Field Trip: Harvard Museum of Natural History (HMNH)

Note: There is no pre-lab for this lab.

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 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.

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.

Phylogenetic Data Gathering and Expression

When studying evolution, it is very important to choose the *characters* - the particular features of the organisms under study - very carefully. It is important to start thinking rigorously in this regard and you will notice that it is useful when making arguments based on observations of organisms. You should strive to be very specific about the characters and traits you are comparing and to specify these in a table format.

First, some definitions:

• **Character** - a feature of an organism. For example, "leg form" or "number of eyes".
• **Trait** - a particular form of a character. For example: the character "leg shape" could have the traits "long", "bent", and "none"; these would be used to describe organisms with long legs, bent legs, and no legs. Similarly, the character "number of eyes" could have the traits "two" and "none".

When answering the questions in the lab manual that require this format, you should first examine the organisms in question, then make a list of the characters you will study, and finally compile a table it could be like the one below (a hypothetical table based on comparing some small animals). The table has one row for each organism and one column for each character; the cells in the table contain the traits.

Organism	**Segmented body?**	**Legs**	**Exoskeleton**
Honeybee	Yes	6	Yes
Ant	Yes	6	Yes
Millipede	Yes	250	Yes
Slug	No	0 (1?)	No

When making tables like this you should use at least 4 characters; you can use more if you like. You could then make an argument that there are two groups of organisms based on this data. It could go something like this, "There are two groups of organisms here. One has an exoskeleton, segmented body, and 6 or more legs - the honeybee, ant, and millipede are all part of this group. The other group lacks these features and includes the slug. The reason these are two different groups is that members of the first group share three of the characters listed with each other while the other does not.

Thus, the members of one group are more similar to each other than they are to the slug."

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. You will hand in answers to these questions next week to your TA for a grade.

Assigned Questions:

Important note: these questions are difficult and involve some speculation and interpretation on your part.

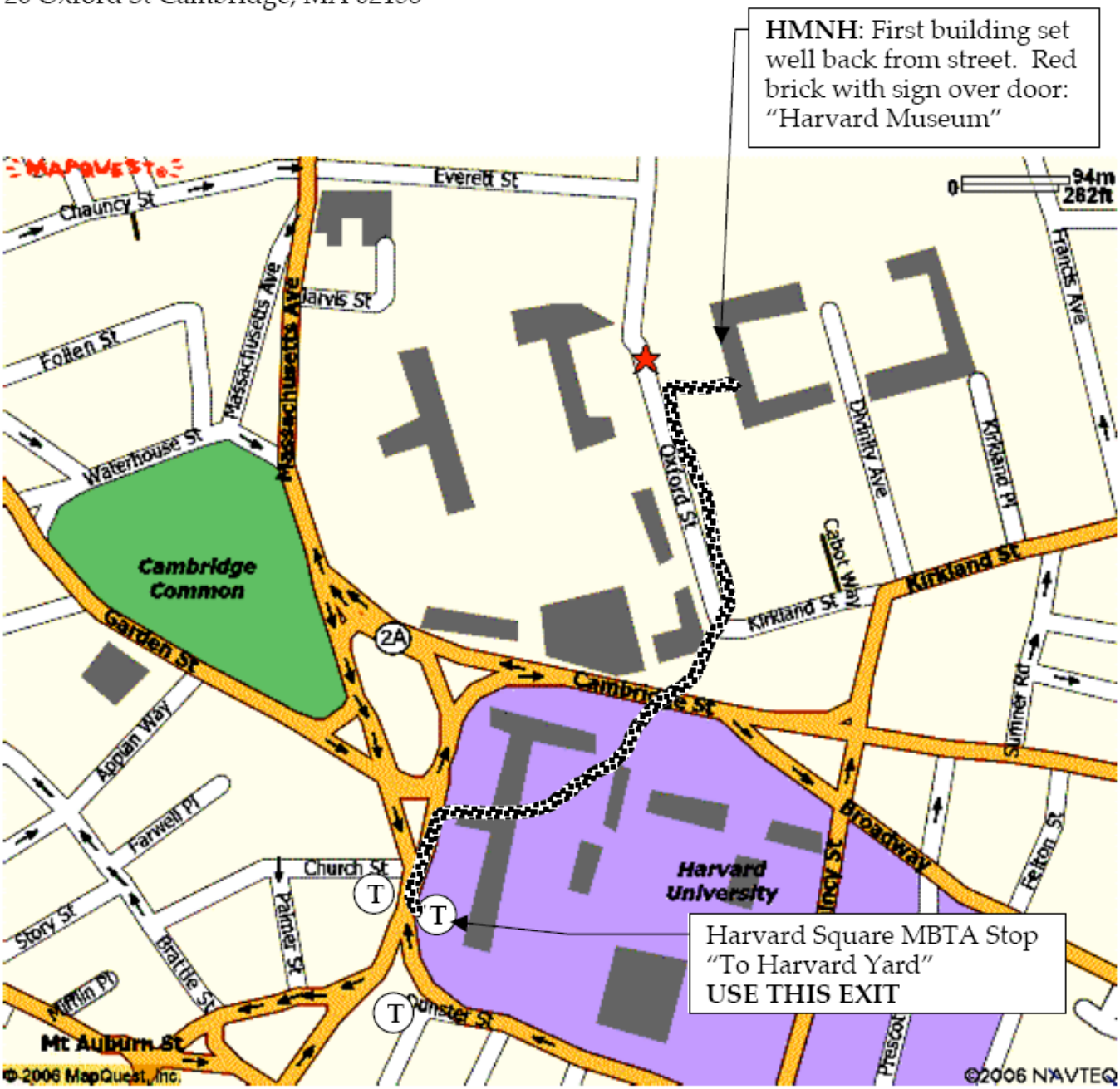
Our purpose is to get you thinking about these issues rather than to emphasize a specific right answer. Your answers should be reasonable and clearly-explained, so you can recall them for in class discussions. Do not plagiarize, your answers must be your own and cite any references used.

Type out your answers and include hand-drawn and labeled drawings. This information will probably help you in lecture as well as in other laboratory exercises.

Answer all the questions in the lab manual they are due at the start of your next lab.

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) Flowers and Pollinators For this question, you should visit the *Glass Flowers* Exhibit gallery. This is the first gallery you come to at the top of the stairs by the Gift Shop. The Glass Flowers are FRAGILE. Please do not lean on or bump the cases.

Flowers are so variable because they have evolved to attract certain pollinators. There are many different types of pollinators: bees, butterflies, moths, ants, beetles, flies, birds, and even mammals. Some pollinators feed on the pollen itself. Many seek another reward — nectar, which the plant makes just for them. As they feed on nectar, these animals are dusted with pollen and inadvertently carry it from flower to flower, thus allowing the plants to mate without having the ability to move. The flowers you will look at could be pollinated by one or more of the following pollinators:

Hummingbird

Wants: Nectar from the base of the flower. Can feed while hovering — doesn't need to land.
Sees: Reds and oranges.
Uses: Its long beak to suck nectar.

Bee

Wants: Pollen and/or nectar. Likes something to land on.
Sees: Some colors — white, yellow, blue. Stripes, dots, or bull's-eye patterns help guide the bee to the center of the flower.
Uses: Pollen sacs on its legs to carry pollen, and its mouth to eat nectar.

Butterfly

Wants: Nectar and a surface to land on for feeding (can't hover while feeding).
Sees: Bright colors, including pink, red, yellow, orange, and purple.
Uses: Its proboscis (long tongue) to sip nectar.

Look at the flowers listed below. Using the descriptions above and your observations of the flower, choose which pollinator(s) you think would pollinate that flower. Explain your reasons why. Pollinators can be used more than once or not at all.

Plant name	Pollinator	Explanation
Blue flag, *Iris versicolor* C21		
Milkweed, *Asclepias syriaca* L63		
Trumpet creeper, *Campsis radicans* M76		
Black-eyed susan, *Rudbeckia speciosa* O90		

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 bird (Northern Harrier) skeleton can be found in case C6 on the balcony in the Hall of Mammals with the hawks.
- 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.

All three wing structures are based on the same tetrapod vertebrate arm and five-fingered hand structure that is shown in *Campbell*, 8th 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."

3. The Functions of Color in Animals

Animals show tremendous diversity of color and pattern in their bodies. Why? View the exhibit "The Language of Color" at the museum and answer the questions below.

a. List 4 different ways that animals use color. State a specific example of each using genus and species names of the animals.

b. From the list of 4 ways animals use color above, state which one you think gives an individual an increased probability of survival. Explain your answer.

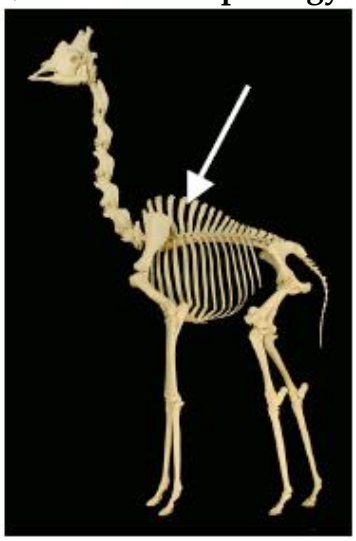
c. From the list of 4 ways animals use color above, state which one you think gives a population an increased probability of survival. Explain your answer.

d. Some animals use "mimicry" as a technique for survival. Give a specific example of an animal that uses this with genus and species names and describe how a species could evolve to "mimic" another species.

e. Describe 2 different ways that animals derive their color.

f. How is a bird's vision different from a human's? What can they see that we can't?

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: (Moose, Whale, Human)
a) State whether the neural spines are **large** defined by being **larger** than the corresponding projections on the lumbar vertebra like the giraffe's, or **small,** not much larger than the corresponding projections on the lumbar vertebra. Note that it is *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*** *in comparison to its size.*
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.**

	a) **Large** neural spines relative to lumbar spines ?	**b)** Plausible explanation for why or why not
Moose		
Whale		
Human		

5. The Arthropod Exhibit

Choose 3 types of arthropods from different classes. Describe the characteristics that show they are all arthropods. Describe the differences between them. In what class does each of your organisms belong? What is the habitat of each organism and what adaptations allow it to survive in that habitat?

Arthropod name			
Class to which it belongs			
Arthropod Traits			
Class Characteristics (differ)			
Habitat			
Survival Adaptations			

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 than 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) Which 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?

9. **Hunting for Headgear exhibit: True Horns, true Antlers and other head structures.**
9a. Define Artiodactyl.

9b. Find an example of an organism with true horns, one with true antlers and one with a structure that looks like a horn but doesn't form in the same way. Is it sexually dimorphic in regards to the headgear? Give the class and phylum. How are these structures useful to these organisms?

	Name of organism, Class and Phylum	Sexually dimorphic headgear ?	Advantage of the structure?
True Horn			
True Antler			
Horn like structure but not a true horn			