Objectives:

• Be able to identify specimens from the main groups of Mollusca and Echinodermata.
• Be able to distinguish between the bilateral symmetry on a bivalve vs. a brachiopod.
• Be able to recognize the major anatomical structures of a cephalopod via dissection of a specimen.
• Be able to identify the four traits shared by chordates: **notochord**, **dorsal hollow nerve cord**, **pharyngeal gill slits/pouches**, and **post-anal tail**.
• Be able to map the following traits on a phylogeny of the chordates: **Notochord, head (cranium), vertebral column, jaws, lungs, lobed fins, limbs with digits, amniotic egg**, and **milk**.
• Be able to identify to which of the major taxonomic groups an animal belongs (all **taxa** indicated in the phylogenetic trees included in this lab).
• Be able to describe important features of the animal taxa covered in this lab

Section I: Mollusca
The Molluscs are the “insects of the sea” in terms of diversity. Particularly the class Bivalvia shows tremendous disparity of shell shapes and sizes, and even for some lack of shell (think of snails). Molluscs play an important ecological role in marine ecosystems and, just as insects do in the land, occupy every conceivable niche in the sea.

In this lab, you will draw specimens from the most important mullusc classes and do a dissection of a squid. Make sure you note all the interesting morphological features. These will help you study for the exam!
PHYLUM Mollusca  
CLASS Polyplacophora  
Chitons. Look at the multiple plates forming the outer shell, which gives the name to group. Which internal organ secretes the shell?

PHYLUM Mollusca  
CLASS Bivalvia  
Clams. Look at the two valves. Draw the line of bilateral symmetry. Look at the jar with brachiopods and draw one, including the line of bilateral symmetry.
PHYLUM Mollusca
CLASS Gastropoda
Snails and slugs. This is the most diverse group of molluscs. Pay special attention the torsion of the shells.

PHYLUM Mollusca
CLASS Cephalopoda
Squids, octopus and nautilus. Make sure to count the legs. What do you think the group name means? Make sure you also draw the chambers of the nautilus. What use do you think these may have (think of jet propulsion)? On the next page, and using the mounted specimen as a guide, do a dissection of a squid.
Squid dissection. Use the preserved specimen and the next page as a guide to identify structures.
Section II: Deuterostomes

**Echinodermata:** Sea stars, sea cucumbers and sand dollars form the basal deuterostomes (remember from lecture that in the deuterostomes, the first hole of the blastula becomes the anus). We humans are deuterostomes, so we are more closely related to a sea star than we are to a squid, an insect, or a coelomate earth worm. Does this make the presence of a coelom a good or bad phylogenetic character?

**PHYLUM Echinodermata**
**CLASS Ophiuroidea (brittle stars) and Asteroidea (sea stars)**

Sea stars and brittle stars. As you draw one specimen of each, make sure you note the difference between the brittle and sea stars. Do the sides of the arms touch before they reach the central disk?

**PHYLUM Echinodermata**
**CLASS Echinoidea**

Sea urchins. Can you tell the pentaradial symmetry pattern? Look at it from the bottom. Can you see how they are related to sea stars?
**PHYLUM Echinodermata**
**CLASS Echinoidea**

Sand dollars. Look again for the pattern of pentaradial symmetry. After you look at the sea cucumber, come back to the sand dollars. Can you see how they are just different extensions of the same body plan?

---

**PHYLUM Echinodermata**
**ORDER Holothuroidea**

Sea cucumbers: These animals are usually at the bottom of the sea, taking in sand and filtering nutrients out of it. Can you spot the pattern of pentaradial symmetry?
**Chordate Phylogeny**

In the following phylogeny label the following traits: **lungs, limbs with digits, vertebral column, amniotic egg, notochord, jaws, lobed fins, and mammary glands.**

**Identifying Chordate Features**

The figure below illustrates the 4 traits that chordates have in common: **notochord, dorsal hollow nerve cord, pharyngeal gill slits, and a post-anal tail**. They do not necessarily possess all of these traits at all stages of their life cycle, but all chordates have these four traits at some point during their life cycle.
> Observe *Amphioxus* (a Cephalochordate). Draw *Amphioxus* in the space below, and label the notochord, dorsal hollow nerve cord, pharyngeal gill slits, and post-anal tail.

---

**The Tetrapods Move onto Land**

When Tetrapods made the move onto land, they faced many of the same challenges that plants had when they made the big leap onto land.

> What were these challenges?

> What challenges do amphibians face with respect to water availability on land?

> Why is the amniotic egg considered a key innovation?
Identifying the major chordate taxonomic groups

Phylum Chordata
Subphylum Urochordata
Tunicates or sea squirts

Tunicates are deuterostomes and chordates, despite looking like a sponge. Even sponge biologists get confused when looking at pictures or while diving and looking at a urochordate colony from a distance! But once you cut them open, you can see tissues and organs. As adults they do not have a notochord, but only briefly during their larval stage. The specimens we have in our lab today are not very well preserved, so look at the images your instructor puts on the screen and look at the diagram in your textbook. Draw a generalized urochordate and at least label the tunic an the siphons.
Phylum Chordata
Subphylum Hemichordata
Acorn worms

Acorn worms diverged early from the rest of the chordates, but most interestingly, the latest data seems to point to them being the sister group to the echinoderms (starfish and sea cucumbers) that we saw during our last lab. Draw the preserved specimen, paying

Phylum Chordata
Subphylum Vertebrata
Class Agnatha
The jawless fish

The Agnatha is a paraphyletic group that contains the “jawless fish”. Draw a specimen from those in the big jar in the lab, and pay special attention to the structure of the mouth. Compare them against the Gnathostomata (the jawed fish, which include us the mammals) when you get to those in this lab.
Phylum Chordata
Subphylum Vertebrata
Class Chondrichthyes
The sharks, skates and rays. This group sits at the base of the Gnathostomata, the jawed animals. Observe and draw a few specimens. Then look at the phylogeny and answer this question: are Chondrichthyes lobe-finned fish or are they ray-finned fish? (hint: it’s a trick question, look at the phylogeny!)

Phylum Chordata
Subphylum Vertebrata
Class Osteichthyes
The bony fish are part of the ray-finned fish, the Actinopterygii. Observe and draw some of the specimens on display, taking special note of the fact that they have jaws.
Phylum Chordata  
Subphylum Vertebrata  
Class Amphibia  
Order Caudata  
The salamanders. Amphibians are lobe-finned fish (look at the phylogeny). Although they are also tetrapods, and thus adapted to the land environment, they are also tied to the water, and unlike reptiles and mammals, cannot be completely separated from the water. What is that adaptation that they lack, and which reptiles and mammals have, that does not allow them to completely move to an environment without water? Draw at least one salamander, and notice how much they look like a lizard, although they are not closely related.

Family Caecilidae  
Look and draw the caecilian, another important amphibian. Can you see any legs? How come it’s still classified as a tetrapod?

Order Anura
Frogs. Draw a frog, and a tadpole. Are frogs lobe- or ray-finned? Are frogs tetrapods? Are frogs reptiles? You can answer all of this questions by looking at the chordate phylogeny.

The amniotes
Phylum Chordata
Class Reptilia
Order Crocodilia
Crocs and alligators. Observe and draw the skulls on display.
Phylum Chordata
Class Reptilia
Order Squamata
Lizards and snakes. This group has scales covering their bodies. Look at the snakes. How can they be tetrapods when they have no legs? Aren’t tetrapods supposed to be the animals with four limbs? Draw a few specimens.

Phylum Chordata
Class Reptilia
Order Testudines
The turtles. Al turtles have shells. Their placement in the phylogeny of the reptiles is still debated. Draw a few specimens.
Dinosaurs
Dinosaurs can be confusing at first because the monophyly of the group depends on how broad of a definition you use. For example, if you only call dinosaurs those animals inside the Dinosauria group (within the reptiles, look at the phylogeny of the amniotes above), and also call birds dinosaurs, then they do form a clade or monophyletic group. If you exclude birds, then they become paraphyletic. On the other extreme, if you call a dinosaur any extinct animal for which we find fossilized big bones, then they are polyphyletic. Look at the phylogeny of the amniotes above. Using the strict definition of dinosaurs, i.e. only those that are inside the Dinosauria clade, are the following prehistoric, big-boned animals also dinosaurs: Pterosaurs, Plesiosaurs, Ichthyosaurs and extinct Crocodilians?

We have on display a large collection of dinosaur models. Using the following phylogeny, try to find as many as you can. From lecture, remember that there are two main groups of dinosaurs: the saurischians (the lizard-hipped dinosaurs) and the ornithischians (the bird-hipped dinosaurs). Look at the phylogeny. Are birds lizard-hipped or are they bird-hipped?