Field Trip: Harvard Museum of Natural History (HMNH)

Objectives
To observe the diversity of animals. To compare and contrast the various adaptations, body plans, etc. of the animals found at the HMNH.

Introduction
Note: There is no pre-lab for this lab.
The most casual observation indicates that not all animals look the same. Darwin's theory of evolution through the process of natural selection tells us that the reason animals (or plants) do not look the same is that they have evolved to fit into particular environmental niches and that most differences which we observe reflect some kind of special adaptation to the environment. One of the easiest ways to examine the changes which have occurred during the course of evolution is to visit the Harvard Museum of Natural History at Harvard University. Here, mounted animal specimens from all parts of the world are arranged in groups according to their evolutionary relationships as well as the geographic regions in which they are found. The purpose of this lab is to examine these animals and for you to teach yourself certain principles of animal diversity by using your own observations to answer the questions in these pages.

You should also visit the Glass Flowers exhibit in the same museum. It contains glass models of many important plant types.

You can easily walk from the Harvard Square MBTA station to the HMNH (see map on next page; tear it out and take it with you). It is best to go to Harvard Square by subway (red line) or by bus since parking places around the museum are either enormously difficult to find, or they are reserved for the faculty and staff of Harvard (and reserved parking is strictly enforced). The trip from UMass to the HMNH takes about 45 minutes each way. Tickets will be given out in class to the HMNH; this will get you free admission (it is normally $7 for students). You can go to the HMNH anytime that the museum is open. TAs will tell the class when they will be at the museum. The HMNH is open daily 9:00 AM to 5:00 PM. Admission is free (even without a ticket) Sundays from 9 to 12.

YOU SHOULD BRING YOUR TEXT FOR REFERENCE.

Procedure

VERY IMPORTANT NOTICE: This lab will take you a while to complete, especially if you are unprepared. In order to be able to complete it in 3 hours, you should **be sure to do the following before you go to the HMNH**:

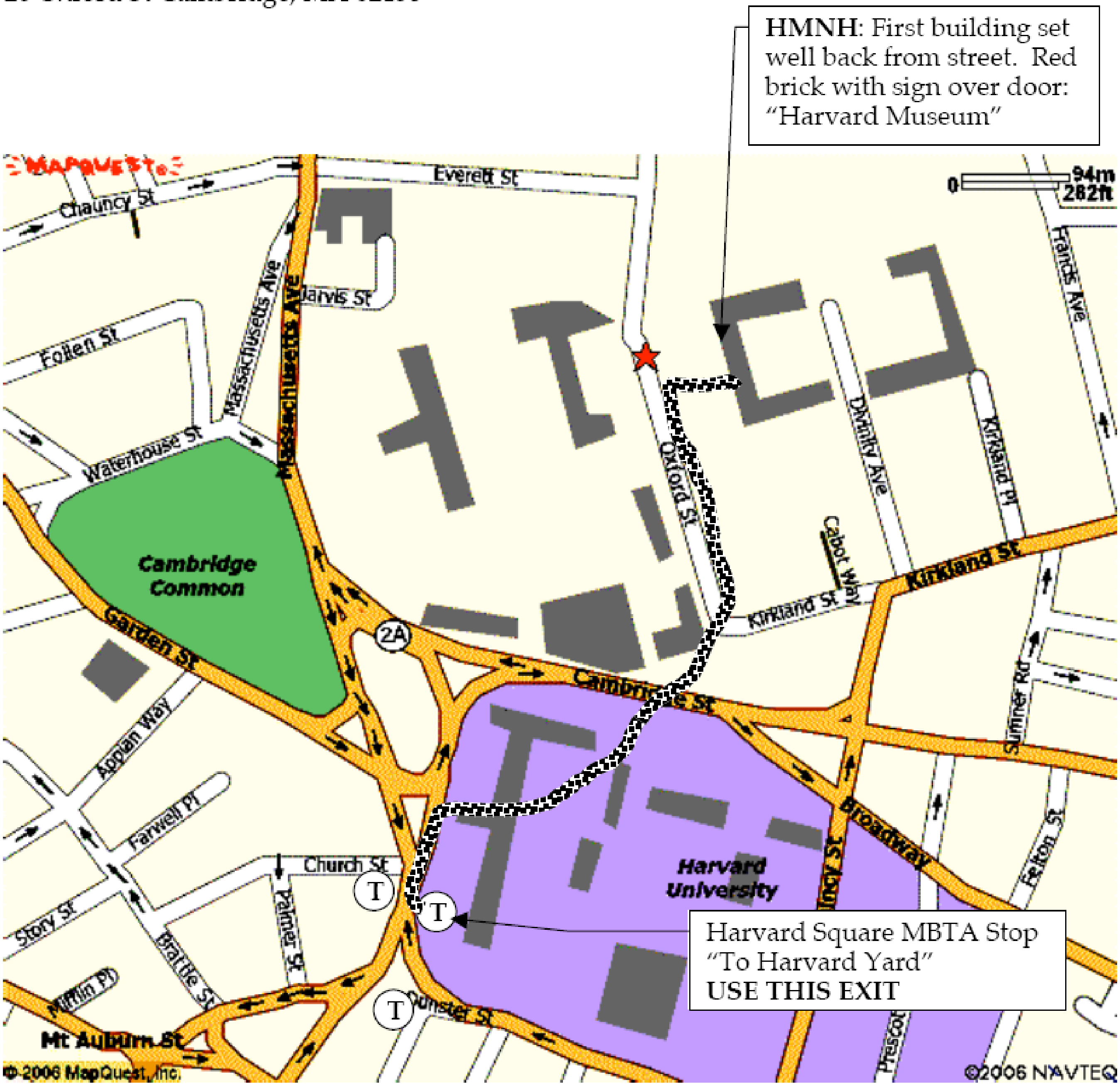
• Read up on classification systems (see your text) and familiarize yourself with terms like kingdom, phylum, etc.
• The following phyla can be found at the HMNH; you should go through your text and make a brief sketch of each phylum so you can recognize it more easily when you are looking for it (each of these is listed in the index):
  • chordata • cnidaria • anthophyta • coniferophyta
  • arthropoda • platyhelminthes
  • cyanobacteria • lycophyta • mollusca
• Read over **all the questions** and make a plan of how you might go about answering them.

At the HMNH
Be sure to get a map - it will show you where to find various types of organisms. During your visit, you should make notes on your lab manual from which you can answer the questions below. Your lab report will consist of answers to these questions. You need only to answer the questions; it is not necessary to assemble your answers into a larger essay.

Questions:
• Important note: these questions are difficult & involve some speculation & interpretation on your part. For that reason, we will grade your responses generously. Our purpose is to get you thinking about these issues rather than to emphasize a specific right answer. As long as your answers are reasonable and clearly-explained, you should get full credit.
• Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine.
• Although you will perform these activities as a group, each member of the group must turn in an individual lab report. Each person's report must be in his or her own words as much as possible.
• Your lab report must contain answers to all the questions in the lab manual.

Getting to the HMNH (not all buildings shown)

26 Oxford St Cambridge, MA 02138



- Exit Harvard station using the "To Harvard yard" exit.
- Go along Massachusetts Ave with the brick and wrought iron fence on your right.
- Go through the first gate you come to; it's near a bus stop.
- Go diagonally across Harvard yard to the gate at the north end (you'll see a big plaza).
- Cross the plaza with the Science Center on your left.
- Cross the street at the corner where Kirkland and Oxford intersect.
- Walk along Oxford with the street on your left until you come to the HMNH.

1. Choose three different phyla listed in your text. For each of the three phyla, find one representative organism at the HMNH or Glass Flowers Exhibit. Be sure to list its genus and species names in addition to its common name (if available). In one brief sentence, describe the organism (size, coloration, feeding, habitat, etc.).

a) Phylum #1 ____

organism: Genus __________________________

Species _________________________

Common name (if available) ________________________

Description:

b) Phylum #2 ____

organism: Genus ________________________
Species__________________________

Common name (if available) _____________________________

Description:

c) Phylum #3 _____________________________________

organism: Genus ________________________

Species _______________________

Common name (if available) _______________________

Description:

2. Convergent Evolution

Consider the wing bones of the following three flying vertebrates:

- Pterandon – a flying dinosaur. Its skeleton can be found on the wall in the Romer Hall of Vertebrate Paleontology.
- Bird - A drawing of a bird wing can be found in figure 34.28a of *Campbell* 8^{th} ed.

• Bat – flying mammal. A bat skeleton can be found in the Hall of Mammals in case A2 which is against the wall that separates the Hall of Mammals room from the Holarctic Mammals and Birds room.

a) All three wing structures are based on the same tetrapod vertebrate arm and five-fingered hand structure that is shown in *Campbell*, 8^{th} ed. figure 22.17. Using figure 22.17 as a guide, sketch the wing bones of a bird, a bat, and a pterandon and identify (as best you can) how the bones in each of your sketches correspond to the bones in the human arm and hand. Be sure to label the parts of the wing skeleton that correspond to:

- Humerus (upper arm bone) {shown in gray in figure 22.17}
- Radius & ulna (lower arm or "forearm" bones) {orange and beige}
- Palm & finger bones (carpals, phalanges, & metacarpals) {yellow and brown}

For each wing, give a one-sentence description of its structure. For example, if we had asked about figure 22.17, you would say something like, "The cat's foot is like a human hand, but it walks in its tiptoes."

b) *Campbell* 8th ed. figure 34.29 shows *Archaeopteryx*, the earliest known bird. If you looked at the wing skeleton of this animal, which would you expect it to be most like: bird, bat, or pterodactyl? Explain your reasoning briefly.

3. Common Structures

Virtually all tetrapod vertebrates (see *Campbell* 8^{th} ed. figure 34.19 for a sample) have the following features (among many others):

• Two “legs” – appendages near the tail end of the backbone.
• Two “arms” – appendages near the head end of the backbone.
• A “tail” – an extension of the backbone beyond the pelvis at the back end of the animal.

These have been extensively modified in certain swimming vertebrates; for example:

• Whales - marine mammals. Several whale skeletons can be found hanging from the ceiling in the Hall of Vertebrates (you can’t miss ‘em).
• Seals – another group of marine mammals. A seal skeleton can be found by the windows in the Hall of Mammals.

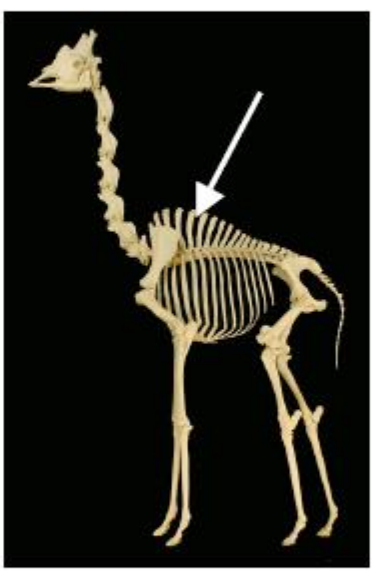
a) To which part(s) (arm, leg, tail) do the front flippers of a whale correspond?

b) How have the leg bones of a “standard tetrapod” been modified in a whale?

c) To which part(s) (arm, leg, tail) does the “tail” (the part(s) of the animal at the back end that are moved up and down for swimming) of a whale correspond?

d) To which part(s) (arm, leg, tail) does the “tail” (the part(s) of the animal at the back end that are moved up and down for swimming) of a seal correspond?

4. Skeletal Morphology and Function



A giraffe skeleton is shown at the left. The arrow indicates the “neural spines” which are bony projections sticking up from the thoracic vertebrae. The thoracic vertebrae are the parts of the backbone to which the ribs are attached. Muscles connect the neural spines to the bones of the neck; these muscles are used to hold the animal’s head up and keep the neck from dropping down. The stronger these muscles have to be, the larger they must be and the larger the neural spines have to be. Thus, a giraffe, which must hold up and very long and heavy neck, has very large neural spines.

For each of the following animals:

a) state whether the neural spines are

- **Large** – like the giraffe’s, which are much larger than the corresponding projections on the lumbar vertebra

- **Small –** not much larger than the corresponding projections on the lumbar vertebra

Note that we are interested in the *relative* size of the spines compared to the size of the skeleton of that animal, not their *absolute* size in inches.

b) Provide a plausible explanation for why this is so.

As an example, here is a satisfactory answer for the giraffe skeleton:
*a) The neural spines on the giraffe skeleton are **LARGE**.*
b) This indicates that the muscles attached to the neural spines must be large and therefore strong. This is likely because the giraffe has a long and heavy neck that it must hold up and away from the body.

Answer questions (a) and (b) for the following animals. All of these skeletons can be found in the Hall of Mammals.

- Moose

- Whale

- Human

5. Marine Mammals I: Skeletons and External Anatomy

a) <u>How many major different groups of marine mammals are there?</u> The answer to this lies somewhere between "All marine mammals are so similar that they are really only one big group." and "Each one is so different that there are 20 different groups." How will you resolve this? You look for similarities and differences and decide for yourself if the similarities are enough to put a few organisms into a group or if the differences are compelling enough to split them up.

A full-credit answer to this question consists of three parts:

- The number of groups of marine mammals that you have determined.
- An explanation of why you chose the groups that you chose. We are not interested in the "right" answer here; just a well-reasoned argument based on your observations. What are the key differences between groups? What are the key features that make members of each group similar?
- Which of the marine mammals from the list below belong to each group?

The following marine mammals can be found at the HMNH:

- Amazon Manatee
- Fur Seal
- Harbor Porpoise
- Harbor Seal
- Narwhal
- Right Whale
- River Otter
- Sea Otter
- Sperm Whale

b) <u>Which is the closest living land relative of a seal?</u> Seals evolved from land-dwelling ancestors. Although that ancestor is now extinct, it has modern-day descendants. Based on the evidence you collect, you must decide which order of land mammals this ancestor came from.

A full-credit answer to this question has two parts:

- The order of land mammals that you think is most closely-related to the land ancestor of seals. Choose from the list below.
- An explanation of why you chose that order. Again, we are not interested in the “right” answer; just a well-reasoned argument based on your observations.

These are the major orders of land mammals that can be found in the Hall of Mammals:

- Marsupialia
- Insectivora
- Chiroptera
- Primates
- Rodentia
- Carnivora
- Perissodactyla
- Artiodactyla

In each part, we are not interested in the correct answer; we are interested in the *data* you cite and your *argument* based on that data. The more specific about the data you are and the more clear your argument is, the more credit you will get.

In this part, you will use external and skeletal anatomy to answer these questions. You should look at the whole animals and the skeletons found in the HMNH to collect data to formulate your answer to each question.

6. Invertebrates:

These include all animals without a back bone. They range from sponges to insects, and greatly outnumber the vertebrates in both number of individuals and number of species.

6a. What are at least two major problems that confront an animal without some form of internal skeleton?

Many invertebrates, such as lobsters and insects, have a skeleton, but rather that being inside the body, the skeleton forms a shell on the outside. It is called an exoskeleton and is composed of hard proteins, a cellulose type substance called chitin, and a very thin layer of lipid.

6b. What is one obvious problem that an exoskeleton causes?

6c. List by phylum and scientific or common name three invertebrates that do not have a head. What important features of their mode of life are associated with the absence of a head?

6d. What functions are located in heads?

7. Fish:

After you have examined some of the bony and cartilaginous fish, return to the rather primitive coelacanth (pronounced “seal’-a’-kanth”). This fish is an example of an animal at an extremely important stage in the evolution of vertebrates. It represents the potential for the vertebrates to leave the water and invade the land. If you look carefully at the so-called lobe-fins of the fish, you will notice that they are in approximately the same position as the limbs of any four-footed terrestrial vertebrate. It is thought that fish such as the coelacanth (once thought to be extinct, but recently found to be still living) gave rise to those forms that first moved from the water to the land. The first land vertebrates were still essentially fish, but they had lungs as well as gills and could breathe air rather that having to extract oxygen from the water. They also had fleshy lobe-fins which differed considerably from the fins of the modern fishes that are more familiar to us. These lobe-fins not only had a primitive musculature but the distribution of the bones within the fin is similar to the patterns of bones in the locomotion once they moved to the land.

7a. What are the basic structures and modifications that you observe in modern fish that are adapted to their life in the water?

8. Reptiles:

Look carefully at the examples of reptiles. The development of a scaly skin in these animals prevents their bodies from drying out. They also developed internal fertilization, and eggs with a tough, leathery covering, so that even the eggs no longer need the presence of water. In the history of life, reptiles were the first vertebrates to live entirely on land.

8a. What are some other adaptations that differentiate the reptiles from the amphibians?

For a long time, (about 100 million years), reptiles were the dominant forms of life on the earth, especially during the age of the dinosaurs ("terrible lizards"). The dinosaurs were dominant for many millions of years, but except for some related forms (like turtle, alligator, and the giant Komodo lizard), all died out. The cause of the dinosaurs' extinction is still debated. This museum has the world's oldest egg, from a dinosaur, located in the room with the coelacanth. Its age is estimated at 225 million years.

8b. What reptiles do not have four limbs?

8c. Do all reptiles look alike? Name at least four reptiles that differ from each other and list the characteristics that make them different.

8d. Mentally compare the reptiles you have seen to vertebrates known for high-speed running. Do you think reptiles would be efficient runners? Why or why not?