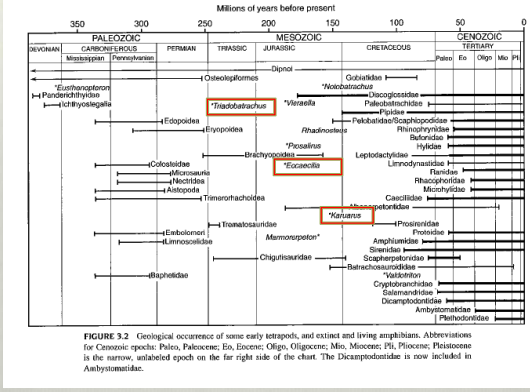
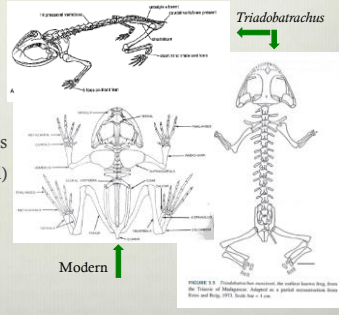
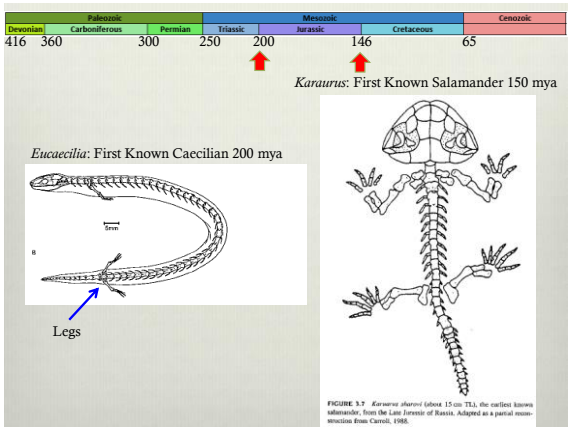


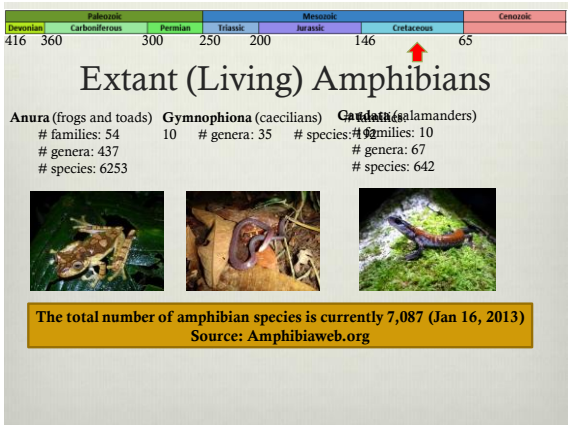
FIGURE 3.2 Geological occurrence of some early tetrapods, and extinct and living amphibians. Abbreviations for Cenozoic epochs: Paleo, Paleocene; Eo, Eocene; Oligo, Oligocene; Mio, Miocene; Pli, Pliocene; Pleistocene is the narrow, unlabeled epoch on the far right side of the chart. The Dicamptodontidae is now included in Ambystomatidae.

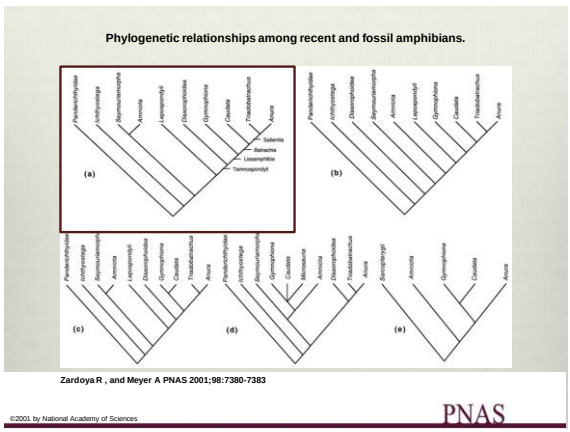
Triadobatrachus: First Lissamphibian, 245mya

- Frog Characteristics
  - Frog-like pelvic limb
  - U shaped pelvis
- Ancestral Characteristics
  - Caudal Vertebrae (Tail)
  - No Urostyle
  - 14 Presacral vertebrae




Paleozoic
Mesozoic
Cenozoic
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
416 360 300 250 200 146 65
Karaurus: First Known Salamander 150 mya
Eucaecilia: First Known Caecilian 200 mya
Legs
FIGURE 3.7 Karaurus sharovi (about 15 cm TL), the earliest known salamander, from the Late Jurassic of Russia. Adapted as a partial reconstruction from Carroll, 1988.


Paleozoic
Mesozoic
Cenozoic
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
416 360 300 250 200 146 65
Extant (Living) Amphibians
Anura (frogs and toads)
families: 54
genera: 437
species: 6253
Gymnophiona (caecilians)
10 # genera: 35 # species: 192
Caudata (salamanders)
families: 10
genera: 67
species: 642
The total number of amphibian species is currently 7,087 (Jan 16, 2013)
Source: Amphibiaweb.org


Phylogenetic relationships among recent and fossil amphibians.
Zardoya R , and Meyer A PNAS 2001;98:7380-7383
©2001 by National Academy of Sciences
PNAS

Anura

Characteristics:

Saltatorial
- •Shortened Presacral Vertebrate (usually 8)
- •Ribs are reduced or absent (2nd or 4th)
- •Presacral Vertebrae Firmly Articulated
- •Large Hind Limbs, No tail (except 1 family)

- •External Fertilization (usually)
- •Flat heads and Large Mouths (usually)
- •Vocal Sacs in Males (usually)

•Global Distribution

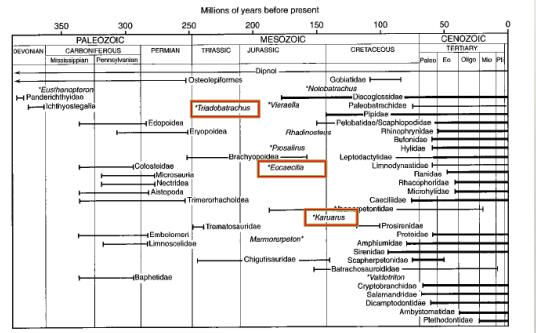
•54 Families!!

Centrolene prosoblepon

Oophaga sylvatica

Hypsiboas rosenbergi

Scaphiopus holbrooki



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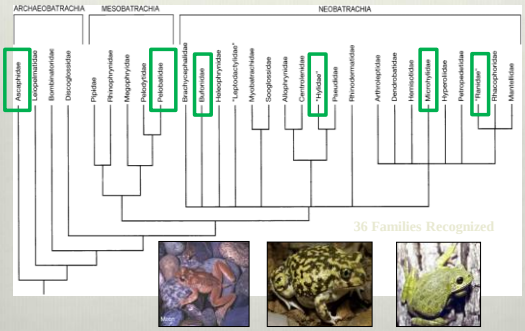
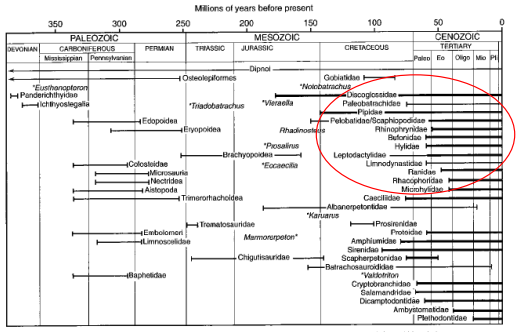
Anuran phylogeny

Primitive → Derived



36 Families Recognized



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Caecus = blind

Gymnophiona

- Earthworm like (7 cm – 1.5 m)
- Limbless (pectoral & pelvic girdles absent)
- Degenerate Eyes (most are fossorial)
- Internal Fertilization (phallodeum)
- 20% Viviparous; 80% Oviparous

- Tropical Distribution

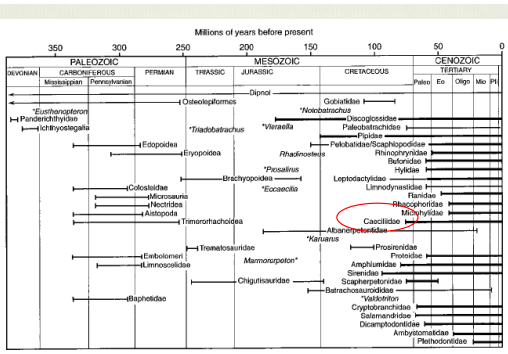
- 10 Families


Dermophis mexicanus


Epicrionops bicolor


Uraeotyphlus


Ichthyophis kohtaoensis



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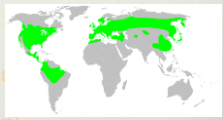
Caudata (Urodela)

•Smokies Diversity (31)

Characteristics:

- •Tailed Amphibians
- •Lizard like (30 mm – 1.5 m)
- •Well-developed limbs (except aquat
- •Internal Fertilization (most)
- •Larval Development External (most)
- •Lack Tympanum & Middle Ear (opercular)

•Mostly Temperate Distribution



•10 Families

Pseudotriton ruber

Ambystoma talpoideum

Amphiuma tridactylum

Andrias japonicus

?

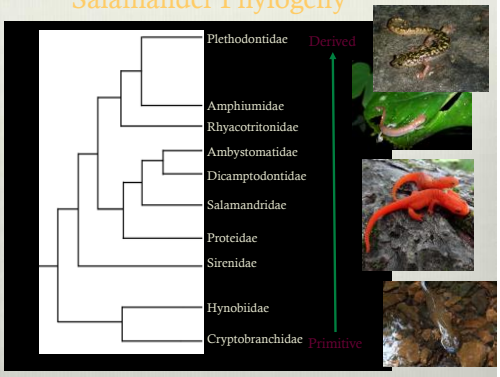
?

Salamander vs Lizard

Moist Skin
Toe tips
Rounder head
More dorsoventrally compressed

Epidermal Scales
Ear holes
Claws
Usually body held up over ground

Salamander Phylogeny



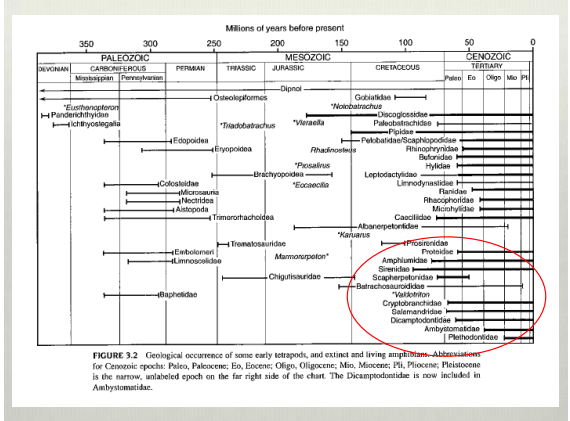
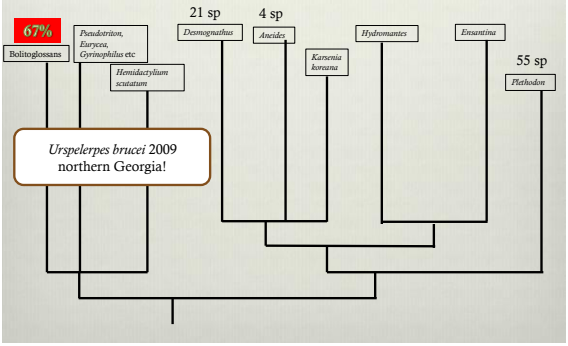
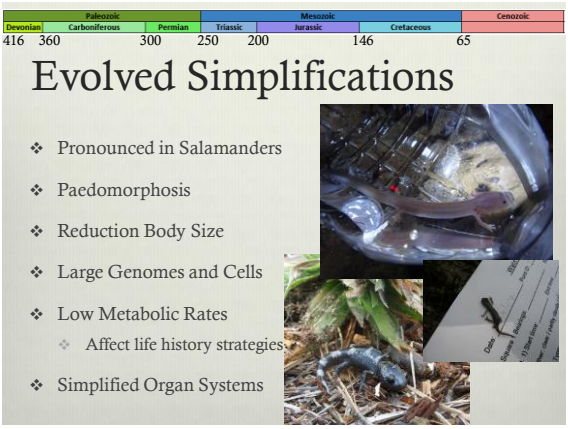


FIGURE 3.2 Geological occurrence of some early tetrapods, and extinct and living amphibians. Abbreviations for Cenozoic epochs: Paleo, Paleocene; Eo, Eocene; Oligo, Oligocene; Mio, Miocene; Pli, Pliocene; Pleistocene is the narrow, unlabeled epoch on the far right side of the chart. The Dicamptodontidae is now included in Ambystomatidae.

Plethodontidae

440 species 27 genera





Evolved Simplifications

- Pronounced in Salamanders
- Paedomorphosis
- Reduction Body Size
- Large Genomes and Cells
- Low Metabolic Rates
  - Affect life history strategies
- Simplified Organ Systems