

Early Vertebrate Environment

- Vertebrates are thought to have first evolved in marine environments:
 - Paleontology: the earliest vertebrate fossils are found in marine sediments
 - Comparative Physiology: all non-vertebrate chordates are exclusively marine with body fluids in the same concentration as the ocean so the concentrated body fluids of the hagfish likely represent the original vertebrate condition

Hagfish and Lampreys



- These are the two groups of extant jawless (“agnathan”) fish
 - Both appear to be more primitive than the armored ostracoderms of the Paleozoic
 - Since they’re living, they can tell us a lot more about these animals than just fossils can
- Let’s take a closer look at these things.....

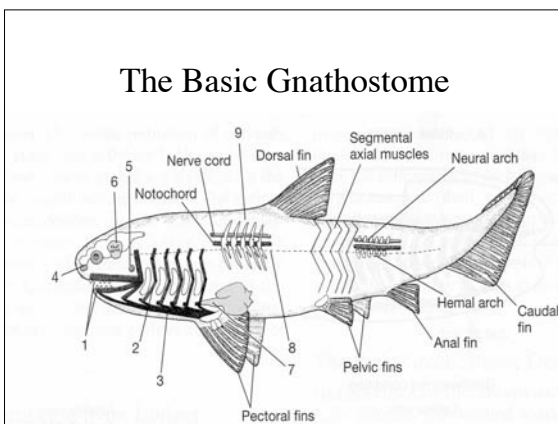
Radiation of the Ostracoderms

- These are all extinct now, but they’re more derived than the extant agnatha
- 10-50cm
- Some had moveable mouthparts but no jaws
- Notochord main axial support
- Probably ate small soft-bodied prey
- From Late Silurian to Early Devonian (so 50my) these guys co-existed with the gnathostomes, so it seems sort of unlikely they were pushed to extinction by gnathostome radiation; more likely they were two different basic animal types exploiting different resources---one lucked out

Why Jaws Are a Big Deal

- Allow a variety of feeding behaviors:
 - Grasp firmly, cut food in pieces, grind hard foods
- Herbivory became possible, allowing many gnathostomes to get much bigger than their agnathan counterparts
- Jaws can manipulate objects, dig holes, carry pebbles and vegetation to build nests, grasp mates, hang onto juveniles, and allows for better aeration of gills

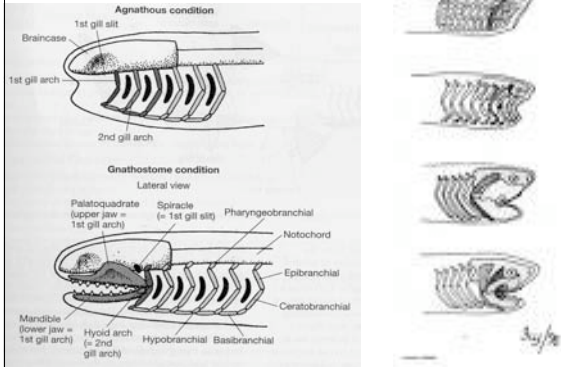
The Basic Gnathostome



Based on Extant Gnathostomes they also have:

- Insulating sheaths on nerve cells
- Thicker spinal cord
- Eye musculature allowing for better focusing
- Lateral line with specialized cells
- True stomach, distinct spleen and pancreas
- Spiral valve in intestine to increase surface area
- Distinct ducts leading from male and female gonads
- More complex muscle microstructure--actin proteins

Origins of Jaws:



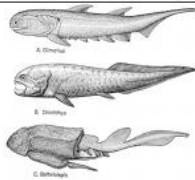
Extinct Paleozoic Jawed Fish

- By the Devonian, the gnathostomes, known by entire body fossils, had divided into 4 distinct clades:
 - Two now extinct: **placoderms** and **acanthodians**
 - Two still surviving: **chondrichthyan** and **osteichthyans**

The Placoderms



- Covered with thick, often ornamented armor shield with separate head and trunk portions linked by a hinge, so unlike the ostracoderms they could lift their heads
- Thrived in the Devonian until the same Late Devonian extinction event that did in most of the ostracoderms also did most of them in; some survived another 5 million years though
- Their massive armor is like nothing around today



The Acanthodians

- Spiny Sharks are named for their stout spines (*acanthi* = spine) anterior to their well developed fins
- 6 pairs of ventrolateral fins in addition to the usual pectorals and pelvics (so if we'd evolved from them we'd have 6 legs!)
- Existed from the Late Ordovician to Early Permian--initially marine but then mostly freshwater
- Slim body and heterocercal tail suggests a mid-water existence
- Small scales, big mouths

