Outline 15: Paleozoic Life
The Evolution of Vertebrates: Fish and Amphibians

Phylum Chordata

- All chordates have a dorsal nerve cord.
- Chordates with vertebrae are the vertebrates. The vertebrae surround the spinal cord.
- Primitive chordates (invertebrates) include sea squirts and arrow worms.

Your spinal cord is a dorsal nerve cord
Tunicates – most primitive chordates

The Lancelet, a living primitive chordate

Vertebrate Phylogeny
Chordate Fossils

- The oldest known chordates are *Pikaia* from the Burgess Shale and the older *Yunnanozoon* from China.
- Both have a dorsal nerve cord, but no vertebrae.
Fossil Fish

• Fish are vertebrates.
• Oldest fish in the Ordovician.
• They are the Agnatha, or jawless fish.
• Teeth on their lips and tongues.

What is a vertebrate?

The simplest vertebrate: a toothless hagfish
A living jawless fish, the lamprey, Class Agnatha

A fossil jawless fish, Class Agnatha

Major Fish Groups
- Agnatha: jawless fish; still living
- Jawed groups:
  - Placoderms: extinct armored fish with cartilaginous internal skeleton
  - Chondrichthyes: cartilaginous fish (sharks and rays); no float bladder
  - Osteichthyes: bony fish; float bladder
Origin of Jaws

- Jaws evolved by modification of the gill arches, tiny bones used to hold open the gill slits.
- Jaws may have evolved to help with respiration by pumping water over the gills when the jaws opened and closed.
- Biting came later.

Evolution of jaws

Jaws evolved by modification of the gill arch bones.
Gill Arches are visible during human embryonic development

The extinct placoderms were the armored fish of the Paleozoic
Fossil tooth of a Great White shark

Megalodon

A modern Great White Shark
The Osteichthyes: Bony Fish

- 2 main groups
  - Ray-finned fish
  - Lobe-finned fish
- 40,000 species of living ray-finned fish - the teleosts, a great evolutionary success!
- 2 kinds of living lobe-finned fish, a great evolutionary failure?
Lobe-Finned Fish

• Include the living lungfish and coelocanth, plus the extinct rhipidistians.
• Bones and muscles of lobe fins could be used to walk on land.
• The rhipidistians walked out of the water in the late Devonian to become the first amphibians.

Bone structure in fins of ray-finned and lobe-finned fish

Comparison of Ray Fins and Lobe Fins
Coelocanth, a living lobe-finned fish, Class Osteichthyes

Skeleton of the coelocanth
Mudskippers, ray-finned fish acting like amphibians.

A Frog Fish, a modern ray-finned fish with “fingers”

The evolutionary step from fish to amphibian was not difficult.
Old Theory: Looking for water in the Devonian led to evolution of lungs.

New Theory: Lungs evolved earlier for rapid swimming by predators in the open ocean

Evolution of the tetrapod walking leg from the lobe fin

Hindlimb of Ichthyostega
Ichthyostega: Photographs of part and counterpart superimposed to show seven digits

Rhipidistian fish

Early amphibian

Rhipidistian fish
Human and Tetrapod bone structures compared.

Lobe-fin fish:

Early Tetrapod Feet:
5, 6, or 7 toes

Tiktaalik rosea:
From the Late Devonian of Ellsmere Island, Canada, 2006
The process of finding fossils begins with a mass in a rock that is gradually removed over time. Here I show a toad as it travels from the field to the lab and is carefully prepared as a specimen: the skeleton of the new animal.

Tiktaalik rosea

Figure 14.18

Early amphibian

Tiktaalik

Lobe-finned fish
Amphibians: Fish out of water

- Reproduction: same as fish
- Breathing: same as lungfish
- Fluid retention: mucous glands of fish, later became oil glands in skin.
- Locomotion: lobe fins modified into walking legs.
- Conclusion: not a big evolutionary jump
Acanthostega and Ichthyostega, with 7 to 8 digits

Summary of the Mid Paleozoic terrestrial invasion

Guinness “Evolution”
Permian amphibian with 5 digits

Life at the water hole, late Paleozoic

Early and large amphibians