Amphibian Evolution and Characteristics

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Goal of the Lecture

To familiarize students with the origin and evolution of amphibians and the characteristics of the Class and extant Orders of Amphibia.

Reading Assignments:
Wells: pp. 1-15

Lecture Structure

I. Class Amphibia Characteristics

II. Amphibian Fossil Record

III. Extant Amphibian Orders
What are Amphibians?

Ectothermic tetrapods that have a biphasic life cycle consisting of anamniotic eggs (often aquatic) and a terrestrial adult stage.

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Amphibia (amphibios: “double life”)
Subclass: Lissamphibia
Orders:
- Anura (frogs)
- Caudata (salamanders)
- Gymnophiona (caecilians)

Amphibia Characteristics

1) Cutaneous Respiration
- Oxygen and CO2 transfer (moist)
- Family: Plethodontidae (lungless salamanders)
- Gills (larvae, few adult salamanders), 2 Lungs (adults)

2) Two Types of Skin Glands
- Mammary Glands (cutaneous respiration)
- Glanular Glands (toxic secretions)
- Parotid Glands

3) Sensory Papillae in Inner Ear and Doubled Transmission Channels in Middle Ear
- Columella – Papilla basilaris
- Opercularis – Papilla amphibiorum (<1000 Hz)

4) Green Rods in Retina (excluding caecilians)
- Function Unknown
- Other Light Receptors: red rods, single and double cones

5) Bicuspid Pedicellate Teeth
- Crown (above gum), Pedicel (connected to jawbone)
- New Crown Emerges from Pedicel

Fossil Record of Amphibians

First Amphibians
Mississippian Epoch 350 MYA

Modern Amphibians (late Permian) 250 MYA
Carboniferous
Fish to Tetrapods

Late Devonian Period 360 MYA

Ichthyostega

- Piscivorous
- Limbs likely used for navigating
- Tail for balance
- Skeletal structure of forelimbs
- Lungs

Acanthostega

- Piscivorous
- Fish-like
- Limbs likely used for paddling
- Skeletal structure of forelimbs
- Fins could set head
- Gills and Lungs

What evolutionary forces encouraged transition to land?

Temnospondylous Amphibians

Late Carboniferous and Early Permian Periods

- 1.5-2 m long
- Bicuspid pedicellate teeth
- Tympanum likely
- Lungs & Cutaneous Respiration
- Shoulder disconnected from skull
- Likely piscivorous
- Engulfed prey
- Not a strong swimmer or fast tetrapod
- Likely hunted by stealth or opportunity

Eryopus megacephalus

Nectrideans and Microsaurs

Carboniferous and Permian Periods

Nectria

- Mostly Aquatic
- Resembled Newts (flat tails)
- Some with triangular heads
- Hydrofoils in slow moving streams
- Small fish and aquatic invertebrates

Diplocaulus magnicornus

Lepospondyli

- 6 groups with uncertain common ancestor

Microsauria

- "Small Lizard"
- Terrestrial (lizards), aquatic (newts), and fossorial
First Tetrapods
Carboniferous and Permian Periods

Labyrinthodontia
1) Anthrazosauria
2) Seymourid    1) Trematosaurida
   2) Seymouirida
3) Dissorophida

Lepospondyli

Temnospondyli
1) Embolomeri
2) Seymourida

Lissamphibia

1) Trematosauroidea
2) Eryopoidea
3) Dissorophida

Anurans
Salamanders
Caecilians

Lissamphibia (Monophyletic Origin)

Is there more support for monophyletic or polyphyletic evolution?

Fossil Record of Lissamphibia
Triassic, Jurassic and Cretaceous Periods

1) Anurans
2) Salamanders
3) Caecilians

Fossil Record: Paleobatrachus
Triadobatrachus massinoti
Karaurus sharovi
Geotrypetes seraphini

• Late Cretaceous
• Origin: Gondwanaland (SA)
• Origin: Kazakhstan
• Late Jurassic

Apodops pricei

• Early Triassic (230 mya)
• Origin: Madagascar
• Early Triassic (100 mya)

Modern Orders of Amphibia

• Gymnophiona (caecilians)
  167 species
  9%
  167 species

• Caudata (salamanders)
  5,420 species
  9%
  500 species

• Anura (frogs)
  280 species in U.S.
  280 species in TN
  86 Species in TN

88%
88%
**Gymnophiona**

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

- Tropical Distribution
- 6 Families

**Caudata (Urodea)**

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
- 18 Families

**Salamander Phylogeny**

- Derived
- Primitive
Anura

Characteristics:
- Shortened Presacral Vertebrae (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

36 (50) Families
Frost et al. (2006)

Agalychnis callidryas
- Flat heads and Large Mouths (usually)
- Vocal Sacs in Males (usually)

Phrynomantis bifasciatus

Dendrobates azureus

Lithobates clamitans

Video

36 Families Recognized