Paleontology Lab: Introduction to the Chordata and their relatives

Objectives:

- Be able to recognize why echinoderms and hemichordates are related to the Chordata.
- Be able to identify the four characteristics of the phylum Chordata: **notochord, dorsal hollow nerve cord, pharyngeal gill slits/pouches, post-anal tail.**
- Be able to recognize the characteristics of the several chordate subphyla, and the diversity among the several groups of fishes.
- Be able to map the following traits on a phylogeny of chordates: **Notochord, head (cranium), vertebral column, jaws, lungs, lobed fins, limbs with digits, amniotic egg,** and **milk**.
- Be able to describe important features of the animal taxa covered in this lab.
- For all the animals included in this lab, be able to identify to which of the major taxonomic groups (**taxa**) that animal belongs to.

Materials needed for this lab:

Preserved specimens, models, and slides of Echinodermata, Hemichordata, Cephalochordata (incl. *Amphioxus*), and various fishes (lampreys, sharks, bony fishes)

DEUTEROSTOMIA

The animals in this group share certain embryological similarities: their early cleavages are radial and indeterminate, so that, in the 8-cell stage, the top 4 cells are stacked directly above the bottom 4 cells, and the embryonic fate of each cell is not determined until much later. Most of all, the gastrula stage is marked by an opening, the **blastopore,** that becomes the animal's tail end, while the mouth is a secondary structure that develops later (Deuterostomia means "secondary mouth").

The two largest phyla in the Deuterostomia are the Echinodermata and the Chordata. A few smaller phyla are also included.

PHYLUM Echinodermata

The Echinodermata are deuterostomes that share several embryonic similarities with the Chordata and a few smaller phyla. The embryonic blastopore is posterior, and the mouth forms at the opposite (anterior) end. Except for a few very early fossil forms, all Echinodermata have evolved a complex pattern of development in which the bilaterally symmetrical larva develops into an adult with a five-fold pattern of radial symmetry.

Attached echinoderms with upward-facing mouths include crinoids, blastoids, edrioasteroids, and several smaller groups. They flourished in Paleozoic times. Most of them are now extinct, except for a few types of crinoids ("sea lilies"). Examine the few specimens that we have.

Free-living echinoderms with downward-facing mouths include the familiar starfish (sea stars), brittle stars, sea cucumbers, sand dollars, and sea urchins. Examine a few of these echinoderms.

PHYLUM Hemichordata (acorn worms and pterobranchs)

The Hemichordata are a small phylum that shares certain characteristics with the Chordata. Acorn worms have pharyngeal gill slits, and all Hemichordata have a dorsal, hollow nerve chord. Structures exist that may be homologous to the notochord, but these homologies are disputed.

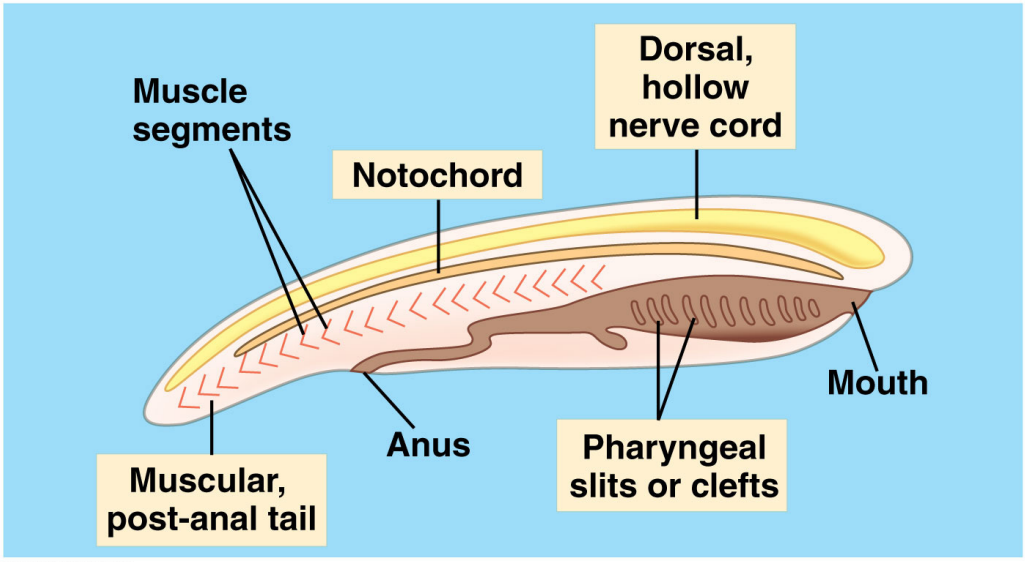
The Hemichordata are now usually treated as a separate phylum closely related to the Chordata and to the Echinodermata. (Larval acorn worms and larval echinoderms are remarkably similar!)

All Hemichordata are filter-feeders. In addition to the free-living acorn worms, the Hemichordata include the tube-building Pterobranchs, as well as an extinct group called Graptolites. Both pterobranchs and graptolites feed using feathery ciliated tentacles that resemble a lophophore. The acorn worms pass currents of water through their gill slits and use their gills as a feeding apparatus.

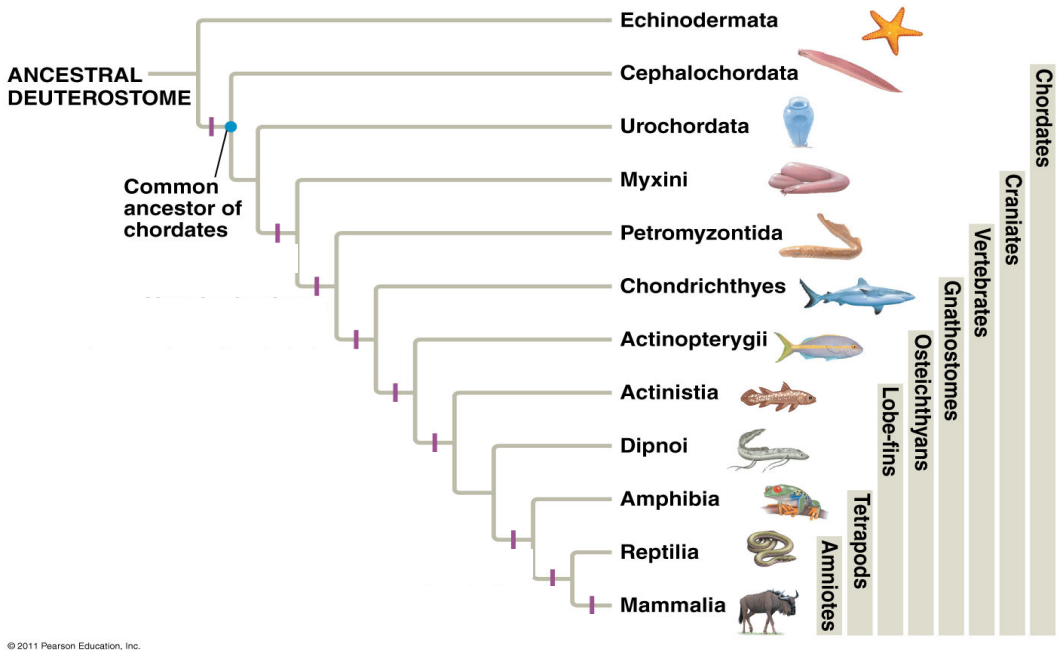
Examine and draw a preserved specimen of an acorn worm. Label the **gill slits** and the muscular **proboscis** used in burrowing.

PHYLUM Chordata

The following figure illustrates the 4 traits that chordates have in common: **notochord, dorsal hollow nerve cord, pharyngeal gill slits,** and a **post-anal tail**. All chordates have these four traits at some point during their life cycle, but not necessarily in the adult stage.

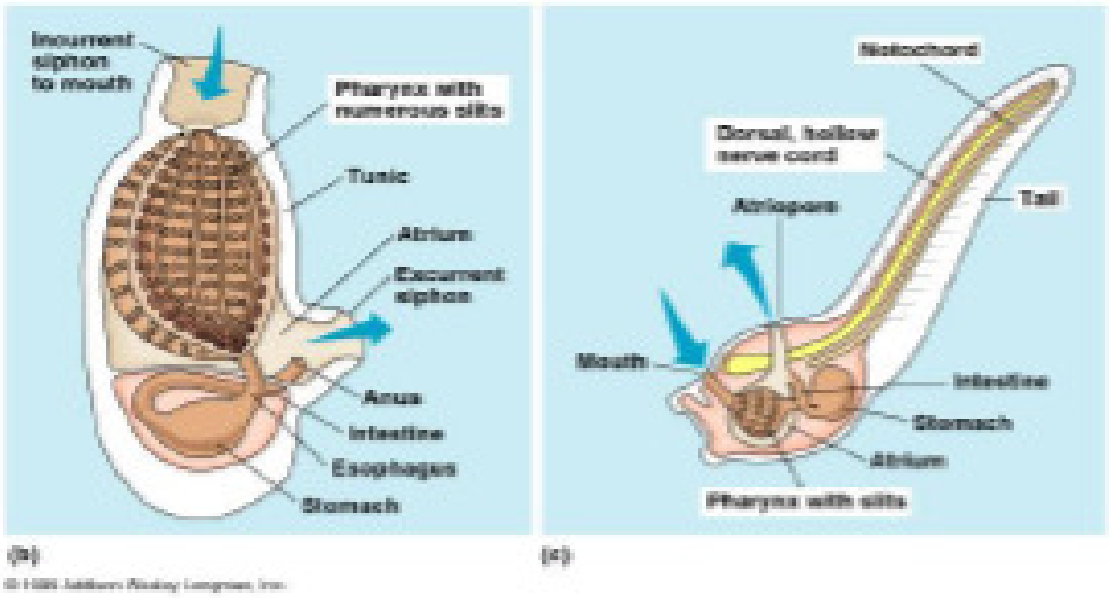


In the following phylogeny of chordates, label the point of origin of the following traits: **Lungs, Limbs with digits, vertebral column, Amniotic egg, Notochord, Jaws, Lobed fins, Milk, Head (cranium).**



SUBPHYLUM Urochordata (tunicates or sea squirts)

Adult tunicates are sessile (attached) organisms that pump water through a seive-like gill basket with hundreds of gill slits. They filter feed by straining tiny food particles out of the water using this gill basket. Their actively swimming larval stage has a notochord, a dorsal hollow nerve chord, a series of segmentally organized swimming muscles, and a strong post-anal tail, but these larval features are lost or greatly diminished in the adult. Observe and draw an adult tunicate. Also, examine a slide of a larval tunicate if one is available.



SUBPHYLUM Cephalochordata (sea lancets)

Sea lancets such as ***Amphioxus*** are active swimmers that filter feed by passing water through their many gill slits and straining out tiny food particles. Their adult stages are in many ways comparable to a larval tunicate. Examine models and slides of ***Amphioxus.*** Draw ***Amphioxus*** on your own paper and label the **notochord, dorsal hollow nerve cord, pharyngeal gill slits,** and **post-anal tail.**

SUBPHYLUM Veretebrata (vertebrates)

Five or more classes of vertebrates are predominantly aquatic and are collectively called **"fishes".** However, "fishes" are quite diverse, and do not represent a single taxonomic group at any level. Among the groups of "fishes" are the following:

Class Agnatha (jawless fishes), often subdivided into hagfishes (Myxini), lampreys (Petromyzontida), and several extinct groups (Cephalaspida, Anaspida, Heterostraci).
Class Placodermi, an extinct group of armored fishes
Class Chondrichthyes (cartilaginous fishes), including sharks, skates, and rays
Class or subclass Actinopterygii (bony fishes with flat fins supported by bony rays). This group includes the majority of fishes alive today.
Class or subclass Sarcopterygii (bony fishes with thick, lobe-like fins that include strong muscles). This group may be further subdivided into the **Actinistia** (or Crossopterygii) and **Dipnoi** (lungfishes).

Study representatives of as many of fish taxa as we have on display. Make note of the characteristic features of each. In particular, note the structure of the **gill slits** (sometimes concealed beneath a flap called the **operculum**), the structure of the paired fins, and the shape of the caudal (tail) fin.

Class Amphibia, and the transition onto land.
The Tetrapoda include the four vertebrate classes that are predominantly terrestrial. When tetrapods first moved onto land, they faced many of the same challenges that land plants or scorpions made independently.

- **What were some of these challenges?**
- **What adaptations permitted the transition from water to land?**
- **In what way are amphibians still restricted to aquatic habitats?**
- **Why is the amniotic egg considered a key innovation?**

The Amphibia are vertebrates with aquatic, gill-breathing larvae that undergo metamorphosis into lung-breathing adults. Important adaptations needed to live on land included:

- Internal nostrils, allowing respiration with a closed mouth
- Lungs, allowing gas exchange directly with the air
- Walking limbs capable of locomotion on land

Which of these adaptations already existed in certain fishes? Which was the last to evolve? The posture of amphibian limbs is sprawling, with the body resting on its ventral surface when not in motion; this posture is best seen in salamanders (**Urodela** or **Caudata**). In addition to salamanders, modern amphibians include two other groups: the legless caecilians (**Apoda**) and the frogs and toads (**Anura**). The class Amphibia also includes a number of extinct groups that flourished in the Devonian through Triassic periods.

Amniote classes (Reptilia, Aves, Mammalia): these will be studied in future labs.