

- **Additional characters**

- Chordate body plan – **bilateral symmetry**
- Segmentation – **myomeres** arranged along body wall

- Additional **Vertebrate** characters:

- Bone
- Specialized kidney tubules; marine origins
- Brain case and vertebral column
- Blood circulation patterns
- Gut outgrowths – liver and pancreas
- Neural crest cells

- Cephalization

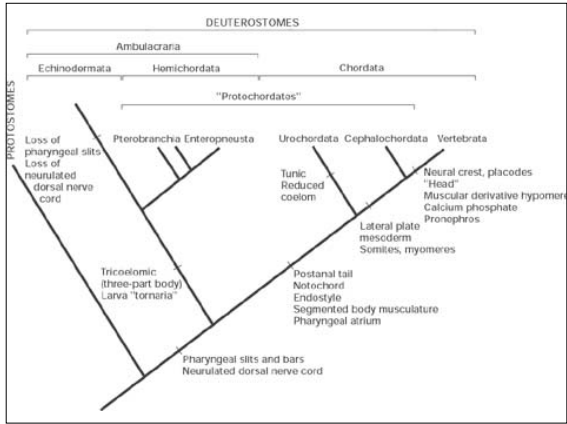
- Neural photoreceptors
- Bilateral cleavage in embryos
- A secondarily formed mouth, not derived from the blastopore

- **Early important new characters**

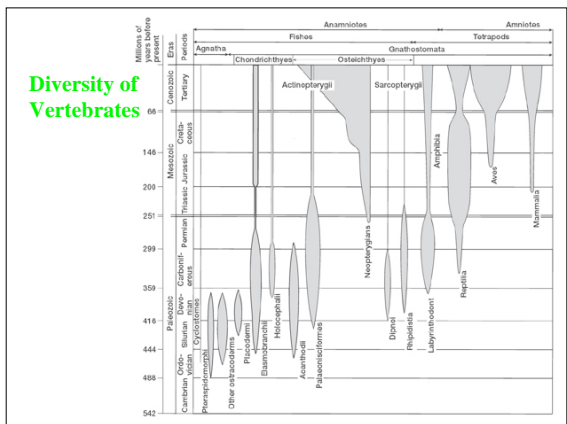
- Pharyngeal pumping mechanism for water circulation and improvement of feeding capabilities
- Jaws

- **Transition to land**

- **Amphibians** adapted to survive on the land-water interface
- **Reptiles** able to remain on land, including reproductive changes not to require water immersion
- **Linnean classification** – heirarchical
- May be based on grade level of organization
- **Cladistic classification** - all lower levels contained within the higher one
- Relationships built on clades



- **Deuterostome** – mouth second – anus forms first
 - Category unites Echinodermata and “Protochordates”
- **Ambulacraria** – Echinodermata and Hemichordata
- **Protochordates**
- **Hemichordata** –
 - Link echinoderms and chordates



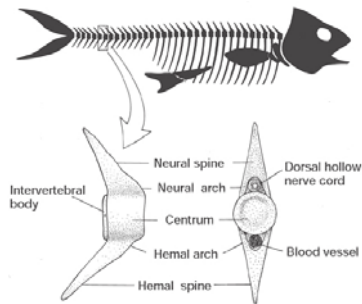
Diversity of Vertebrates

- **Evolutionary innovations of Vertebrates**

- **Vertebral column**

- Separate bones or cartilage blocks that define body's major axis
- Separated by thin compression pads, **intervertebral disks**
- **Solid body (= centrum)** encloses the notochord
- **Neural arch** encloses spinal cord dorsally
- **Hemal arch** encloses blood vessels ventrally
- **Neural and hemal spines** = arch extensions

- In mammals, the notochord persists as the jelly-like nucleus pulposus of the intervertebral disks



- **Cranium = another vertebrate innovation**

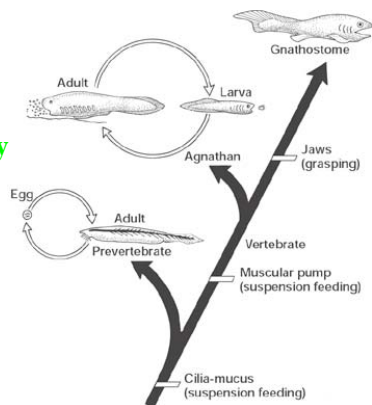
- Contains organs of **special senses**
- Anterior end of spinal cord enlarged to form **brain**
- **Neural crest** source of many head structures and these cells are found in vertebrates only

Vertebrate origins in marine waters

- **Prevertebrate conditions**
 - **Suspension feeders** common among Hemichordates, urochordates and cephalochordates
- **Cilia pump**
 - Similar to that in prevertebrates
 - Able to tolerate estuary conditions
 - Pharynx acquired encircling band of muscle

- Cartilage replaced collagen of pharyngeal bars
- Muscle contraction squeezed water from pharyngeal slits
- At relaxation, spring action of cartilage restored shape and took in new water
- Initially assisted ciliary pump in moving water through the pharynx
- Increased body mass made muscular pump necessary
- Muscular pump allowed greater body size

Body size increase important evolutionary trend in many lineages

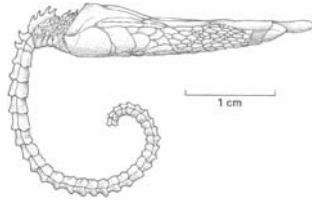


Vertebrate Pretenders

- **Calcichordates**

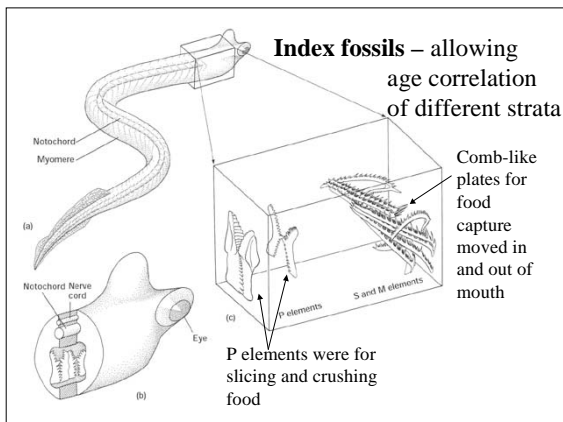
544- 400 mybp

- Echinoderm-like skeletons
- Resembled flattened crinoids
- Probably related to echinoderms



- **Conodonts** – Cambrian to Triassic

- Laterally compressed, slender
- Soft-bodied vertebrates identified in 1980's
- Contain conodont elements, tooth-like microfossils
- V-shaped myomeres
- Notochord
- Caudal fin rays
- Post-anal tails
- Possible dorsal nerve cord
- Tissues as in vertebrates, indicating neural crest cells present

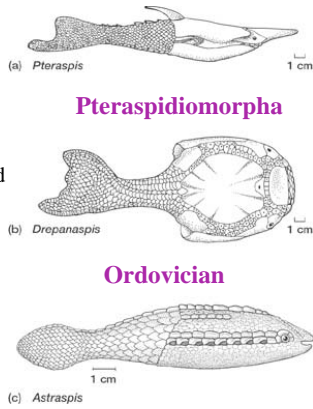


Agnathan phylogeny

- **Jawless forms**
 - Lack biting apparatus that is derived from branchial arches
 - Appeared in Late Cambrian
 - Greatest radiation in Silurian and early Devonian
 - First vertebrates to have bone in their exoskeletons
- **Ostracoderms** – extinct jawless fishes
 - Late Cambrian, radiated in Silurian and early Devonian
 - Bony exoskeletons and dentinlike tissues
 - Small size, complex eye muscles

Ostracoderms

- Bony head plates fused into a solid head shield (exoskeleton)
- Long spines and fins
- Paired fins present
- Lateral lines
- 2 semicircular canals



Ostracoderms

Late Ordovician to Late Devonian

Single nasal opening, often merged with hypophyseal opening to form a keyhole-shaped nasohypophyseal opening

Small scales cover posterior of body

