Natural History of Vertebrates
Lecture Notes
Chapter 9 - Origin and Radiation of Tetrapods

These notes are provided to help direct your study from the textbook. They are not designed to explain all aspects of the material in great detail; they are a supplement to the discussion in class and the textbook. If you were to study **only** these notes, you would not learn enough to do well in the course.

Be sure to study the List of Terms

Nonamniote Tetrapods

The tetrapods evolved from the sarcopterygian lineage during the Middle Devonian (figure 9-1).
Osteolepiformes (figure 9-3)

- cylindrical-bodied, large-headed fish
- thick scales
- single, external nostril on each side
- paired crescentric vertebral centra (figure 10-1)
- some may have specialized for life at the water's edge

Elpistostegidae (figure 9-3)

- a family within the Osteolepiformes
- lost the dorsal and anal fins, much reduced caudal fin
- dorsoventrally flattened, eyes on top of the head, long snout
- ventrally projecting ribs (figure 9-4)
- single pair of frontal bones anterior to the parietals in the skull (figure 10-1)
- sister taxon to the tetrapods
- *Ttiktaalik* is an intermediate form, but *Tiktaalik* is 20 million years older than *Acanthostega* and *Ichthyostega*, but 2 million years younger than *Panderichthys*.

Selective forces on the earliest tetrapods
The thing to keep in mind, is that the characteristics that were advantageous to the earliest tetrapods were also characters that were advantageous to the various lineages of the Elpistostegidae from which the tetrapods came. Evolution does not work by anticipating a future environment. Whatever characteristics the appeared in this group of fish and were subseqyently advantages on land, also had to be advantageous to the fish in the water.

Panderichthys was a predator that probably laid in wait for victims to come by. It may have used its paired-fins to support the body as it waited or used the paired fins to move through the vegetation that dominated the edges of ponds or estuaries. Phylogenetic comparisons indicate that it would have had lungs and gulped air to breathe.

The most likely explanation for the evolution of the early tetrapods is one in which predation on

terrestrial invertebrates allowed the earliest tetrapods to exploit an abundant food resource. Adults of the earliest tetrapods may not have been able to move about on land, but the juvenile stages were probably light enough and mobile enough to move about on land in pursuit of prey. The ability to breath air is also important. Any vertebrate living along the edge of a warm body of water (especially a slow-moving stream or estuary) will find itself in water that is **hypoxic**. In this case, the ability to breath air is very necessary. Thus, the characteristics that we see as advantageous to panderichthyids are also advantageous to the earliest tetrapods.

There are several tetrapod genera that are known from the Late Devonian. It is clear that by the end of the Devonian, the tetrapods had managed to evolve several forms that were able to exploit different niches of the time.

Acanthostega (figures 9-7 and 9-8)

- Retained functional internal gills and thus could respire like a fish (the only one of the early tetrapods known to retain internal gills).
- had a functional opercular apparatus
- had eight toes on its front feet
- well-developed limbs with girdles for support

Ichthyostega (figure 9-8)

- Had seven toes on its hind feet
- Showed development of a vertebral column in which the neural arches of the vertebrae articulate with the adjacent vertebrae (figure 8-2). This provides greater rigidity to the vertebral column and allows it to support the weight of the body when on land.
- Had broadly overlapping ribs which also helped to strength the vertebral column.

In the evolution of the tetrapod limb, we see several new innovations that increase the load carrying capacity of the limbs as these animals adopt an increasingly more terrestrial life style. In the pectoral girdle, there is a new bone (the **sternum**) and the **scapulacoracoid** attaches to the vertebrae via muscles. In the pelvic girdle, the **illium**, **ischium**, and **pubis** unite and attach firmly to the vertebrae in a bone-to-bone connection. In the forelimb itself, there is one large proximal bone (**humerus**) that articulates (elbow joint) with two more distal bones (**ulna** and **radius**). These articulate (wrist joint) with two smaller bones (**ulnare**, **radiale**). The radiale and ulnare then articulate with the **carpals** and these with the **digits**. Study figures 8-4, 8-5, and 9-5 to learn the development of the limb. The hindlimb is very similar.

From the Devonian to the beginning of the Cretaceous, there were many different forms of nonamniote tetrapods. Several terrestrial forms probably gave rise to aquatic forms and thus we see the reappearance of traits that are associated with an aquatic lifestyle. This led to many cases of **convergent** and **parallel evolution** that make producing a phylogeny of these organisms very difficult.

The extant amphibians (**Lissamphibia**) are very different from the many nonamniote tetrapods that were present during the Paleozoic and Mesozoic. The Paleozoic forms are divided into several different groups (though these are probably not monophyletic assemblages),

- the **Bactrachomorpha**, represented by the Temnospondyli. generally aquatic, with flat immobile skulls,and reduced numbers of fingers in the hand. Many of these had labyrinthodont teeth (sharp, pointed teeth with a complex folding of the wall of the pulp

cavity) and two parts (bipartite) to each vertebral centrum (figure 8-3).The modern Lissamphibia probably came from this group, but see below.

- the **Reptilomorpha**, (figure 9-9) were more terrestrial, had somewhat kinetic skulls, and retained five fingers per hand. The Amniota probably came from this group
- the **Lepospondyli** (figure 9-10) tended to be long-bodied and in some forms legless. They were generally small (skull less than 5 cm); single, spool-shaped centrum; no labyrinthine form of enamel. Possibly gave rise to the caecilians, which would place the caecilians in a clade different from frogs and salamanders

Ecologically all of these organisms were predaceous. Some were primarily terrestrial and some were exclusively aquatic. Several forms retained external gills (a larval character) as adults through neoteny. Many were **sit-and-wait predators** that prowled the edge of bodies of water eating any smaller organism that came close enough to be ambushed.

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