Objectives

- Define Tetrapod/Amphibian
- Origin of Tetrapods
- Split of Amphibians
- 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
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- function unknown
- Singular Sacrum
  - Lost in caecilians

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
- Important to determine for fossil relationships
Darwin’s Tree

Geologic Time Scale

Devonian: Age of Fishes
- Lobed-Finned Fishes
  - Lungfishes; Coelacanths
  - Tetrapodomorpha
- Panderichthyids
  - Ichthyostega, Acanthostega
- Tetrapods
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

Devonian: Fish to Tetrapod

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

* Dorsoventrally Flattened: This term refers to the fish-like species being dorsoventrally flattened, which is a characteristic feature in the evolution of early tetrapods.
**Missing Link or “Fishpod”: Tiktaalik 375 mya**

**Tetrapod Adaptations**

- **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
First Amphibians
- Diverse
- Many large fully terrestrial predators
- Dermal Armor
- Little Cutaneous Respiration
- Aquatic Lifestyle and Reproduction
- Scary!

Early Split of Amphibians from All other Tetrapods
- Reptilomorphs
  - Anthracosaurs and all other tetrapods
- Batrachomorphs
  - Temnospondyli – ancestors of modern amphibians
  - Lepospondyli

Carboniferous period ~370 MYA. All other tetrapods split from amphibians because of appearance of amniote eggs.
MAJOR AMPHIBIAN GROUP: TEMNOSPONDYLI

- Group fossil amphibians from early Permian
- Diverse and cool
- Many similar to modern species
- Did not succeed - why?
- Hypothesis: wrong time for these adaptations?
- Hypothesis: Ancestors for living caecilians - not well supported

Lepospondyli ~300 mya

- Ancestors of all living amphibians
- Large diverse group spanning all major amphibian periods
- Diverse forms
  - Some with armor
  - Some pedomorphosis
  - Terrestrial and aquatic
- Diverse land tetrapods of Carboniferous-Permian (many now extinct groups)
- Aquatic species radiation in Triassic - specifically Stereospondyli
- Gave rise to Lissamphibia (extant amphibians)

Temnospondyli 330-120 mya
**Triassic - Aquatic Shift 245mya**

- Temnospondyli: Stereospondyli*
  - All mostly aquatic
  - Terrestrial Reptiles dominated
  - Miniaturization through progenesis
  - Scales and dermal armor
  - Still much diversity
  - One group marine
  - Extinct group
  - (or maybe not??)

**Amphibia Evolution: Recap**
Lissamphibia: Modern Amphibians*

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

Lissamphibia: contentious relationships

- Class: Amphibia
  - Monophyletic (most likely)
  - Temnospondyls

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Triadobatrachus: First Lissamphibian, 245 mya

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

Karaurus: First Known Salamander 150 mya

Eucaecilia: First Known Caecilian 200 mya

Chondratesphus (Caecilian) 215 mya

1. Third caecilian fossil discovered in Colorado
2. Dates to Carboniferous
3. Shows strong evidence of a common ancestor of both caecilians and stereospondyls

What does this mean??

Caecilians date back farther than thought
Stereospondyls group within Gymnophiona and are part of the Lissamphibia group.
Recap

- What period is considered "age of the fishes"
Recap

- Which specimen linked the fish-like limb with a weight-bearing limb?

Recap

- Which of the following is the first known Lissamphibian?
  - A. Triadobatrachus
  - B. Eucuecila
  - C. Karaurus

Which of the following groups include modern amphibians?

- Lepospondylii
- Ceolacanths
- Temnospondylii
- Nectrideans
Which vertebrates are not considered tetrapods?
Which are?

True or False: Weight-bearing limb development was a result of selective pressure for animals to live on land during drought.

<table>
<thead>
<tr>
<th>Extant (Living) Amphibians</th>
<th>Anura (frogs and toads)</th>
<th>Gymnophiona (caecilians)</th>
<th>Caudata (salamanders)</th>
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</tbody>
</table>

The total number of amphibian species is currently 7,087 (Jan 16, 2013)
The total number of amphibian species is currently 2,231 (Jan 21, 2014)
The total number of amphibian species is currently 2,384 (Jan 12, 2015)
The total number of amphibian species is currently 7,998 (Jan 22, 2018)

Source: Amphibiaweb.org
Amphibian Characteristics - Italic only applies to living amphibians

- 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

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

Evolved Simplifications

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

Anura

- 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

- 55 Families!!
Anuran phylogeny

36 Families Recognized

Ascaphidae (2 sp)
Tailed frogs
Appendage for copulation
Pac NW only
Ascaphus

© Brad Moon
Microhylidae (687 sp)
Diverse strategies
New and Old World
Gastrophryne (Americas)
Cophixalus (Australia)
Dyscophus (Madagascar)

Bufonidae (607)
New and Old world
True Toads
Cosmopolitan except Australia/New Zealand
Bufo/Anaxyrus
Rhinella marina
Atelopus- Harlequin Frogs
Often toxic secretions, and thick glandular skin

Centrolenidae (153)
New World Only
Glass Frogs
Digit 1 points inward
T-shaped terminal phalanges
Transparent venter
Tropical stream breeding
Dense capillaries in tadpoles= red appearance
Arboreal
Hylidae (900+ sp)

Hyla new world
Hypsiloba
Osteopilus
Scinax
Pseudacris
Phyllomedusa
Litoria old world
Many Others
Arboreal
Toepads with columnar epithelial cells = good capillary adhesion

Ranidae (300+)

Cosmopolitan Distribution
Conraua goliath: Goliath Frog
300 SVL; world’s largest frog
Rhacophorines
Flying frogs etc
Intercausal Cartilage (like hylids)
May be own family - NOW ARE
Mantellas (now mantellidae)
Madagascar “poison dart frogs”
Rana and Lithobates

Strabomantidae (687 sp)

New world only
Prosimantis: 515 species! - most speciose vertebrate genus!
All direct development
“rain frogs”
Triangular terminal phalanges
Scaphiopodidae (New and Old) + Pelobatidae (Old World Only)
Spadefoots
Europe and NA
Fossorial
Scaphiopus
Spea
Pelobates

Characteristics:
- Limbless (pectoral & pelvic girdles absent)
- Degenerate Eyes (most are fossorial)
- Internal Fertilization (phalodeum)
- Tropical Distribution
- 20% Viviparous, 80% Oviparous

Gymnophiona

Caecus = blind

Characteristics:
- Tropical Distribution
- 10 Families

Dermophis mexicanus
Ichthyophis kohtaoensis
Epicrionops bicolor
Uraeotyphlus

Tropical Distribution
- 10 Families
Caudata (Urodela)

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

• Pseudotriton ruber
• Ambystoma talpoideum
• Andrias japonicus
• Amphiuma tridactylum

Smokies Diversity (31) • 10 Families
Salamander Phylogeny

- Plethodontidae
- Amphiumidae
- Ambystomatidae
- Dicamptodontidae
- Salamandridae
- Proteidae
- Hynobiidae
- Cryptobranchidae

Primitive

Derived

Salamander vs Lizard

Moist Skin
Toe tips
Rounder head
More dorsoventrally compressed

Epidermal Scales
Ear holes
Claws
Usually body held up over ground