Field Trip I: 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

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). 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.

You will need to pick up a ticket to the HMNH in lecture; this will get you free admission (it is normally ~$5 for students). You can go to the HMNH anytime that the museum is open. TAs will be at the HMNH during all of the scheduled lab periods during the week listed on the syllabus. The HMNH is open daily 9:00 AM to 5:00 PM. Admission is free (even without a ticket) Sundays from 9 to 12 and Wednesdays from 3 to 5.

YOU SHOULD BRING YOUR COPIES OF *Campbell* and the *Lab Atlas* FOR REFERNCE.

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** read over **all the questions** and make a plan of how you might go about answering them **before you go to the museum**.

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 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.

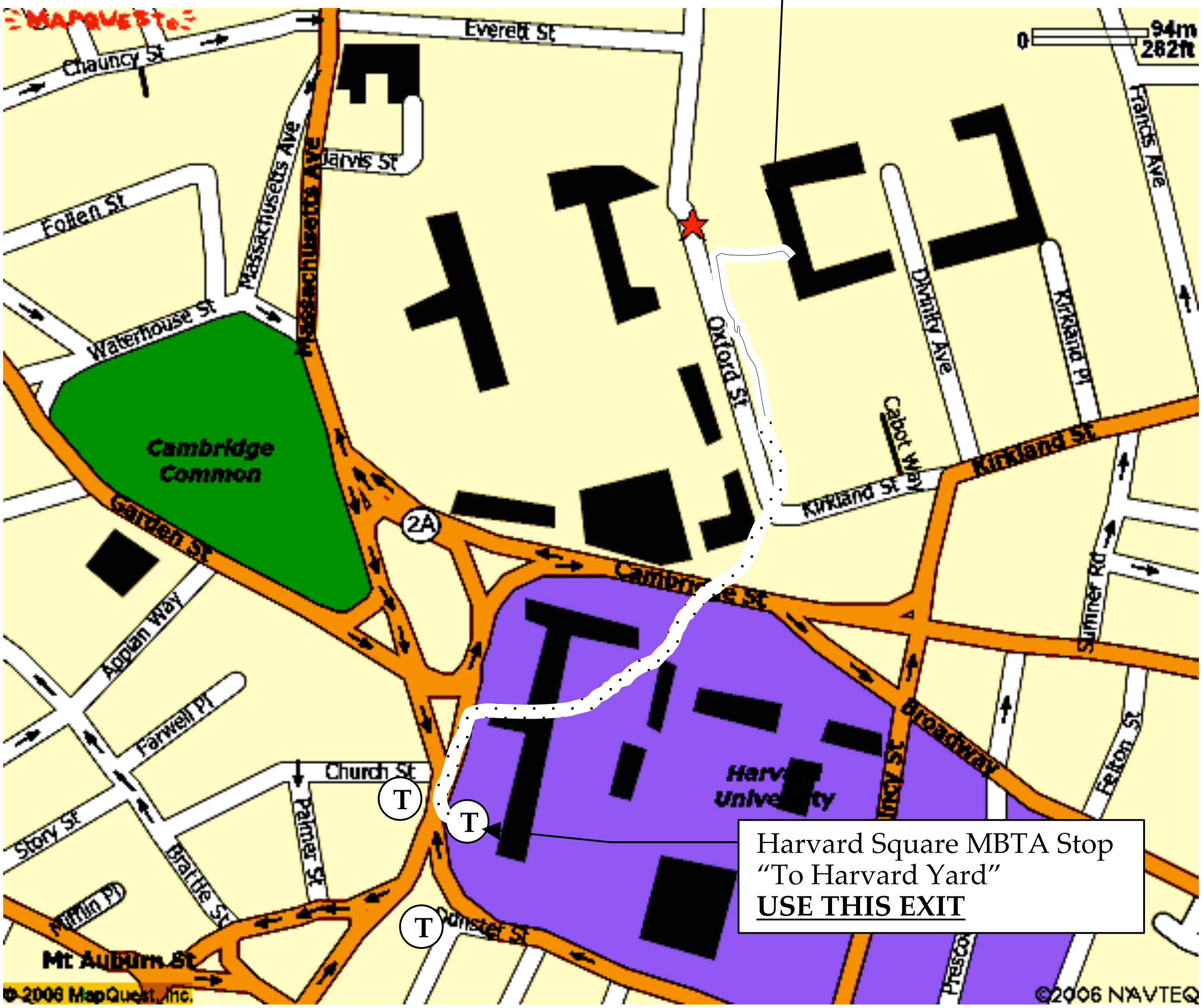
Lab report:

- 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; photographs are not acceptable.
- Due at the start of the lab session you are currently in during the week listed on the syllabus. This is a firm deadline.
- 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 the questions on pages HMNH-4 through HMNH-8.

Getting to the HMNH (not all buildings shown)

26 Oxford St Cambridge, MA 02138

HMNH: First building set well back from street. Red brick with sign over door: "Harvard Museum"



- 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 (8 points)

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 (9 pts)

Consider the wing bones of the following three flying vertebrates:

- Pterandon – a flying reptile from the "dinosaur era". Its skeleton can be found on the wall in the Romer Hall of Vertebrate Paleontology.
- Bird. A bird (probably a peregrine falcon) 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 A6 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* figure 22.15.

Using figure 22.15 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 purply gray in figure 22.15}
- 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 22.15, you would say something like, "The whale's flipper is like a human hand, but with very long fingers."

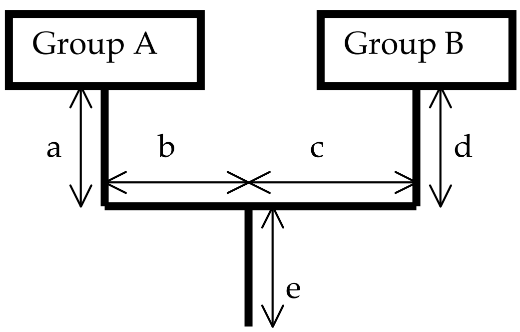
3) Arthropods (8 pts)

The HMNH has a room devoted entirely to diversity in the phylum arthropoda. Arthropods come in a huge variety of shapes and sizes and live in a huge range of habitats.

For this problem, consider the large wall display opposite the windows that shows the many groups of arthropods.

a) Using the "arthropod family tree" – the phylogeny of arthropod groups – determine which of the following organisms is most closely related to the true spiders (aranae): sea spiders, horse shoe crabs, scorpions, or opilones (daddy longlegs). Draw the phylogenetic tree for the organisms listed above using the wall display as a guide and give the name of the group from the list above that is most closely related to the true spiders.

<u>Hint</u>: phylogenetic trees like these indicate the "relatedness" of any two groups of organisms by the *distance* you must travel along the lines connecting the two groups. However, there is one very important note for the kind of tree shown here in the HMNH – *only the vertical distance matters; the horizontal distance is irrelevant.* That is:



Here, the "evolutionary distance" from Group A to Group B is = (a + d). The distances, b, c, and e are irrelevant.

b) Consider the insects at the far right of the "arthropod family tree". Most of the groups can be differentiated by the form and/or number of their wings. For example, *all* members of the odonata have two pairs of identical wings and *none of the other groups have this feature.* For each of the following groups, what feature(s) of the wings of all the members of that group distinguish them from the other groups?

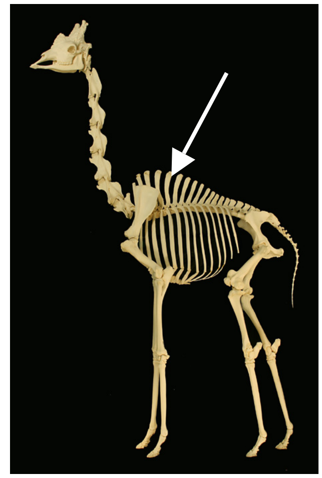
i) Othoptera

ii) Hymenoptera

iii) Lepidoptera

iv) Coleoptera

4) Skeletal Morphology and Function (6 pts)



A giraffe skeleton is shown at the right. 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; they are indicated by number 16 in figure 8.88 of the *Lab Atlas*.

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 a very long and heavy neck, has very large neural spines. Note that a long neck may not be the only reason for large neural spines - other factors are sometimes involved. Note also that, in each case, "large" means "large compared to the overall size of the organism".

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 (see #17 in figure 8.88 of the *Lab Atlas*).
- **Small** - not much larger than the corresponding projections on the lumbar vertebra (see #17 in figure 8.88 of the *Lab Atlas*).

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 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.

- Moose

- Whale

- Human

5) Marine Mammals I: Skeletons and External Anatomy (29 pts)

This is the first part of a three-part exploration of marine mammal anatomy, diversity, and phylogeny. In each of the three parts, you will address the following two questions using evidence collected during the lab:

a) How many major different phylogenetic groups of marine mammals are there? 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 phylogenetic 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? This part must include a *data table* of the format described on the next page and an explanation of how you used the data in the table to draw the conclusions you drew.
   - 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
   - Harp Seal
   - Harbor Porpoise
   - Steller's Sea Cow
   - Narwhal
   - Right Whale
   - River Otter
   - Sea Otter
   - Sperm Whale

b) Which is the closest living land relative of a seal? Seals evolved from land-dwelling ancestors. Although that ancestor is now extinct, it has modern-day descendants. The scientifically-accepted group to which seals belong is *carnivora*. Your task is to collect evidence to support this assertion.
A full-credit answer to this question is an explanation of why seals belong in the order carnivora and not in the other orders. As above, you must provide a *data table* in the format specified on the next page and an explanation of how you used the data in the table to support that conclusion. Note that this must be a *separate data table* from the one you used in part (a). Again, we are not interested in the "right" answer; just a well-reasoned argument based on your observations.

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.

Your answer here must contain *two data tables*; one for part (a) and one for part (b), along with other written parts as described above.

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.

Phylogenetic Data Tables in Bio 112

When studying evolution, it is very important to choose the *characters* - the particular features of the organisms under study - very carefully. Even though we will not be concerned here with the 'correct' characters, it is important to start thinking rigorously. For that reason, when making arguments based on observations of organisms, we will require you 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 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 for your lab reports, 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."