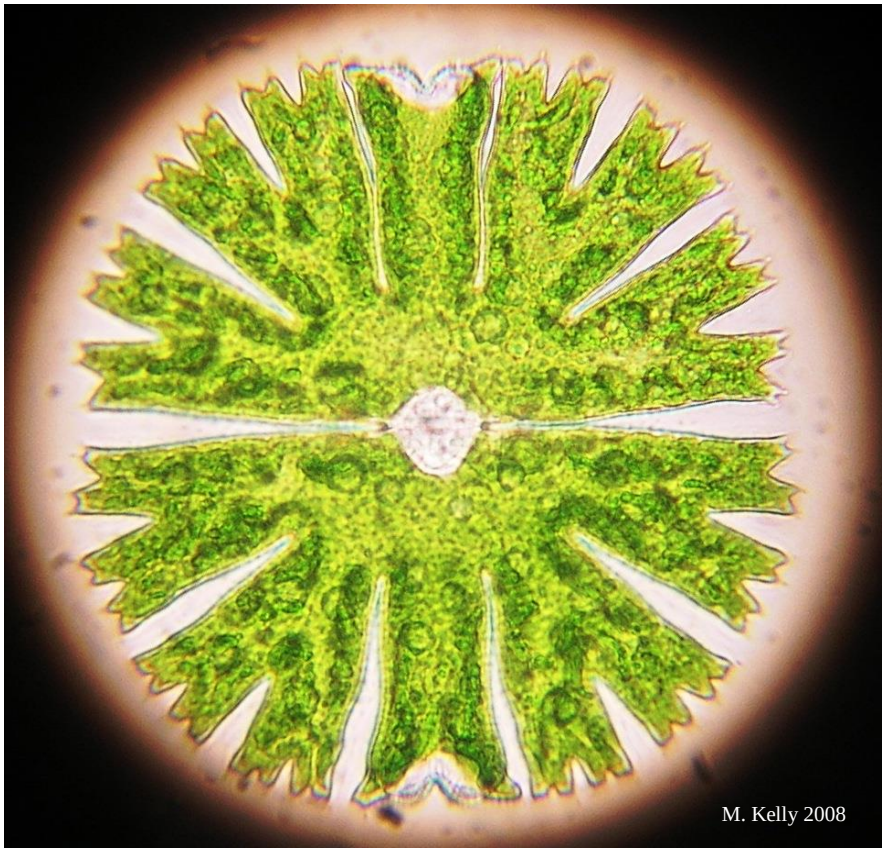
LABORATORY MANUAL

BIOLOGY 112

SPRING 2014



Micrasterias sp. a unicellular green alga

UNIVERSITY OF MASSACHUSETTS, BOSTON
College of Advancing and Professional Studies
At Braintree High School

Biology 112 Lab Syllabus
Spring 2014
At Braintree High School

Many of the labs in this manual were originally developed by Brian T. White (brian.white@umb.edu). Other labs and revisions by T. Spoon, W. Hagar, Y. Vaillancourt, R. Ciccariello and M. Kelly.

Lab 1: Pre-Lab Name_____
Skulls & Evolution

1) Figure 34.46 in Campbell, 9th ed., page 729 shows several hominid skulls. Rank the following skulls from figure 34.46 (*Australopithecus afarensis, A. africanus, Homo habilus, H. erectus, H. sapiens*) in order from the one with the longest snout to the shortest snout, relative to the size of the skull. Where does the skull on page 15/16 of the lab manual fit in to this series? Note that some skulls are very similar; we will grade your answers generously.

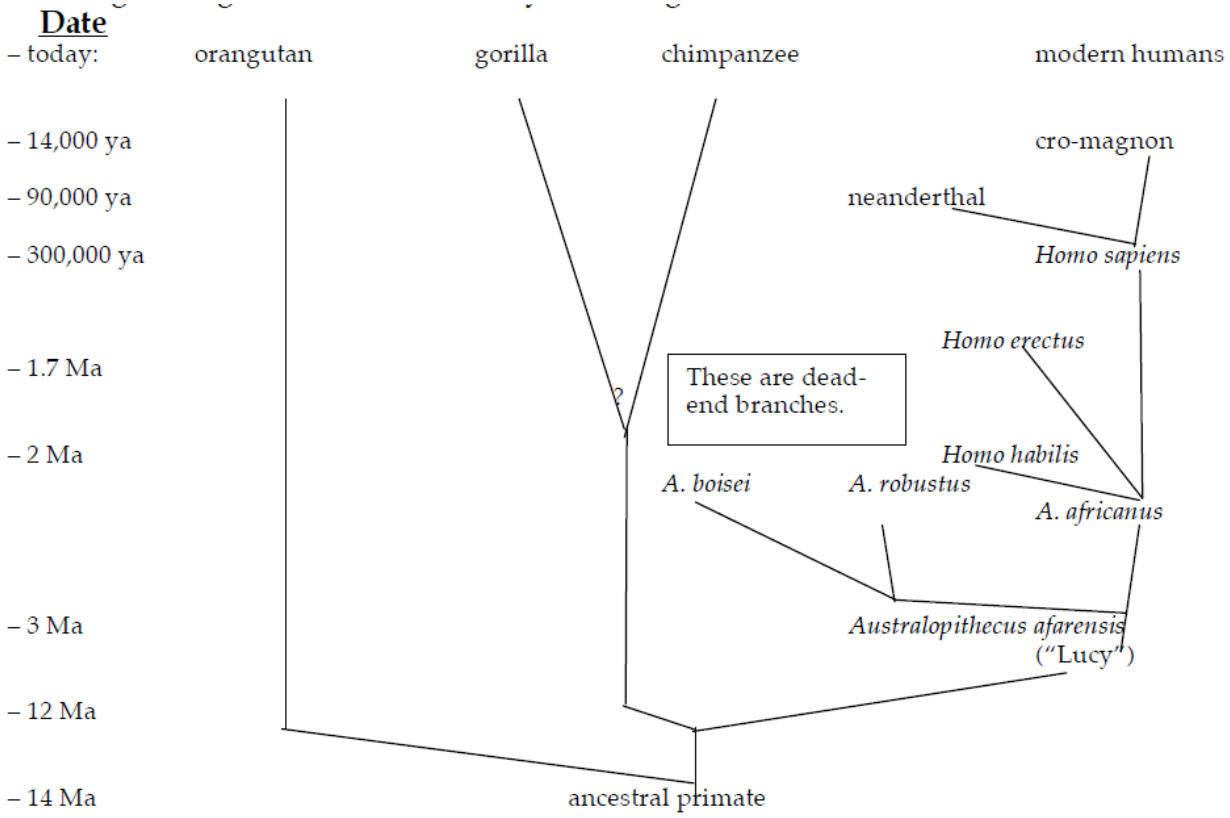
2) Figure 34.46 in Campbell, 9th ed., page 729 shows several hominid skulls. Rank the following skulls from figure 34.46 (*Australopithecus afarensis, A. africanus, Homo habilus, H. erectus, H. sapiens*) in order from the one with the most pronounced brow ridge to the least pronounced brow ridge, relative to the size of the skull. Where does the skull on page 25/26 of the lab manual fit in to this series? Note that some skulls are very similar; we will grade your answers generously.

Lab 1: Skulls & Evolution

Purpose
- To illustrate trends in the evolution of humans.
- To demonstrate what you can learn from bones & fossils.
- To show the adaptations of various mammals to different habitats and food sources.

Introduction
Much of what we know about evolution comes from the study of comparative anatomy. In many cases, bones (either as fossils or skeletons) have been useful in these studies. Bone and skeletal structures can reveal how an animal moves, eats, reproduces, etc.
In this lab, we will look at the skulls of various mammals.

Procedure
Part I: Human Evolution
Shown below is a *very rough* outline of human evolution. While the general form is agreed on by most scientists, many of the details (exact dates & branching patterns) are still subjects of debate. Although gorilla, chimp, and orangutan are modern primates (and therefore have been evolving as long as humans have) they are thought to resemble ancestral forms.

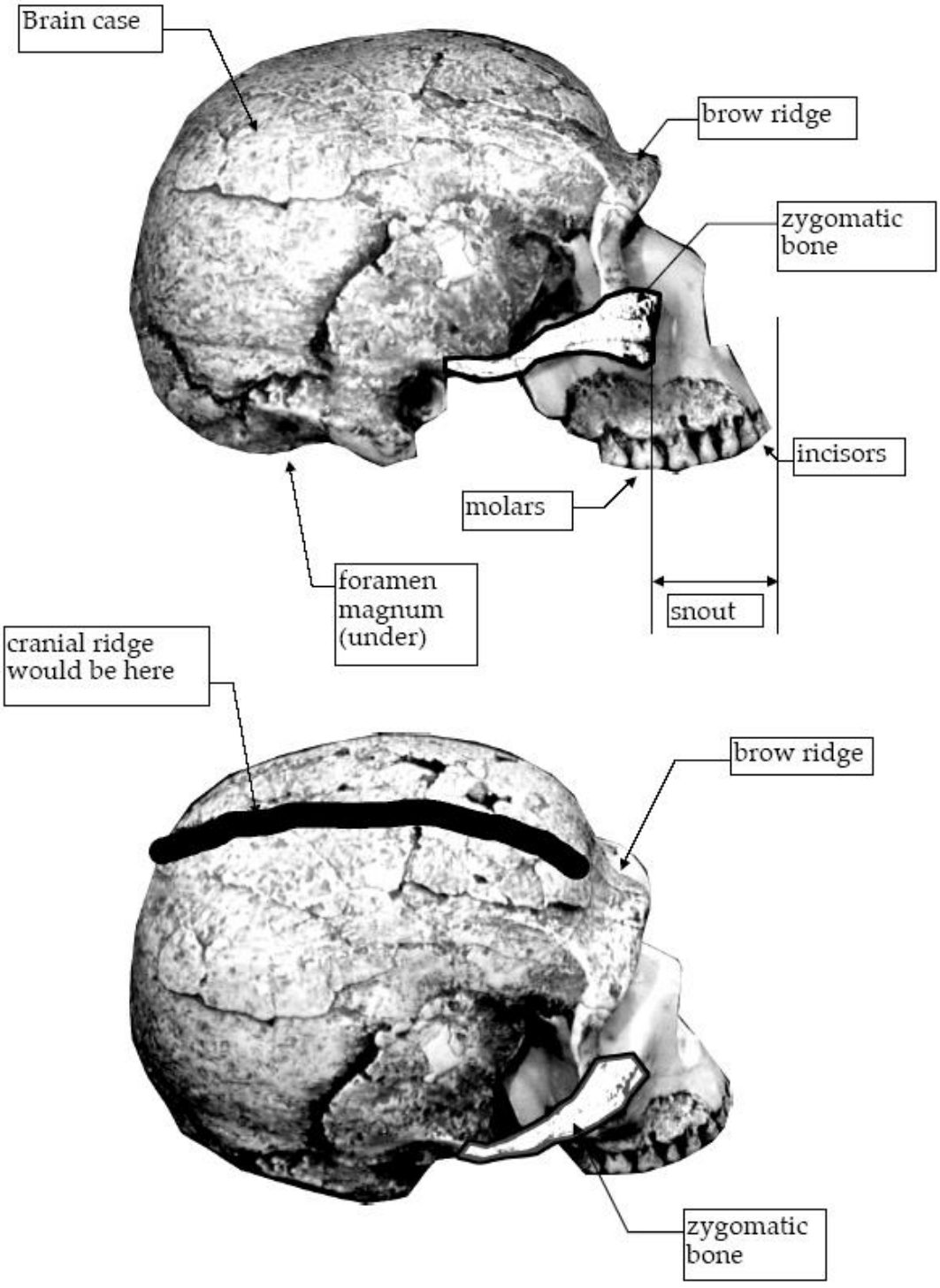


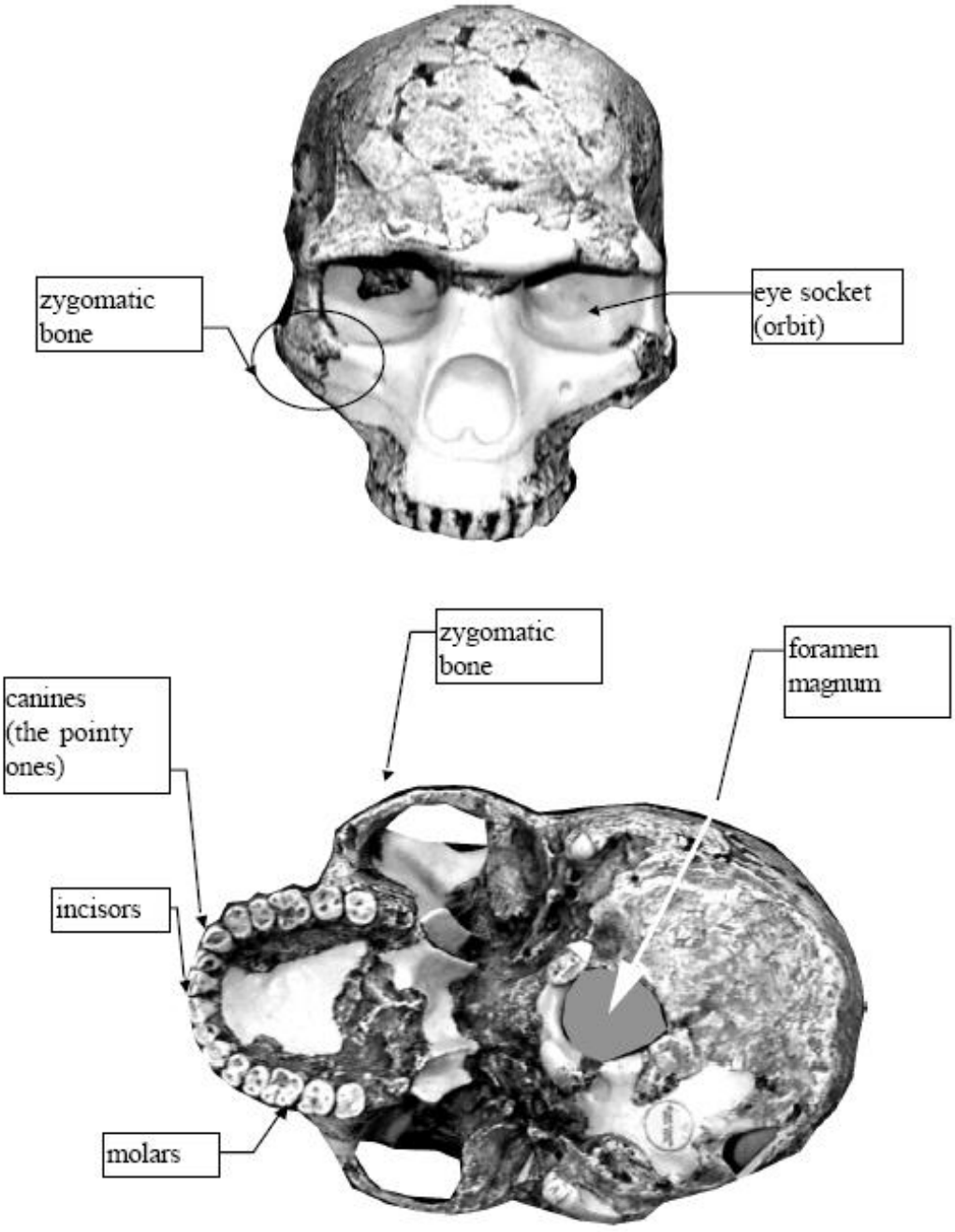
From the comparison of skulls from different primates, seven (somewhat overlapping) trends in the evolution of humans have been found. Note that not all the traits in a given skull will be equally "human" – that is, you will likely find skulls where one feature is ancestral and others are modern.
This chart describes these seven trends. The following pages illustrate the skull features described in the table.

	Feature	**Details**	**Explanation**
1	Brain case	– size? – cranial ridge? – brow ridge?	The bigger brain case allows a bigger brain which, in general, allows greater intelligence.
2	Teeth	– size? – canines – large and sharp or more like incisors?	See under "Snout"
3	Palate	– sides more parallel "U" or splayed out "V"	See under "Snout"
4	Forehead (compared to face)	– size? – height?	Related to size of brain case.
5	Location of eye sockets (orbits)	– sides/ front of skull	Eyes in front allows binocular vision (seeing most objects with both eyes at once) which allows depth perception and 3-d vision.
6	Snout	– present? – length?	A reduced snout moves the molars under the rest of the skull which allows more flexibility in chewing and grinding food. This allows a more varied diet. The snout also blocks vision below the face.
7	Foramen magnum (where the backbone attaches)	– location – rear or bottom of skull?	Foramen magnum at bottom of skull allows walking erect, as opposed to walking on 4 legs.

You can also determine if an animal is carnivorous, herbivorous, or omnivorous (eats both meat and plants) by looking at its molars. In general (there are, of course, exceptions), blade-like molars are characteristic of carnivores and are used to shear the meat into small pieces for digestion. Flat molars are characteristic of herbivores and are used to grind the plant material for digestion. The molars of omnivores (like humans) are intermediate.

Here are the parts of the skull that are important for this lab.





The palate is the lower jaw, which is not present in this skull. However, you can infer the shape of the palate by looking at the shape of the upper jaw. In this case, it is rather splayed out (V-shaped).

1) Each group will be given several skulls of primates. Using the chart on the first page of this lab section, put your skulls in order from ancestral primate to modern human. Note that the orangutan, chimp, and

gorilla are considered to be more ancestral than any of the other samples; the orangutan is the most ancestral, followed by the gorilla, then the chimp.

2) For each property listed in the table, determine how that property changes as you go from ancestral primates to modern humans. You should discuss this as a class.

3) To the best of your ability, try to determine when, on the chart on the first page of this lab section, humans first walked upright.

Part II: Comparing skulls of other mammals

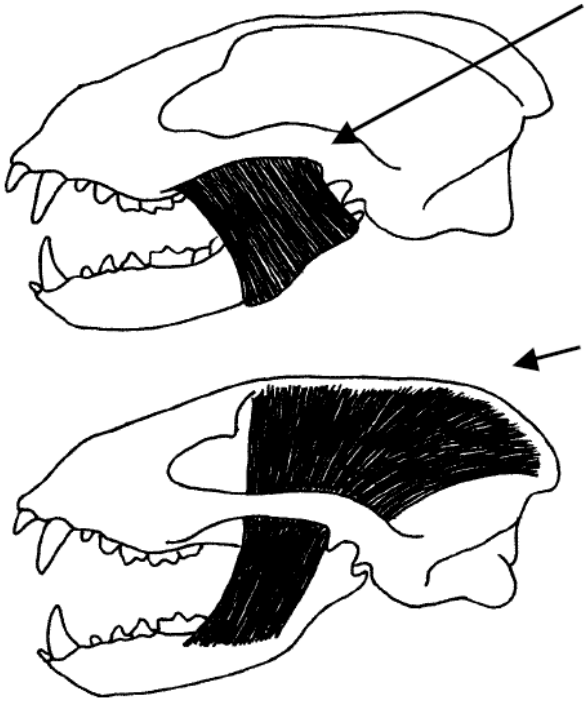
4) Each group will be given three skulls, one from a carnivore (exclusively meat-eating: leopard, or cougar), one from an omnivore (eats both meat and plants: wolf or Great Dane), and one from an herbivore (exclusively plant-eating: deer or sheep). The skulls will be marked with the animal they came from.

5) Consider the following features and determine the trends in these features as you go from carnivore to omnivore to herbivore.

	Feature	**Details**	**Explanation**
1	Canine teeth	• present? • large or small	Used for cutting and tearing of food.
2	Molars	• flat • pointed	Used for grinding food.
3	Eye Sockets (orbits)	• allow for overlapping fields of vision? • allow for greater visual field coverage	Overlapping fields of vision allow for better depth perception; more visual field allows better observation.
4	Masseter muscle attachment points (see next page for description)	• large • small	Used for moving jaws when grinding food.
5	Temporalis muscle attachment points (see next page for description)	• large • small	Used for moving jaws when biting and tearing food.

Masseter & Temporalis Muscles

These muscles are found in all mammals. They are different sizes and have slightly different attachment points depending on the animal's diet, etc. The figure below shows the difference between the two muscles on the skull of a badger (carnivore). The figure was taken from *Skulls and Bones* by Glenn Searfoss, an excellent and very readable book on this subject.



Masseter muscle. One end of this muscle attaches at the rear of the lower jaw (mandible) and the other attaches to the zygomatic bone. This muscle is used to bring the molars together in grinding motions. The attachment points are not always as obvious for the masseter as they are for the temporalis.

Temporalis muscle. One end of this muscle attaches at the rear of the lower jaw (mandible), the muscle passes between the zygomatic bone and the rest of the skull, and the other end attaches to the temples, the top of the skull, or the cranial ridge (if present). In some cases, there is a 'tab' of bone on the mandible that fits between the zygomatic bone and the rest of the skull; the temporalis muscle attaches here. You can feel your temporalis muscle working if you put your finger on your temple as you chew something,

6) Each lab room will have at least one bottle-nosed dolphin skull. The dolphin is a marine mammal – that is, it lives in the ocean but has evolved from a land-dwelling mammalian ancestor. Compare the skull of the dolphin with that of the carnivore.

Lab report:

- Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. Include a title page with the name and date of the lab and your name.
- 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 following questions.

Part I: Human Evolution

1) Describe how each of the seven properties changes as you go from ancestral primates to modern humans using specific details listed in Table 1. Describe the *trend* not just the individual observations. Format your answer as a table.

2) At which stage in human evolution did hominids first walk upright; explain your reasoning.

Part II: Comparisons of other mammals

3) Describe how each of the five properties changes as you go from carnivore to omnivore to herbivore. For each property, briefly explain how this change fits in with the animals' changed diet. Describe the *trend* not just the individual observations. Format your answer as a table.

4) On the pictures of the dolphin skulls on the next pages, label the following parts:

    - Blowhole
    - Eye sockets (or where the eyes would be)
    - Zygomatic bone
    - Foramen magnum

    If a part appears in more than one picture, you need only label the one where it is shown most clearly.
    Attach the labeled pages to your lab report.

5) To which part of a terrestrial mammal skull does the blowhole of a dolphin correspond?

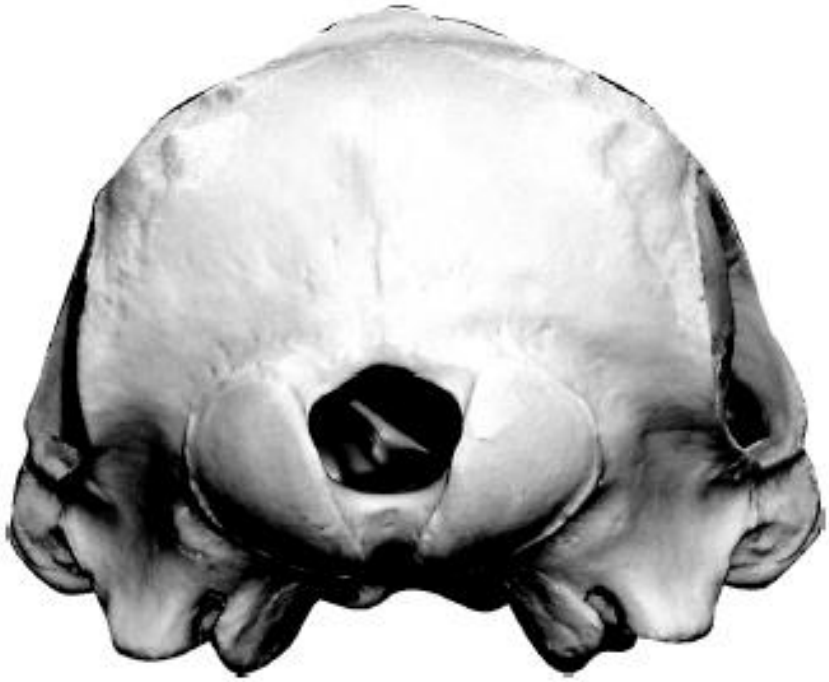
6) Looking at the teeth of the dolphin, which is more likely: (explain your reasoning)
    - Dolphins grind up their food like a herbivore
    - Dolphins bite off pieces of food and chew them up like humans
    - Dolphins grab and kill their prey with their teeth and swallow them whole or in large pieces.

Dolphin worksheet (attach to your lab report)

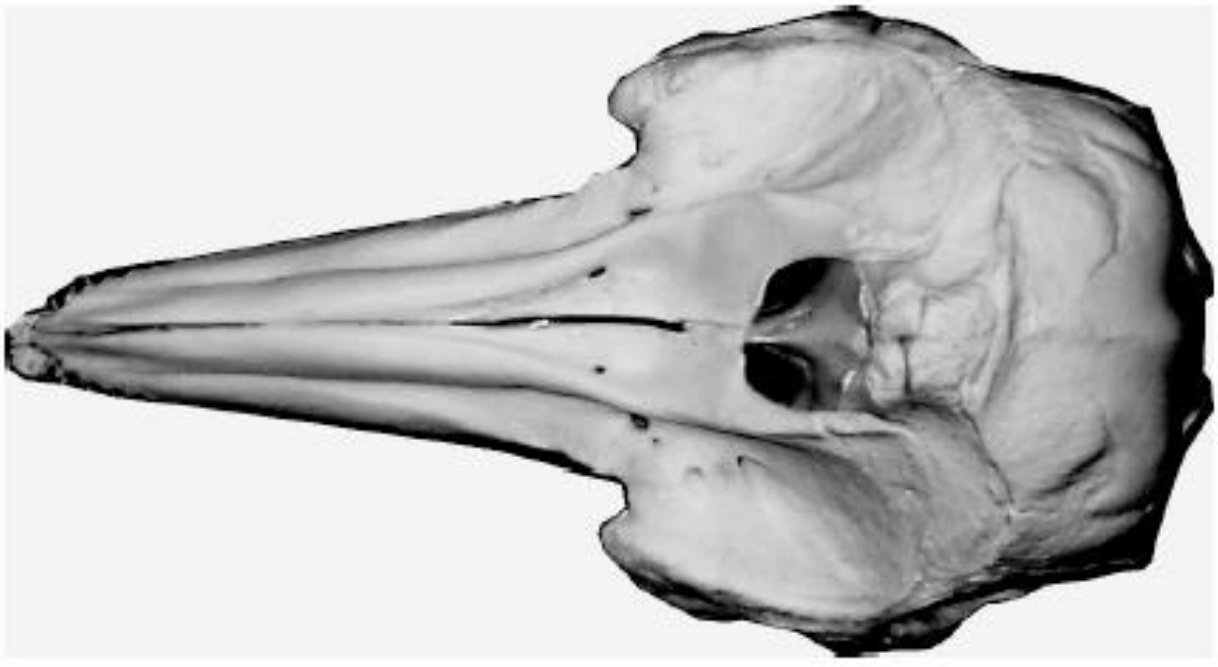
An intact dolphin, left side view

• Dolphin skull; left side view:

Rear view:



Top (dorsal) view:



Lab 2: Field Trip I
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. The website for the museum is http://www.hmnh.harvard.edu.

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.

Tickets to the HMNH will be given out in lab; this will get you free admission. You can go to the HMNH anytime that the museum is open. Your lab instructor will be there on _____. 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 A COPY OF *Campbell* 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 in Campbell and familiarize yourself with terms like kingdom, phylum, etc.
- Read over **all the questions** and make a plan of how you might go about answering them.

At the HMNH

Be sure to look at the Galleries Map in this lab manual and pick one up in the museum - 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.

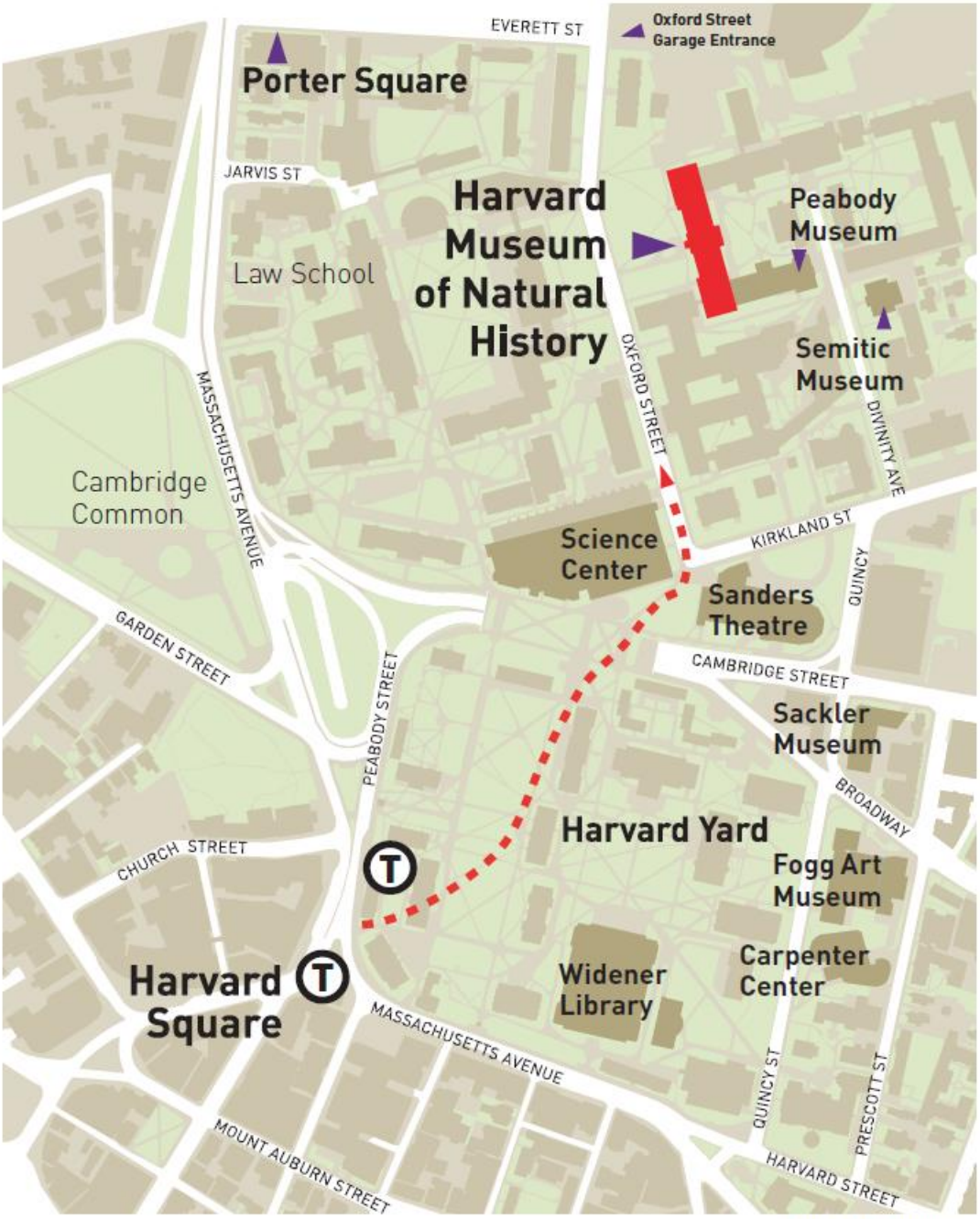
Lab report:

• 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. Include a title page with the name and date of the lab and your name.

• 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 of the questions. Questions should be retyped with the answers and number the questions.



Harvard Museum of Natural History

26 Oxford Street | Cambridge, MA | 02138
617.495.3045

Open daily from 9 am to 5 pm, 361 days a year.
The museum is closed on New Year's Day, Thanksgiving Day, Christmas Eve, and Christmas Day.

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.
  - o **Sees**: Reds and oranges.
  - o **Uses**: Its long beak to suck nectar.
- **Bee**
  - o **Wants**: Pollen and/or nectar. Likes something to land on.
  - o **Sees**: Some colors — white, yellow, blue. Stripes, dots, or bull's-eye patterns help guide the bee to the center of the flower.
  - o **Uses**: Pollen sacs on its legs to carry pollen, and its mouth to eat nectar.
- **Butterfly**
  - o **Wants**: Nectar and a surface to land on for feeding (can't hover while feeding).
  - o **Sees**: Bright colors, including pink, red, yellow, orange, and purple.
  - o **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:

1. • 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 (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 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*, 9th ed. Fig. 22.15, p. 463 (*Campbell*, 8th ed. figure 22.17). 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}

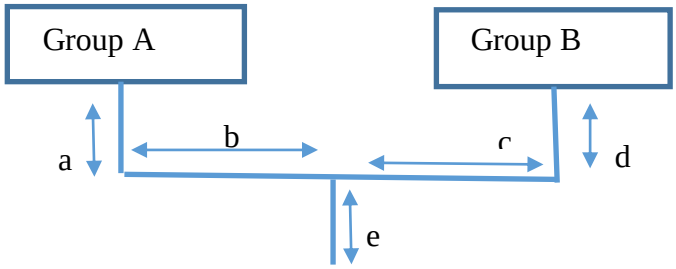
   For each wing, give a one-sentence description of its structure. For example, if we had asked about figure 22.15, you would say something like, "The whale's flipper is like a human hand, but with very long fingers."

3. Arthropods

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.

Hint: 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?

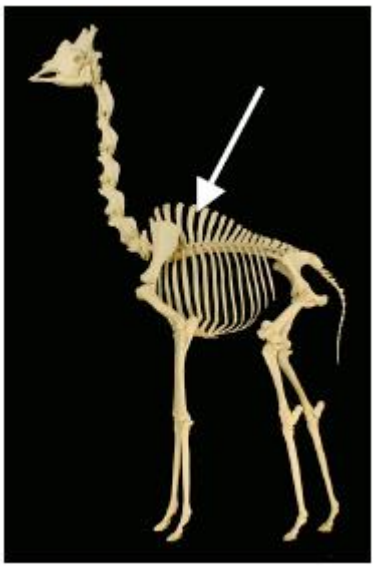
i) Othoptera

ii) Hymenoptera

iii) Lepidoptera

iv) Coleoptera

4. Skeletal Morphology and Function



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. The Mollusk Exhibit:

Choose 3 species of mollusks from different classes. Describe the characteristics that show they are all mollusks. 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? Many of the specimens are just shells use the diagrams to explore the differences in the internal anatomy of each class.

Mollusk Name			
Group to which it belongs			
Mollusk Traits			
Group Characteristics (differ)			
Habitat			
Survival adaptations			

Pre-Lab 3: Name_____
Microbial Diversity & Microscopy I

1. You see a cell in your microscope and you can identify that it has a cell wall, a cell (or plasma) membrane, a nucleus and chloroplasts.
   a. Could it be a bacterial cell? Why or why not?

   b. Could it be a plant cell? Why or why not?

   c. Could it be an animal cell? Why or why not?

   d. Could it be a fungal cell? Why or why not?

2. Define these terms as they apply to the microscope:
   a. resolution (or resolving power)

   b. contrast

3a. If your microscope has a 10X objective lens and a 40X objective lens which lens would you first use to view organisms in a drop of pond water on a slide? Why?

b. After focusing on an organism in your pond water, would you change your objective lens? Why?

4. If the field of view is 0.45 mm in diameter, and a cell occupies about a tenth of the field, what is the cell diameter,

   a. in mm?

   b. in μm?

   c. If the nucleus is about a tenth as big as the cell, what is the nuclear diameter, in μm?

Lab 3: Microbial Diversity & Microscopy I

Objectives:
To become familiar with the proper use of a compound microscope in order to study bacteria and protist organisms. To learn how to make a wet mount of a living culture and to measure the general size of objects in the microscope.

Introduction:
All living things are made up of cells. Prokaryotes (Archaea and Bacteria) lack true nuclei and many organelles; Eukaryotes (Fungi, Plants and Animals) have true nuclei and a variety of other organelles. Anything needing magnification to be seen is a microbe, and many (but not all) of these are single-celled rather than multicellular. In this lab, look at and learn to recognize some representatives of the major microbial groups. These include bacteria, some fungi, and within the protists, protozoa and some algae. To do this you will need to learn to use a microscope in order to distinguish the basic cellular structures: cell wall, nucleus, vacuole, flagellum and chloroplast. As you examine each species, try to determine its method of movement and nutrition, and check out its phylogenetic classification.

		Cells			
Cell Parts and		**Prokaryote**	**Eukaryotes**		
Organelles	**Function**	**Bacteria**	**Fungi**	**Plant**	**Animal**
true nucleus	houses chromosomes	no	yes	yes	yes
cell wall	structural support	yes	yes	yes	no
cell membrane	cell barrier	yes	yes	yes	yes
chloroplasts	produce food	some	no	yes	no
vacuole	excretion/digestion/ regulation	no	yes	yes, large	yes, small
flagella	locomotion	some	no	no	some

Table showing which cell parts and organelles can be found in the major types of prokaryotic and eukaryotic cells. There are some exceptions to this table.

Materials and Methods

1. To see small things like cells one must learn to use a microscope. Always treat the microscope with great care. Make certain that you do not touch any part of the lens system with anything abrasive (such as a slide or dirty water) or greasy (such as even the cleanest fingers). Never clean a lens with anything except clean lens paper! If the view gets foggy (as it probably will sometime during the semester), and lens paper will not clean it, call your laboratory instructor.

   A. First, familiarize yourself with the parts of the microscope and their function. Locate the main parts named in the diagram. These include the stand (arm and base), the light, the condenser lens with its diaphragm, the movable stage or the non-movable stage with slide clips, the objective lenses, the nosepiece, the body tube, and the ocular lens.

B. Plug in the light cord, turn on the light, and then move the diaphragm lever as far to the left (closed) as possible. Place a clean slide on the stage over the condenser and put a piece of white paper about 25 mm square on top of the slide. Now move the condenser up and down while observing the light on the piece of paper (do not look through the microscope yet, just continue to look at the paper with your naked eye). Note that you see a fairly intense small circle of light when the condenser is at its uppermost position and that this circle gets larger and more diffuse as one lowers the condenser. For most work with the l0X and 40X objectives it is best to have the condenser near the top of its travel.

C. Put your eye at table level and look up at the bottom of the condenser. Now move the diaphragm lever and observe what happens. This is an iris diaphragm. Why do you suppose it is called this? Look at the piece of paper again while opening and closing the diaphragm. The diaphragm serves to regulate the amount of light passing through the condenser. It also serves to cut down stray light. Later when you look through the microscope you will see that the diaphragm can be kept partly closed without cutting down on the light passing through the lens (i.e., only light beyond the field of the lens is being blocked). Further closing of the diaphragm will cause less light to enter the lens and decrease the resolving power of the lens while increasing contrast in the viewed object. (Resolving power is how close two points can be and still be distinct. Contrast is the distinction of a particular detail against its background.)

D. Light passes through the condenser, through the object which is placed on the slide, and into the lens system. The lens system consists of: (l) an objective lens - the revolving nosepiece of your microscope has at least two of these, (2) a body tube - in your microscope the body tube has prisms in it to allow the tube to be inclined and (3) the eyepiece (ocular) lens. Basically, the objective lens magnifies the object and forms an image in the tube which is further magnified by the eyepiece lens. The objective lens is the most important (and most expensive) part of the microscope and the quality of a microscope is largely a question of the quality of its objective lens. The ones in your microscope are very good indeed and deserve care. The l0X objective (low power) has a working distance (the distance from lens to object when the object is in focus) of about 4 mm. The 40X objective (high power) has a working distance of about l mm.

E. Move the stage down well clear of the objective lenses by turning the coarse adjustment knob. Now rotate the nosepiece and notice that each lens clicks into the proper position. Move the l0X objective into position. Next move the stage up until the objective lens is about 4 mm from the slide. Notice while doing so that the knob you are turning is both a coarse and fine adjustment and that extreme movement of the knob moves the stage rapidly, but immediately after you reverse the direction of movement, the stage moves almost imperceptibly for a short distance. This fine adjustment allows precise focusing. The compound microscope has a very limited depth of field. It is necessary to continually focus up and down to get an impression of depth.

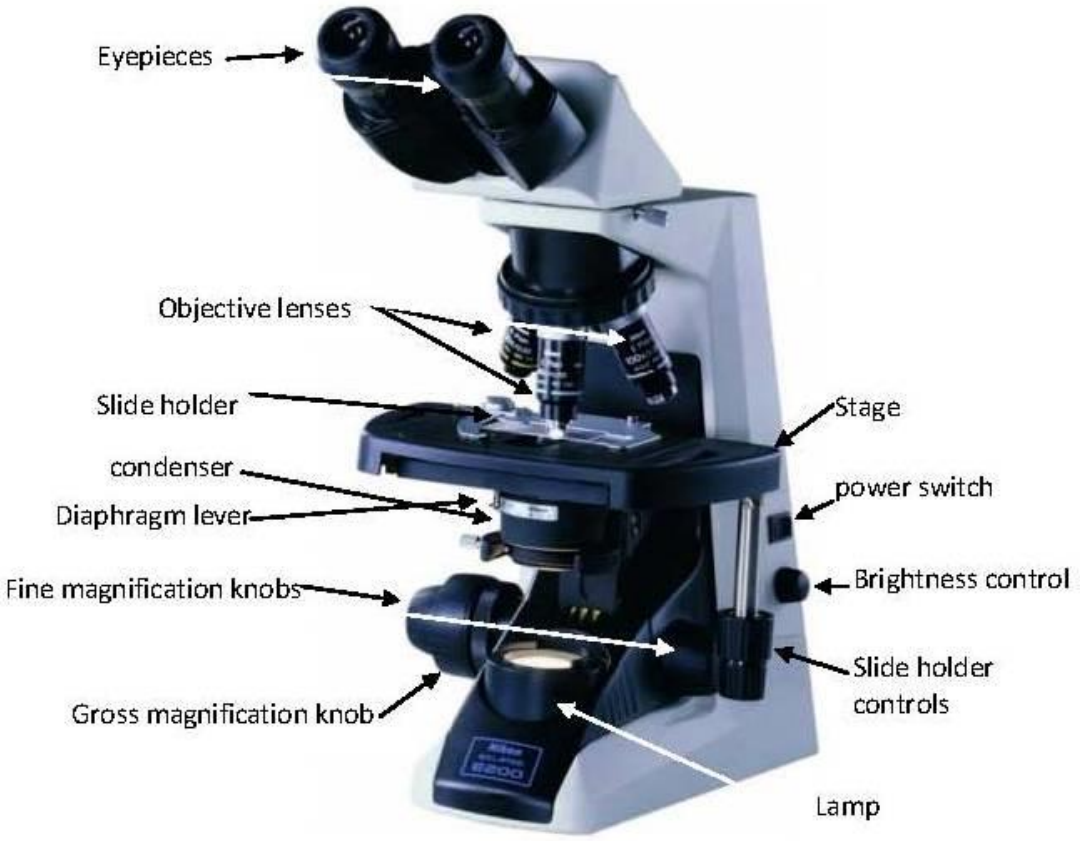


Diagram of a typical bright-field compound microscope. Though various styles exist, all compound microscope have the same basic components and they are labeled in the picture above.

F. Only when the object is in focus under low power should you go up to higher power. Move the object to the center of the field of view, and then rotate the 40X objective into place. You may need to adjust the light strength, condenser height and the diaphragm opening. When you adjust the focus, use only small fine movements, or you run the risk of hitting the coverslip with the lens and damaging both.

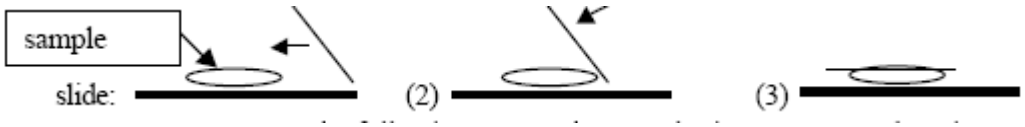
Procedure:

1. During this lab, inoculate a bacterial growth plate with a sample from some common environment. You may expose the plate to room air, or dust, or a drop of water from the fish tank. (Do not use human samples because we are not equipped to diagnose possible pathogens). Seal the plate with parafilm, turn it upside down, and label it with your name and the date, and what sample was taken. Give it to your instructor to leave on a shelf in the lab room. In lab 4, you can look at it and describe the different kinds of colonies present, and their relative numbers. You can view the cells under the microscope to see their structure.

2. Work in groups of 3, and take turns looking at a variety of prepared slides of bacteria, protists and colonial organisms. When one person has arranged a demonstration, take turns observing and sketching it. Look for distinguishing features between the various types of organisms' cells. Become familiar with the shapes and sizes of the different protists so that in lab #4 as they move about you will be able to identify them more easily.

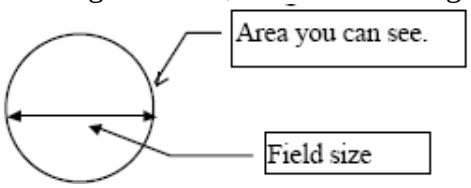
3. Observe the chlorella or other live culture available: sketch and label: cell shape and approximate size (see below), colors, nucleus, and if present vacuoles, cell walls, chloroplasts, or other features.

4. Preparing a Wet Mount Slide and Making Observations: Your lab instructor will show you how to make a slide. The great art here is to avoid air bubbles when you lower the coverslip! A useful trick for this is to:
(1) put a drop of sample on the slide
(2) while holding the coverslip at an angle, slide the edge of the coverslip to the edge of the drop
(3) slowly let the coverslip fall flat:



- Place the wet mount on the microscope stage, and use the slide clamp to hold it. Move the slide holder until an edge of the coverslip is right over the center of the condenser.
- Start with the low power (4X) objective, and focus up and down until you see the edge of the coverslip. This puts you in the right focal plane. Adjust the light strength, the condenser height, and the condenser diaphragm for good contrast.
- Move the slide so the drop is under the objective and look for cells. When you find one, put its image in the center of the field of view, and only then rotate the high power (10X, then 40X) objective into place. Do not use the 100X lens for most purposes because it requires special immersion oil between the lens and the object.

How big is it? You can use the microscope to measure the approximate size of the objects you are looking at. For each magnification, the table below gives the diameter of the field of view (field size).



Once you know that, you can estimate the size of what you're seeing. If the field size is 450μm and the thing you're looking at it half as wide as the field, then it's about 220μm wide. For the microscopes we use:

Magnification shown on objective lens	Actual magnification		Field size (millimeters, mm)	Field size (microns, µm)
4X	40X	→	4.9	4900
10X	100X	→	1.8	1800
40X	400X	→	0.44	440

Lab Report

• The report must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. Include a title page with the name and date of the lab and your name.
• Due next week at the start of the lab session you are currently in. 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:

Part I: The Microscope

- A drawing of a typical microscope with the parts labeled and a brief description of each.
- A description of how to focus a slide under the microscope.

Part II: Observations

- Description of how to prepare a wet mount, or slide of a living culture.
- Drawings of prepared slides of spirogyra and paramecium; drawings of live cells or organisms you looked at with nucleus, chloroplasts, cell wall, cell membrane labeled and size clearly marked.

Part III. Discussion.

1. What happens to the relative surface area (surface area to volume) as cells get larger, and how might this limit cell size? (Just think about this, rather than trying to look it up)
2. Similarly, What happens to the relative amount of cytoplasm (nuclear to cytoplasmic volume) as cells (with a fixed amount of DNA) get larger? How might this limit cell size?
3. Describe two mechanisms that prevent microbial cells from swelling osmotically and bursting.

References:

Campbell et al., 1999. pp 502-517,520-543, 583.

Van De Graaff, K. M., and J. L. Crawley, 1996. A Photographic Atlas for the Biology Laboratory. Morton, Englewood CO. pp 24-44.

Brocks JJ, Logan GA, Buick R, Summons RE, 1999. Science 285:1033. Archean molecular fossils and the early rise of eukaryotes.

Lab 4: Pre-Lab Name_____
Microbial Diversity & Microscopy II
Protozoa & "c-ferns"

1) Using Campbell, draw a rough sketch and briefly describe the following organisms:

Amoeba

Paramecium

Vorticella

Spirogyra

Diatoms

2) Using the information in your text book, draw a phylogenetic tree that includes the following organisms. You do not need to include information about *when* the last common ancestor existed. Do include the names of the kingdoms and phyla. Please draw it on the back of this sheet.

• humans • c-ferns (they are regular ferns)
• *Paramecium* • *Amoeba* • Diatoms

3) Which two organisms from question 2 are the most closely-related?

Lab 4: Microbial Diversity & Microscopy II
Protozoa & c-Ferns I

Part I: Protozoa

Objectives:
To observe unicellular organisms, protozoa and to see their subcellular components. To look at some organisms on the border between plants and animals.

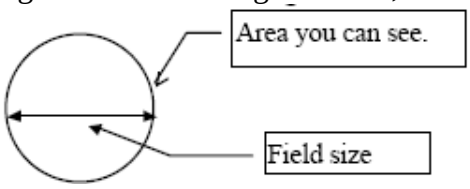
Introduction
All living things are made up of cells. Bacteria lack true nuclei and organelles and are termed PROKARYOTES. All other cells are EUKARYOTIC. Larger animals, we humans for instance, are made of trillions of cells. At the other extreme are single-celled living things. Some of these creatures are animal-like and called Protozoa (*Paramecium* and *Amoeba*); others are more like plants (green algae, diatoms); and still others seem to be both plant and animal at the same time (*Euglena*). In the past, biological classification took all of the single celled organisms (except bacteria) and put them together in one kingdom called Protista. Today the protists are all contained in the Domain Eukarya in many different kingdoms and phyla reflecting their great diversity. All eukaryotic cells have a nucleus, cytoplasm, and a plasma membrane surrounding the cell. The typical plant cell has in addition a cell wall - a rigid structure made up chiefly of cellulose that surrounds the plasma membrane. Plants also possess chloroplasts - structures within the cell that contain the green pigment chlorophyll. Most animal cells are largely filled with cytoplasm, whereas the typical plant cell has much of its volume taken up by a large vacuole containing water, salts, sugars, and other compounds.

Procedure
You should look at pictures in your text book and online to familiarize yourself with what you will be looking at.

Points to Remember: The following are worth remembering as you use the microscope.
l. Be sure that you are using the condenser and diaphragm correctly.
2. Do all preliminary focusing under low power.
3. Do not move the stage upward when first getting the object in focus (i.e. beware of smashing slide and lens together).
4. Try to use the microscope with both eyes open - it will seem hard at first, but is easier in the long run.
5. Use the fine adjustment constantly to keep things in focus.
6. Use lens paper to clean the lenses occasionally, you will find that the microscope works best when clean.

Protozoa-1
To slow down fast-moving protozoa:
1. Take a clean slide.
2. Make a small ring about 1/2 inch in diameter of "Proto-slow" – viscous methyl cellulose that slows protozoa because it is thick and difficult for them to swim through.
3. Drop a drop of the protozoa in the middle of the ring.

4. Put on the coverslip and observe. The protozoa will gradually slow down as the proto-slow reaches them. How big is it? You can use the microscope to measure the approximate size of the objects you are looking at. Given the magnification, the table below gives the diameter of the field of view. See diagram:



Once you know that, you can estimate the size of what you're seeing. If the field size is 450μm and the thing you're looking at it half as wide as the field, then it's about 220μm wide.

COMPOUND MICROSCOPE - These are good for looking at small things. You adjust the magnification by changing the objective lens. Be sure it clicks solidly when changing magnification or you won't see anything.

Magnification shown on objective lens	Actual magnification		Field size (millimeters, mm)	Field size (microns, μm)
4X	40X	→	4.9	4900
10X	100X	→	1.8	1800
40X	400X	→	0.44	440

(1) Looking at Prepared Protozoa
You will be given samples of the following protozoa to look at. Names in *italics* are genus and species names. Those in normal type are names of phyla. The abbreviation *sp.* means *"species"*, that is, the genus is known but the exact species is not.

Amoeba proteus
Paramecium caudatum
Vorticella sp.
Diatoms
Euglena sp.
Spirogyra sp.
Volvox globator

You should try to look at them all. Make a wet mount of each sample: a small drop of culture on a slide with a cover slip on top. Draw what you see and try, as best you can, to label all the parts you can see and estimate the size of what you're looking at.

(2) Looking at organisms in the pond water or plankton sweep
Take a drop of water from the pond or sea water samples and place it on a clean slide with a cover slip. Quickly scan the slide to find an observable living cell. Look at it under all magnifications you have on your microscope. Try to determine what type of cell it is by its components and its behavior. Draw your cell; label all parts you can and determine its size. Try to identify it with the protist keys in the lab.

Part II: c-Ferns part I

Objectives

To observe the phenomenon of alternation of generations and its genetic consequences. To follow the life cycle of a plant through a complete cycle. Today, we will observe gametophytes and sperm release.

Introduction

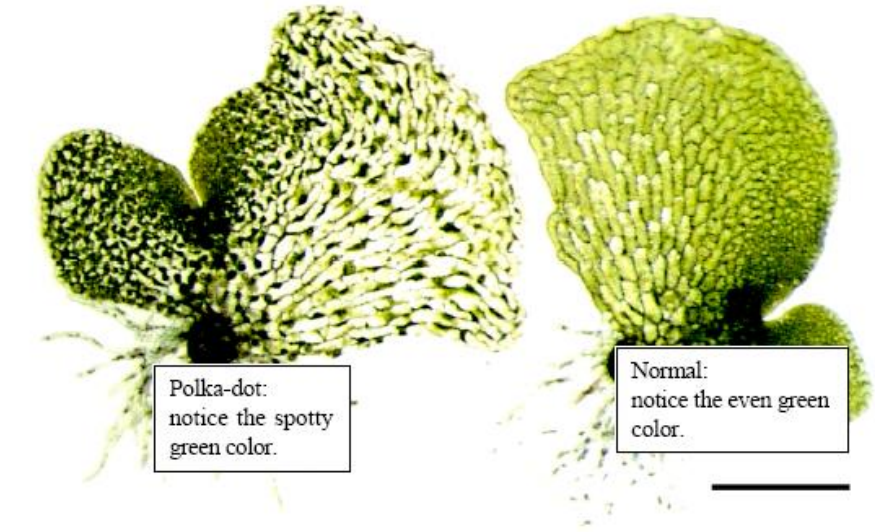
Variations on the pattern of alternation of generations are an important part of the diversity among living things. It varies extensively – see figure 13.6, p. 252 in Campbell 9th ed. for a general description; page 602 shows it for a generalized plant.

You will be following the development of a fern *Ceratopteris richardii* – "c-fern" for short. It is a tropical homosporous fern. Its life cycle is like that of most ferns with one exception: the text shows a hermaphroditic gametophyte – the gametophytes have both male (antheridia that make sperm) and female (archegonia that make eggs) parts; c-ferns have hermaphroditic gametophytes which are "heart-shaped" as well as male gametophytes (which have only antheridia).

The strain of c-ferns you will be observing also has a mutation:

Allele	**Contribution to phenotype**
normal: D	normal distribution of chloroplasts – dominant phenotype
mutant: d	chloroplasts clumped ("polka-dot") – recessive phenotype

Some pictures are show below:



Male c-fern gametophyte (left) and hermaphrodite gametophyte (right)

This phenotype is visible in both haploid and diploid forms of the fern (except the spores, eggs, and sperm). As a result:

For haploids:	**Genotype**	**Phenotype**
(gametophytes)	D	normal
	d	polka-dot

For diploids:	**Genotype**	**Phenotype**
(sporophytes)	DD	normal
	Dd	normal
	dd	polka-dot

Two weeks ago, we sowed spores produced by a Dd sporophyte onto the Petri dishes you have. The gametophytes have grown up by now and are ripe for fertilization (not in the sense of fertilizer, but in the sense of egg and sperm). When you add water, the sperm will be released from the antheridia and will swim towards the archegonia to fertilize the eggs there. At this stage, it *may* be possible to tell normal from polka-dot, but in a further two weeks the differences will be plainer.

Procedure

(1) Get a plate of gametophytes from your instructor and label it with your group name on the bottom.

(2) Place two separate drops of water on a slide. Using a toothpick, scoop up 1 male gametophyte and place it in one of the drops of water. Cover it with a cover slip. Scoop up a hermaphrodite gametophyte and put it in the other drop of water; cover with a cover slip. Try to get a gametophyte of each type – the males are much smaller than the hermaphrodites and look like a bunch of green grapes.

(3) Draw one gametophyte of each type. Label the diagrams with their approximate sizes as well as hermaphrodite vs. male. Also label the rhizoids.

(4) Observe the release of sperm from both gametophytes. Fern sperm are propelled by flagella and you can see the whipping motion of the flagella causing the sperm to spin. It may take a couple of minutes for this to start. Draw the sperm.

(5) Try to tell if the hermaphrodite gametophytes are normal or polka-dot. Mark the bottom of the plate under the gametophyte with a + for normal and a p for polka-dot.

(6) Add 3 ml of sterile water to your c-fern plate and swirl it around to fertilize all the ferns. Leave this plate with your instructor and you will see the sporophytes growing from the gametophytes in 2 weeks during the Plant Diversity Lab at UMass.

Lab Report

You may find it necessary to consult your textbooks for some of the information required.

• The report must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. Include a title page with the name and date of the lab and your name.

• Due next week at the start of the lab session you are currently in. 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:

Part I: Protozoa:

(1) Drawings of the organisms you looked at with size clearly marked. Label all cell parts and organelles that you can identify.

(2) How does it move (except *Spirogyra* and *Diatoms*)? What parts of the cell are involved and how do they move the organism?

(3) (for each organism). How that organism gets Carbon (organic from food, or from CO_2), Nitrogen (in water, or organic from food), and energy (from food or from light).

(4) Sketch a crystal of table salt. Next to it, sketch the outline of each organism you observed **to scale** with the salt grain. Your drawings need not include all details, but should show the relative sizes of the organisms and the salt grain. Note that, since all the sizes you will measure are approximate, your drawings only have to be roughly correct – we will not grade on the precision of your measurements.

Part II: c-ferns:

(1) Drawings of male and hermaphrodite gametophytes with sizes indicated.

(2) Draw the fern life cycle and indicate which parts you have seen today (use Campbell).

(3) Compare the human life cycle (adults, eggs, sperm, and zygote) with the fern. What are the similarities? What are the differences?

Pre-Lab 5: Population Genetics Name_____

1) Consider the starting population of Part I of this lab experiment: 40 total tribbles, 16 are blue, 16 are green and 8 are yellow. A blue tribble carries the "AA" genotype; a green tribble carries the "Aa" genotype and a yellow tribble carries the "aa" genotype. Is this population at Hardy-Weinberg Equilibrium (HWE)? Justify your answer mathematically.

2) Suppose that you wanted to simulate Natural Selection in this lab.

a) What would you do at step (c) in every generation to simulate natural selection?
What instructions would you give for that step? There are many correct answers here; give only one.
Hint: see Part II of this lab.

b) Which of the experiments in Part II simulate natural selection? Give all the numbers that apply.

Lab 5: Population Genetics

Note: Bring a calculator to use for this lab.

Objectives

To see how the genetics of populations can be modeled using Hardy-Weinberg population genetics. To see the effects of various deviations from the Hardy-Weinberg assumptions on the allele frequencies of a population (micro-evolution).

Introduction

Mendelian genetics deals with inheritance among individuals or small families. It is not useful for dealing with large groups of individuals which are called populations. For example, the genetic disease cystic fibrosis is inherited in an autosomal recessive manner; that is:

allele	**contribution to phenotype**
D	normal - dominant phenotype
d	cystic fibrosis - recessive phenotype

as a result:

genotype	**phenotype**
DD, Dd	normal
dd	cystic fibrosis (diseased)

Mendelian genetics could tell you that two carriers (Dd) would have a 1/4 chance of having a diseased child. However, Mendelian genetics cannot help us to find the chance that the parents are carriers in the first place.

In Bio 112 we are also interested in evolution, which has a large genetic component. However, since *populations* evolve, not *individuals*, Mendelian genetics is no help here either.

As a result of these deficiencies in Mendelian genetics, Hardy and Weinberg in 1908 developed a mathematical scheme for modeling the genetics of populations which is based on Mendelian genetics. In its most general form, Hardy-Weinberg population genetics can model the evolutionary behavior of many genes with many alleles each. However, in order to best illustrate the principles involved, we will consider the simplest case: one gene with two alleles (A and a).

In order for the Hardy-Weinberg model to work, they had to make 5 simplifying assumptions:

(1) Very large population size
(2) Isolation from other populations
(3) No net mutations
(4) Random mating
(5) No natural selection

A population that satisfies these five requirements is said to be at Hardy-Weinberg Equilibrium (HWE) because the allele frequencies will not be changing over time – the population will not be evolving. All of these are **never** true in real life, but the Hardy-Weinberg model is still very useful. In the case of human diseases, we can make the simplifying assumption that the population is at HWE and then calculate the frequency of carriers, given the frequency of diseased individuals. In the case of evolution, we can compare a population with what we'd expect to see if it was not evolving (that is, at HWE) and see how it is evolving. We can also use Hardy-Weinberg population genetics to model how certain conditions can influence allele frequencies – that is what we'll be doing in this lab.

We will consider the hypothetical creatures known as tribbles. Tribbles come in three colors: blue, green, and yellow. We will simulate the tribbles by beads colored blue, green, and yellow. The color of the tribbles is controlled by one gene with two alleles that are incompletely dominant:

	allele	**contribution to phenotype**
	A	blue color - incompletely dominant
	a	yellow color - incompletely dominant
as a result:	**genotype**	**phenotype**
	AA	blue
	Aa	green
	aa	yellow

Procedure

Part I: You will start by simulating a randomly-mating population under conditions that satisfy most of the requirements for HWE. You will randomly select pairs of parent tribbles and each pair will give birth to two tribble offspring. After each pair is selected, it is removed from the population; you will do this until you have mated all the individuals in the population. Using Mendelian genetics, you will predict the colors of these offspring and see if our findings fit the predictions of HWE. (Notice that population genetics is really just an extension of Mendelian genetics.)

You should work in groups of three.

(1) Each group will start with a population of 40 tribbles with the following colors:

16 blue 16 green 8 yellow

(2) Put the population in a container.

(3) Draw a random pair of tribbles from the population (close your eyes and pick two beads). These are the parent tribbles.

(4) Fill in the sheet on the next page for "Pair #1":

a) Write in the colors of the parents (it doesn't matter which is father or mother)

b) Write in their genotypes based on the table above.

c) Predict and write in the genotypes of their two offspring using Mendelian genetics:

i) if the parents are AA and AA, both children will be AA

ii) if the parents are aa and aa, both children will be aa

iii) if the parents are AA and aa, both children will be Aa

iv) if the parents are AA and Aa, the children have a 50/50 chance of being either AA or Aa. Flip a coin for each child:

if Heads, then the child is AA,

if Tails, the child is Aa

v) if the parents are aa and Aa, the children have a 50/50 chance of being either aa or Aa. Flip a coin for each child:

if Heads, then the child is Aa,

if Tails, the child is aa

vi) if the parents are Aa and Aa, the children have

a 1/4 chance of being AA

a 1/2 chance of being Aa

a 1/4 chance of being aa

– so flip a coin twice for each child:

if heads-heads, the child is AA
if heads-tails (or tails-heads), the child is Aa
if tail-tails, the child is aa

d) Write in the colors of the children using the information above.

(5) Discard the parental beads.

(6) Pick a new pair of tribbles from the population and repeat steps (4) through (6) for pairs #2 through 20.

(7) Total your results and pool with the class. These numbers are the numbers of children of each color that would be produced, assuming each pair of parents had two offspring.

(8) Discuss the answers to the following questions:
Which of the requirements of HWE does this simulation fit?
Does your data fit the predictions of HWE?

Pair #	Colors of Parents		Genotypes of parents		Resulting offspring		
	Mother	Father	Mother	Father	# Blue (AA)	# Green (Aa)	#Yellow (aa)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
TOTALS:							

Part II:
You will now simulate and observe the effects of various experimental deviations from the requirements of HWE on the allele frequencies of a population of 100 tribbles. This is an example of micro-evolution. The 4 experiments are as follows:

- Experiment 1: All Blue tribbles die before reproducing.
- Experiment 2: All Yellow tribbles die before reproducing.
- Experiment 3: Every generation, a **random** 95% of the population dies before reproducing.
- Experiment 4: Every generation, a **random** 98% of the population dies before reproducing.
- You will then repeat the selected experimental treatment for 10 generations.

One experiment will be assigned to each lab table; all the groups at that table will do that experiment. Each group will present their results at the end of class.

(1) Count out the beads for the starting population.
40 Blue 40 Green 20 Yellow

(2) Follow the directions on the following pages. At Step (c) in each generation, apply your experimental condition.

Be sure to check that your numbers add up as indicated – it is OK if they are off by a little (0.01 for those that must be 0; 1 for those that must be 100) – but since the next generation is based on the last, a mistake early will make all later results invalid.
You should start off using the beads to simulate the population. Once you get a feel for what's going on, and are sure that you don't need them anymore (check with your instructor), you can stop using them.

Keep going for all 10 generations unless one allele goes extinct ($p = 0$ or $q = 0$).

<u>Here are the details of each step and what they correspond to in real life:</u>
Notes:

- you should look at the worksheets on the following pages to see what these steps mean
- the boxes on the worksheets have been assigned arbitrary letters to help identify them in the calculations; you do not need to know these equations for any exam

• Step 0 (start of generation 0): the starting population
• Step 0a: Calculate the alleles contributed to the gene pool from the raw data.
– each blue (AA) individual contributes 2 A's. So: d = 2A
– each green (Aa) individual contributes 1 A and 1 a. So: e = B and f = B
– each yellow (aa) individual contributes 2 a's. So: g = 2C

– the total number of A's contributed to the pool (h) = d + e
– the total number of a's contributed to the pool (i) = f + g

– the total number of alleles in the gene pool (j) = h + i
(since each individual contributes 2 alleles, this should = 2N)
• Step 0b: Calculate the allele frequencies from the numbers of the alleles. This calculates the fraction of the gametes with each allele produced by the reproductive adults.

$$\text{the frequency of A alleles} = \frac{\text{\# of A's}}{\text{total \# of alleles}} = \frac{h}{j}$$

the frequency of a alleles = $\frac{\text{\# of a's}}{\text{total \# of alleles}} = \frac{i}{j}$

• Step 1a (generation 1): Calculate the fraction of each genotype in the progeny using the allele frequencies of the gametes produced by the previous generation. This assumes that the population satisfies the requirements for HWE. (Actually, in the experiment, it doesn't. But all the requirements are present in this particular step, and we will model the deviations in the next step, so it is OK to use the Hardy-Weinberg model here.) So you can use the modified punnet square:

	gamete: A probability of getting it: p	gamete: a probability of getting it: q
gamete: A probability of getting it: p	genotype: AA probability: p^2	genotype: Aa probability: pq
gamete: a probability of getting it: q	genotype: Aa probability: pq	genotype: aa probability: q^2

So:	**Progeny Genotype**	**Probability of occurrance**
	AA	p^2
	Aa	pq + pq = 2pq
	aa	q^2

• Step 1b: Calculate raw numbers. This model assumes that, in each generation, all the adults die and give birth to a total of exactly 100 newborn tribbles (in some cases, this will represent an enormous reproduction rate!). The number of each genotype (color) is just 100 times the fraction with that genotype (genotype frequency). So:

A = 100x B = 100y C = 100z

Between steps (b) and (c) is what happens to the tribbles during their lives before they reproduce.

• Step 1c: Simulate your experiment here. The results of this calculation give the tribbles who have survived to reproductive age.

– Experiment 1: Make the number of blue tribbles = 0, keeping all the others the same. Adjust the total number (N) accordingly.
– Experiment 2: Make the number of yellow tribbles = 0, keeping all the others the same. Adjust the total number (N) accordingly.
– Experiment 3: Put 100 beads in a container to represent the newborns. Mix them, close your eyes and pick 5. These are the survivors. N is therefore 5.
– Experiment 4: Put 100 beads in a container to represent the newborns. Mix them, close your eyes and pick 2. These are the survivors. N is therefore 2.

Steps (d) and (e) set up the calculations for the next generation; then calculate the allele frequencies in the gametes (eggs & sperm) produced by the tribbles that made it to reproductive age.

• Step 1d: Calculate the numbers of alleles from the raw numbers (like step 0a)
• Step 1e: Calculate the allele frequencies from the numbers of alleles (like in step 0b).

(3) Graph your results. Draw a graph of p and q as a function of generation number on the overhead transparency your TA will provide (these are the values you calculated: generation 0, use 0b; generation

1, use 1e; generation 2, use 2e, etc.). Be sure to use a blue pen for p and a red pen for q and write which experiment you were performing at the top of the sheet.

(4) Each group will briefly present their data. The class will then discuss the results. The objective of the discussion is to answer the questions required in the lab report (see later).

Lab Report

• Must be typed; hand-drawn graphs are acceptable. Include a title page with the name and date of the lab and your name.
• Due at the start of lab during the week indicated on the syllabus; this is a firm deadline.

Your lab report must include:
(1) A copy of your group's Random Mating Simulation Worksheet.
(2) A copy of the graph of the data (p and q vs. generation) from your group.
(3) A copy of the graph of the data (p and q vs. generation) from another group.
(4) A brief (not more than a page total) discussion of the following questions:

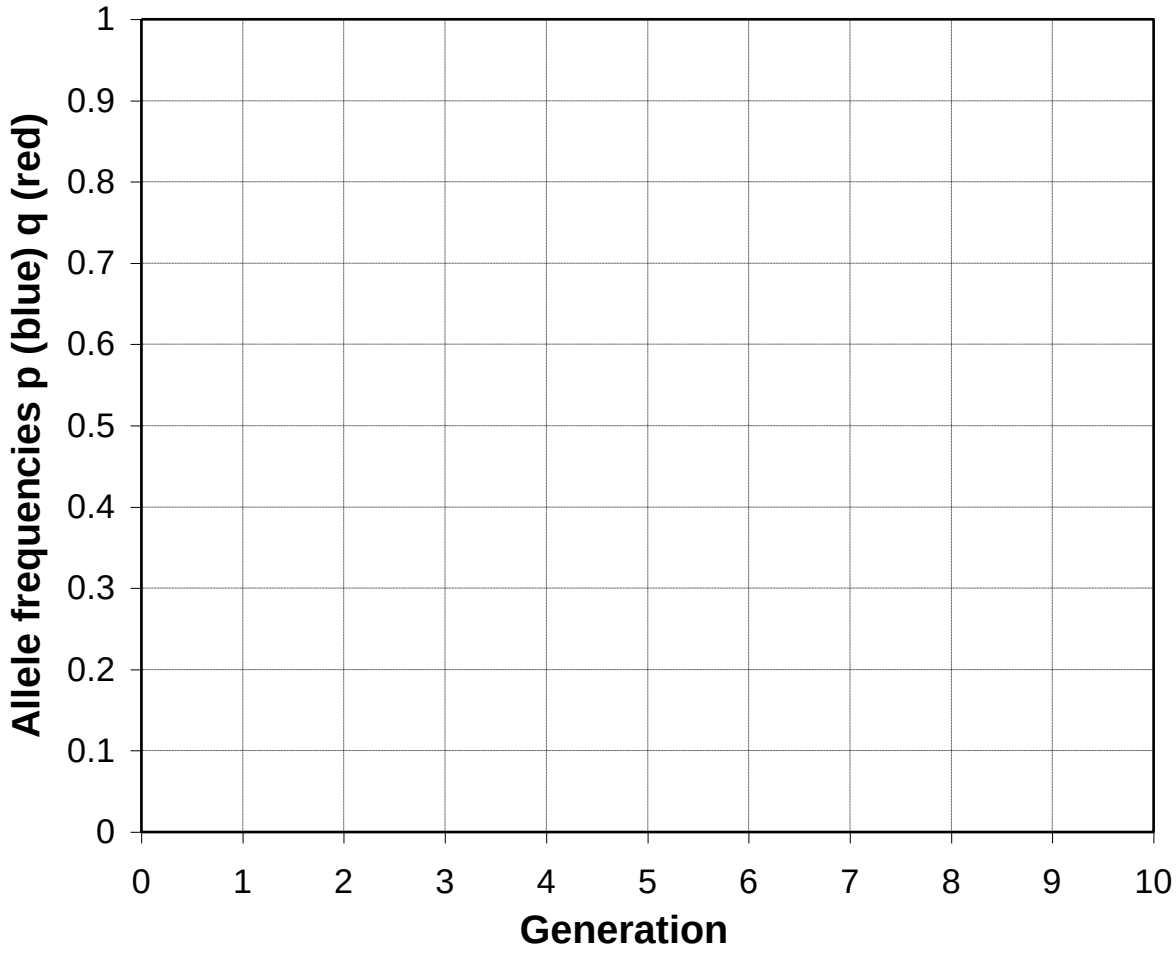
a) In your experiment, briefly describe what happened to the allele frequencies (went up, etc.). Explain how your experimental conditions led to this behavior.

b) Compare your results to those of the other group you included. What are the similarities and differences and how can you explain them in terms of what you know about population genetics?

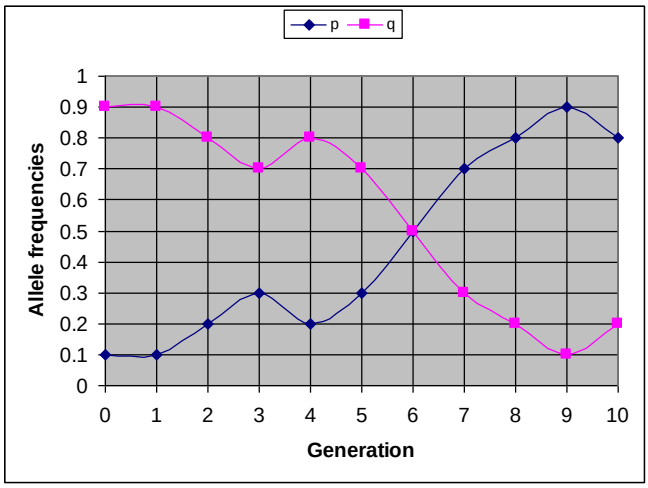
c) Migration of individuals (also called Gene Flow) can also change allele frequencies. How would you alter the steps in Part II of this lab to simulate migration? Describe clearly which step(s) you would alter and how you would alter them. There may be more than one correct answer here. Hint: think of migration as a few individuals of specific genotypes entering the population in each generation.

Group Members: _____

Experiment:_____

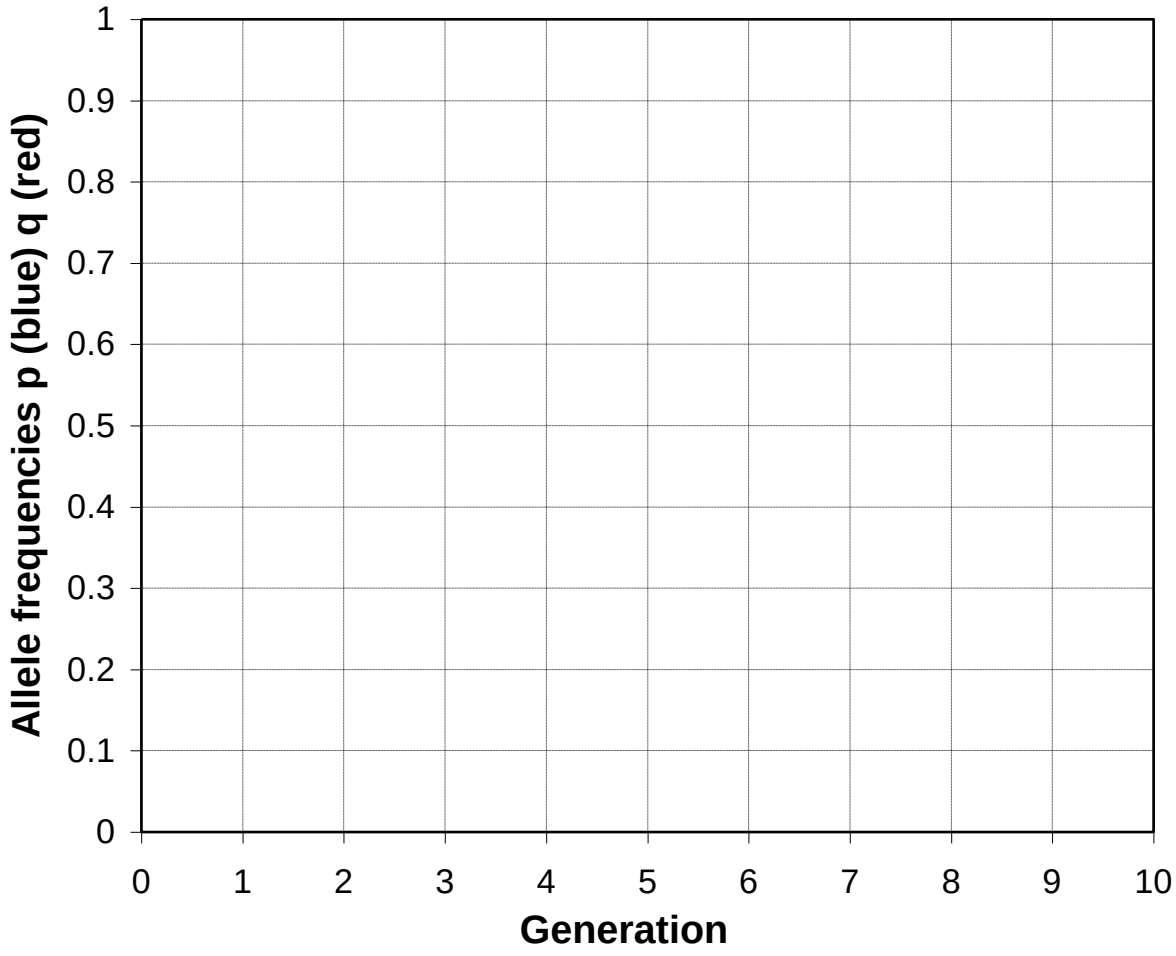


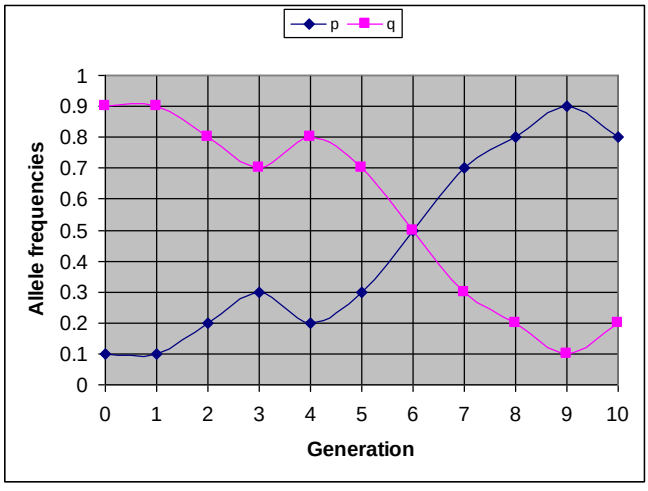
Example



Group Members: _____

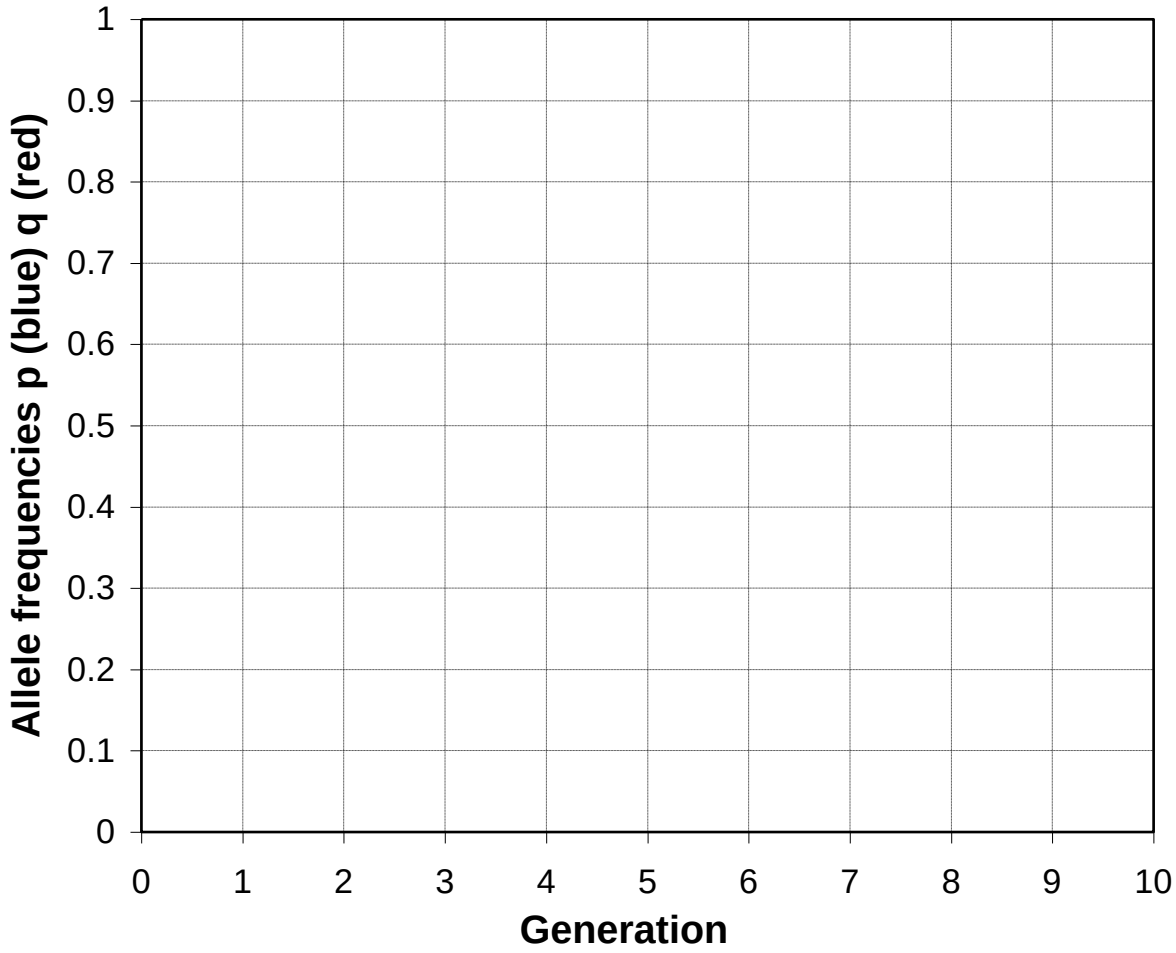
Experiment:_____



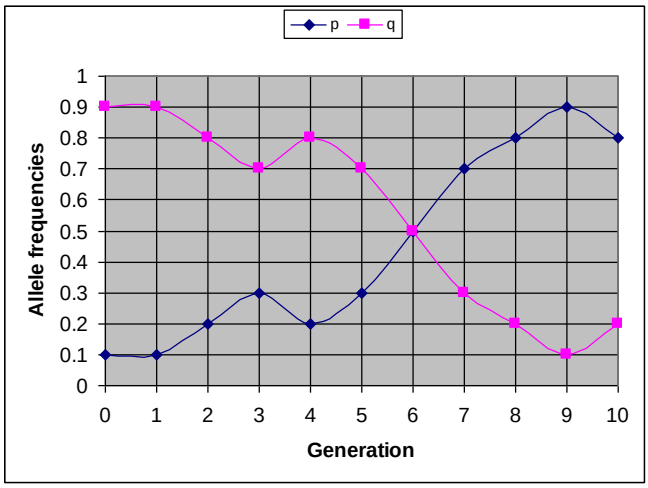


Group Members: _____

Experiment:_____

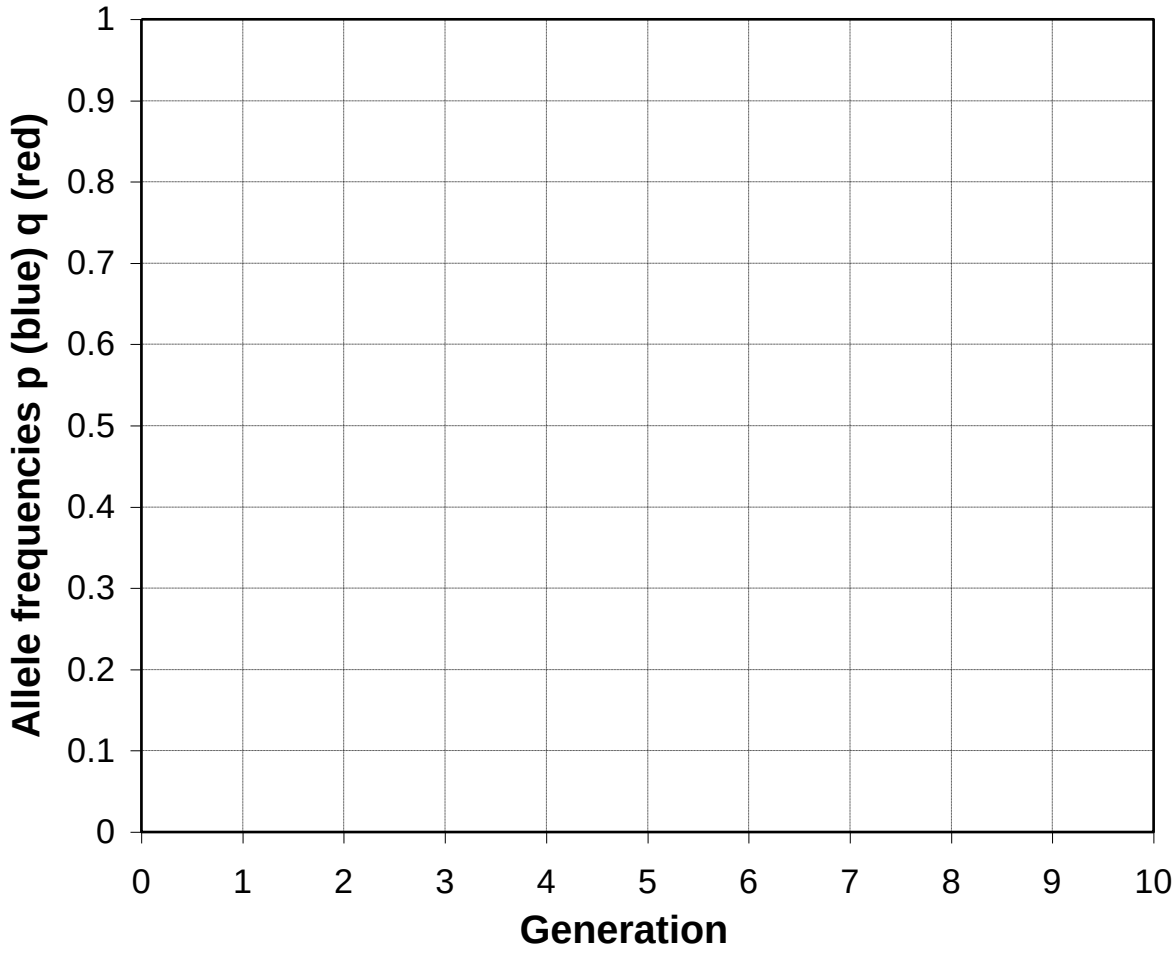


Example

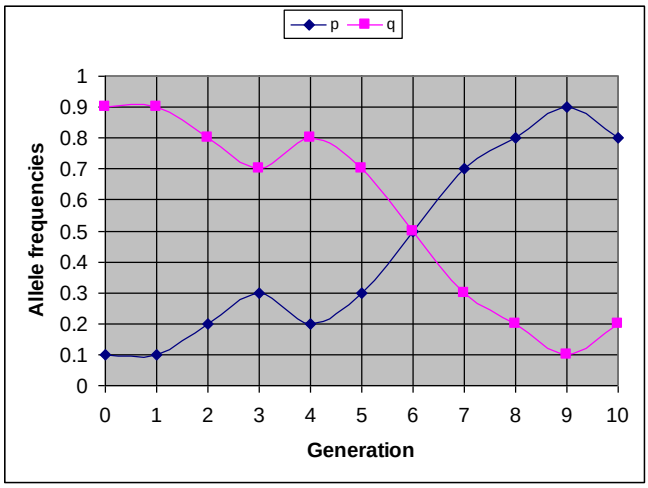


Group Members: _____

Experiment:_____



Example



Population Genetics Simulation Experiment#_____ Generations 0 &1

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
0	Starting Numbers	40	40	20	100					
0 a	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
0 b	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									
1 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that x + y + z = 1									
1 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
1 c	Simulate your Experiment HERE (Experiments 1 through 4)									
1 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
1 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 2

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 1e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i	d	e		h	Total # alleles				
	#a's⇒		f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 3

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of grn (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 4

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 5

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of grn (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 6

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i	d	e		h	Total # alleles				
	#a's⇒		f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 7

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that x + y + z = 1									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i	d	e		h	Total # alleles				
	#a's⇒		f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 8

Step	Instructions	Raw Numbers				Genotype Frequencies			Allele Frequencies	
		Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 9

Step	Instructions	Raw Numbers: Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Genotype Frequencies: Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Allele Frequencies: Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i #a's⇒	d	e		h	Total # alleles				
			f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Experiment#_____ Generation 10

Step	Instructions	Raw Numbers				Genotype Frequencies			Allele Frequencies	
		Num. of blu (A)	Num. of gm (B)	Num. of yel (C)	Total Num. (N)	Freq. of AA (blu) (x)	Freq. of Aa (grn) (y)	Freq. of aa (yel) (z)	Freq. of A (p)	Freq. of a (q)
1 e	Copy over allele frequencies from previous page (line 2e)									
2 a	Assuming conditions for HWE, calculate genotype frequencies from allele frequencies: $x = p^2$; $y = 2pq$; $z = q^2$									
*	Check to see that $x + y + z = 1$									
2 b	Assuming a population of 100, calculate numbers from genotype frequencies A = 100x B = 100y C = 100z				100					
	Check to see that A + B + C = 100									
2 c	Simulate your Experiment HERE (Experiments 1 through 4)									
2 d	Calculate # of each allele contributed. #A's⇒ d = 2A; e = f = B; g = 2C; h = d + e; i = f + g; j = h + i	d	e		h	Total # alleles				
	#a's⇒		f	g	i	j				
2 e	Calculate allele freq. from allele #s $p = \frac{h}{j}$ $q = \frac{i}{j}$									
*	Check to see that p + q = 1									

Lab 5: Pre-Lab Plant Diversity Name_____

1) For each of the following, indicate whether it is a sporophyte or a gametophyte.

a) The antheridium in Campbell, 8th ed., figure 29.8, p. 607.

b) The archaegonium in Campbell, 8th ed., figure 29.8, p. 607.

c) An adult pine tree.

d) The trunk of an adult pine tree.

e) The wrinkly outside shell of a peanut.

f) A blade of grass.

g) A pine needle.

2) Give an example of a gametophyte you can see without a microscope.

Lab 5: Plant Diversity

Objective

To observe and analyze the diversity of plants by looking at 4 major land plant groups
To identify the parts of plants at different life stages
To observe dissected seeds and flowers

Introduction

"Members of the plant kingdom are multicellular, sexually reproducing eukaryotes. Their cells contain green plastids, chloroplasts, which contain the pigments chlorophyll a and b, xanthophylls, and other yellow and red carotenoid pigments. Today, they are the major mechanism for transforming solar energy into food, fiber, coal, oil and other usable forms. Photosynthesis by plants sustains the biosphere, not only converting solar energy into food but producing oxygen as well."
(Margulis, L. and K.V. Schwartz. 1982. *The Five Kingdoms*. W.H. Freeman & Co. San Francisco)

Photosynthesis:

$$6CO_2 + 12H_2O + \text{light energy} \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

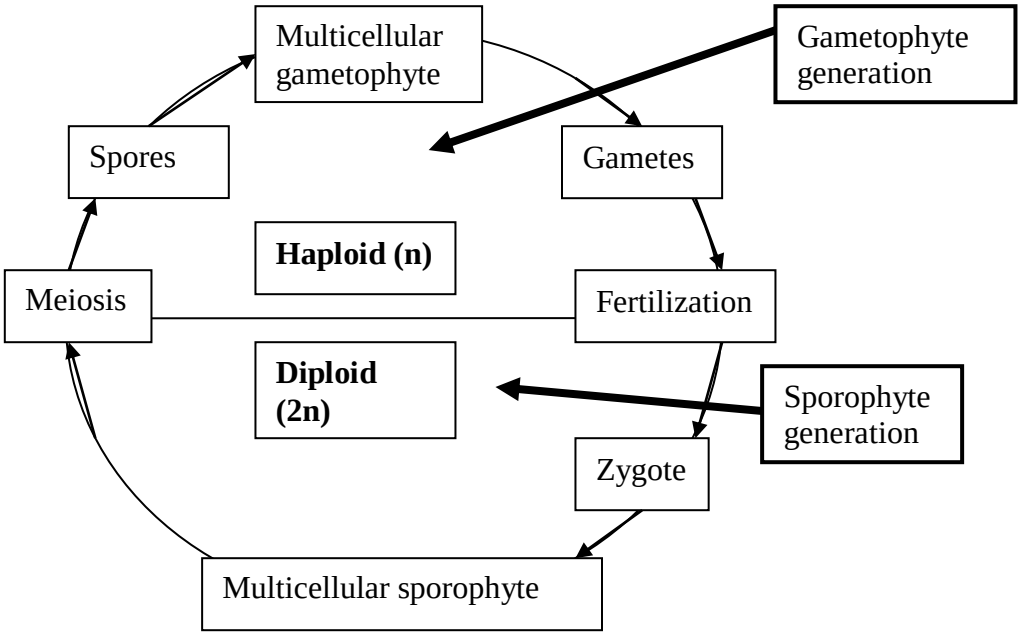
Plants are the dominant form of photosynthetic life on land. Algae, both microscopic forms and larger seaweeds, are the dominant photosynthetic life forms in fresh water and marine environments.

The best context within which to examine the plant material in this lab exercise is the increasing complexity of plants as they have become better adapted to terrestrial environments. The earliest land plants were obligated to live in moist environments. They didn't need or have water-conducting roots or vascular tissues like xylem. Modern mosses and liverworts are still like that. Reproductive strategies and structures have also changed with increasing adaptation to terrestrial environments. The gametophyte stage is less pronounced in the more evolved plant taxa. Plant embryos in these taxa are packaged in containers that can withstand prolonged desiccation. We call these containers seeds.

Plant Characteristics

Phylum	**Plant**	**True Roots?**	**Dominant generation** ← **Haploid (n) or Diploid (2n)**		**Spores? n or 2n?**	**Seeds?**	**Flowers?**
Bryophyta	Moss	No	Gametophyte	Haploid –n	Yes - n	No	No
Pterophyta	Fern	Yes	Sporophyte	Diploid -2n	Yes - n	No	No
Coniferophyta	Pine	Yes	Sporophyte	Diploid – 2n	Yes - n	Yes	No
Anthophyta	Lily	Yes	Sporophyte	Diploid – 2n	Yes - n	Yes	Yes

Alternation of generations cycle

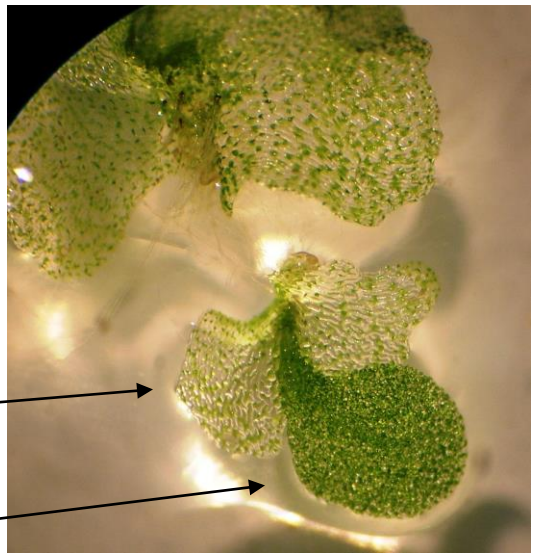


Procedure

You will begin this lab with a tour in the greenhouse at UMass Boston where Jim Allen, the manager, will guide you and have plant examples set up to help you answer the greenhouse questions. Then you will walk to the second floor of the Wheatley building to the freshmen biology labs (W/2/032) and observe the plant diversity display and make your drawings. The lab is divided into sections of moss, fern, pine and lily (angiosperm) and in these sections you will find all the materials to make your drawings.

Part I: c-fern sporophytes

Look at the c-ferns growing in the Petri dishes that you fertilized two weeks ago under a dissection microscope. You should be able to see small sporophytes (smooth-edged) growing out of the gametophytes (wavy-edged). You should be able to tell "polka-dot" from normal (see the first c-fern lab in the Protozoa lab section); note the phenotype of the sporophyte and gametophyte as best you can.



Gametophyte – wavy-edged
- "polka-dot" phenotype

Sporophyte – smooth-edged
- normal phenotype

Part II: Plant Diversity Look at the plants and microscope slides in the lab. Draw what you see, using the textbook as a guide. The Lab Report section of this lab lists the pictures you must have.

Part III: Seed Dissection Open a peanut and a pine nut with your fingernail and draw the embryo, seed coat, and endosperm or cotyledons. Consult your text for labels.

Part IV: Flower Dissection Look at the flower model, floral diversity posters, and the dissected flower. Draw the parts you can find and compare it to the flower in figure 30.7 of Campbell. Look in the Lab Report section for the structures you must have labeled.

Other resources: Life cycle diagrams for the plant groups can be found at the end of this section, though Campbell and the internet.

Lab report Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. Include a title page with the name and date of the lab and your name.
• Due next week at the start of the lab session you are currently in. This is a firm deadline.
• 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:

1. Labeled drawings with sizes indicated on 15 plant structures listed in the table below. Your pictures should also indicate any features in {braces}: (big - how it looks to the naked eye; small - how it looks in the microscope). Label each drawing with the type of plant, whether it's a gametophyte or a sporophyte, whether it's big or small and what the structure is. For example, your drawing of a female pine cone should be labeled, *Pine, Sporophyte, Big, Female Pine Cone.*

Type of Plant	**Gametophyte**	**Sporophyte**
Moss (bryophyte)	*big *small {no vascular bundles}	*big *small {spores in capsule}
Fern (pterophyta)	*small {male and hermaphrodite forms}	*small{vasculature} {spores in "sori"} *big
Pine (coniferophyta)	*small of both megagametophyte (in ovule) and microgametophyte (pollen)	*big of female cone and male cone
Angiosperm (angiospermae)	*small of both megagametophyte (in ovule) and microgametophyte (pollen)	*small of stem cross section {vasculature}

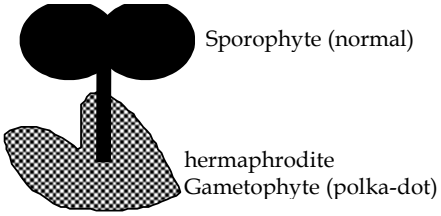
2. Drawings of the peanut and pine nut with the following labeled:
• embryo • seed coat (if present) • endosperm or cotyledons

3. Drawing of a dissected flower in the lab. Label all parts that you can find including petal, stamen, stigma, style, pistil, ovary, ovule, anther, filament, pollen,

4. You must also have a sketch of each of the 4 types of plants. On these pictures, draw arrows to indicate where each of the things in the table above can be found. For example, if you were doing this with a human, and we asked for a drawing of brain cells, you

would draw:

5. Answers to the following questions:



c-ferns:

1. If you found a normal sporophyte growing out of a polka-dot hermaphrodite gametophyte,
a) What is the genotype of the hermaphrodite gametophyte?
b) What is the genotype of the sporophyte?
c) What will be the genotypes of the spores produced by this sporophyte and in what ratio will they be produced?
d) Could you find a polka-dot sporophyte growing out of a normal gametophyte? Why or why not?

Greenhouse Questions

2. Leaves are not the only photosynthetic organs of plants. What other kind of photosynthetic structure have you seen in a greenhouse plant? Give two examples with genus and species names.

3. What plants do you find in the greenhouse that are specialized for defense against herbivores and what adaptations do they exhibit? Give two examples with genus and species names.

4. All plants require mineral nutrients (nitrogen, phosphorus, potassium, etc.). Terrestrial and epiphytic plants obtain these in different ways. How do these plants differ in the way they get their nutrients? Give examples of each type found in the greenhouse.

5. Give two examples, with genus and species names, of plants found in the greenhouse that you might also find in the supermarket in one form or another.

6. The middle greenhouse contains samples of psilotum and selaginella. What phylum of plants do these represent? You may need to look these up in Campbell.

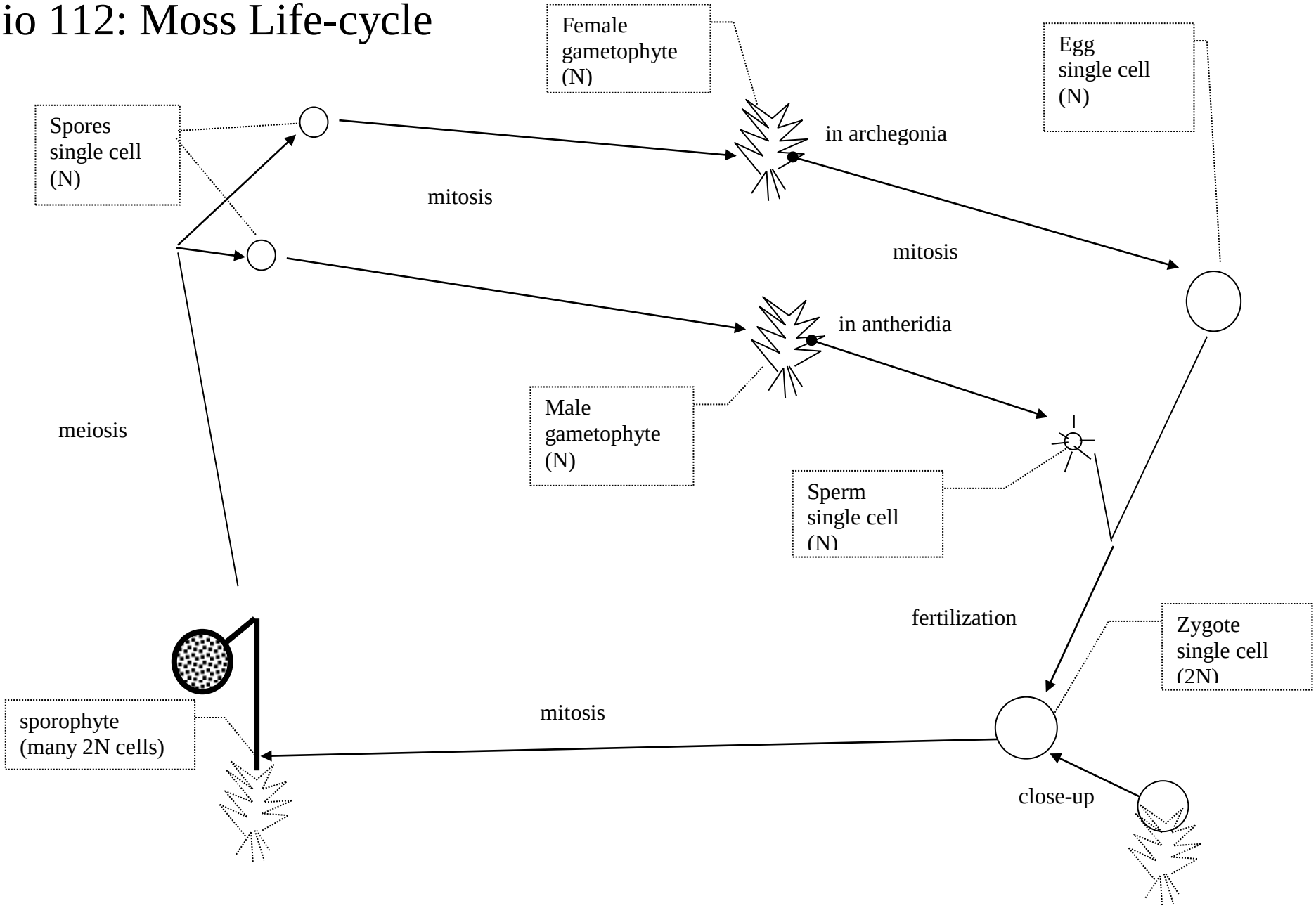
7. In the greenhouses, there are several plants which are part of the Lamiastraceae or mint family. Surprisingly, these all look and smell very different. What can you observe that is the same in all these plants?

8. Angiosperms (anthophyta) are either monocots or eudicots (sometimes called "dicots" for short). Give four example plants from the greenhouse, classify them as either monocot or eudicot, and briefly explain your reasoning.

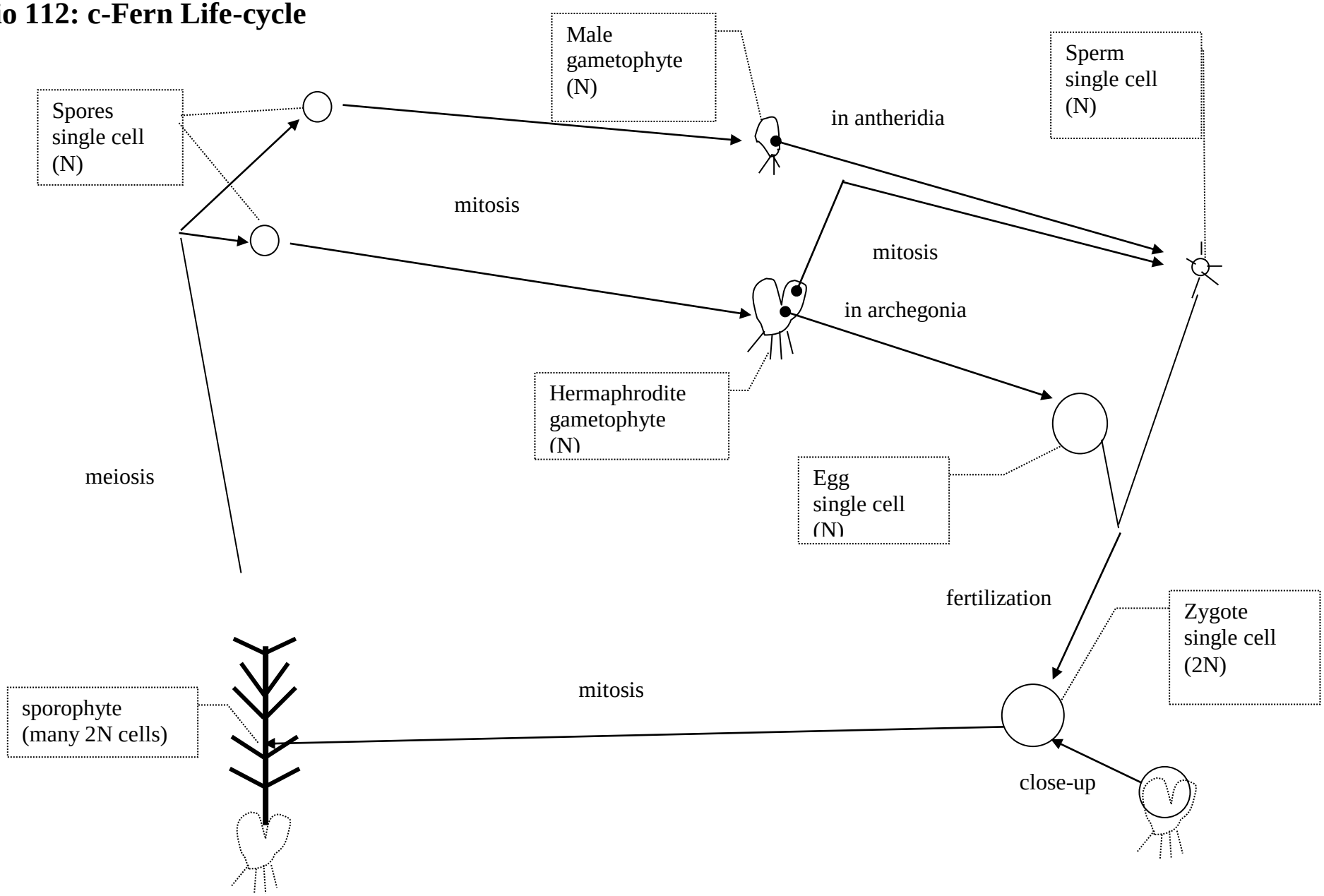
- Plant 1: Name_____ monocot eudicot
- Plant 2: Name_____ monocot eudicot
- Plant 3: Name_____ monocot eudicot
- Plant 4: Name_____ monocot eudicot

9. In the third greenhouse are several succulent plants. What do they have in common? Is this an example of convergent evolution? Why/why not? How are these advantageous in dry climates?

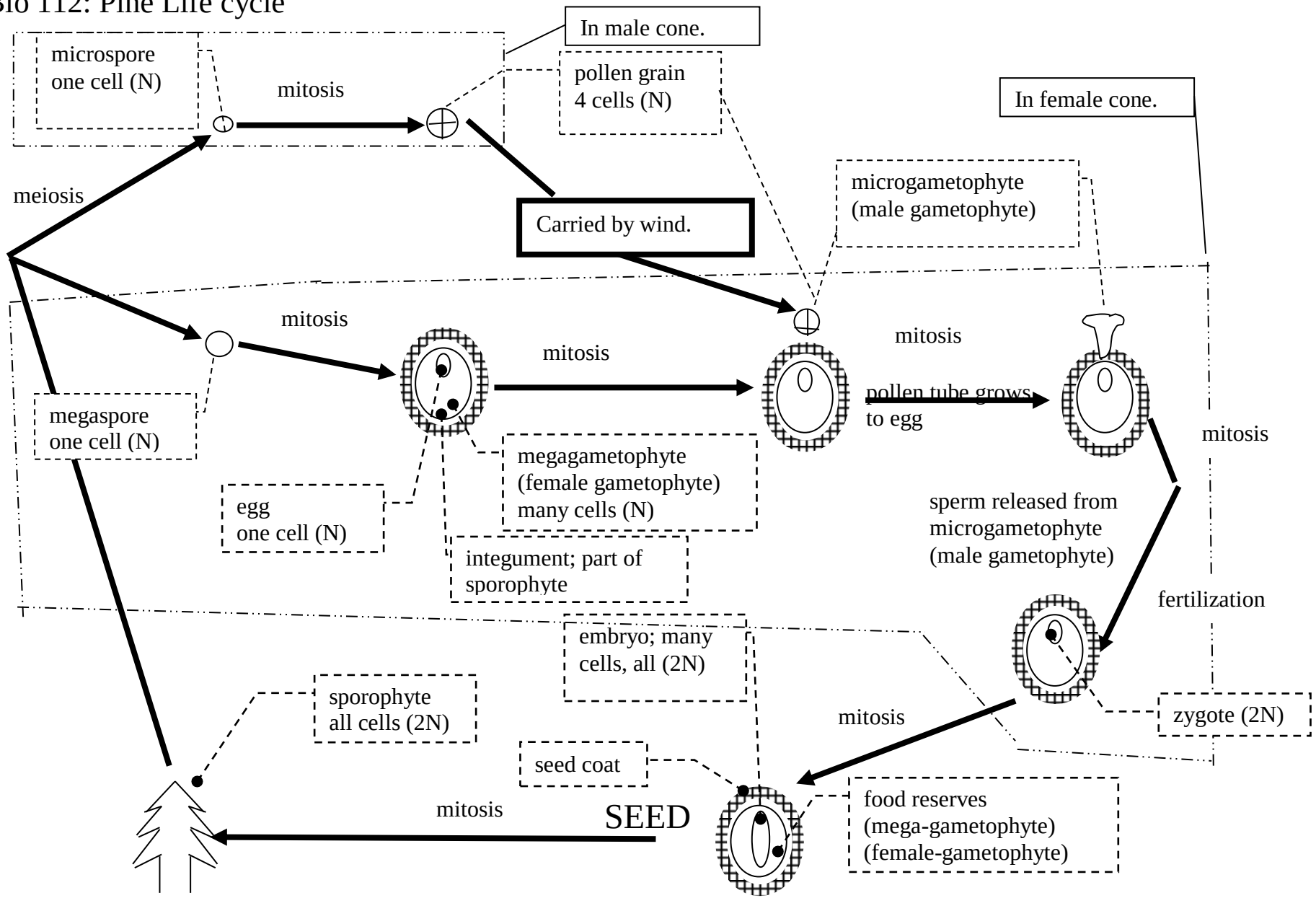
Bio 112: Moss Life-cycle



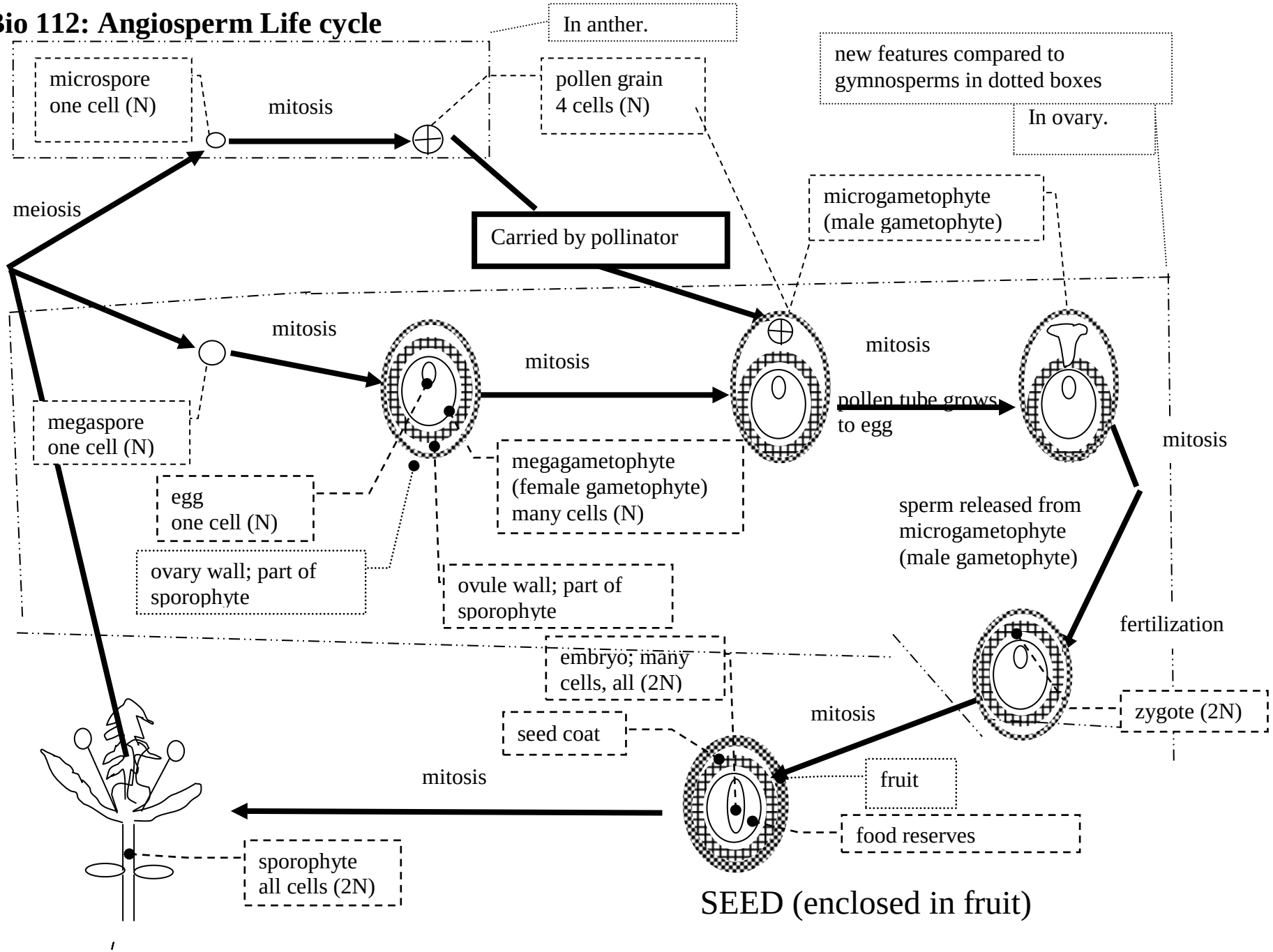
Bio 112: c-Fern Life-cycle



Bio 112: Pine Life cycle



Bio 112: Angiosperm Life cycle



University of Massachusetts Boston
Biology Department Greenhouses

The Biology Department greenhouses serve the faculty and students at the Boston Harbor campus by providing the ideal environment to learn about plants. Numerous collections of plants native to tropical, desert and temperate climates are present for research and for demonstration of the diversity of the plant kingdom. The greenhouses are located on the fourth floor of the Science Building at the University of Massachusetts Boston campus.

Greenhouse Director: Jim Allen - call (617) 287 - 6580 for special arrangements or tours.
Hours: Monday - Friday 9:00 - 4:00 the greenhouses are closed Saturdays, Sundays and all holidays.

Directions **Show Turn by Turn Maps**

1. Starting in **BRAINTREE, MA** on **ELM TER** - go **0.1** mi
2. Continue on **CHURCH ST** - go **0.4** mi
3. Take **I-93** towards **BOSTON/DEDHAM** - go **6.3** mi
4. Take exit **#14** towards **J.F.K. LIBRARY** - go **0.2** mi
5. Continue on **MORRISSEY BLVD** - go **0.9** mi
6. Arrive at **100 WILLIAM T MORRISSEY BLVD, DORCHESTER,** on the Ⓡ

Once on the perimeter road of the campus, you can enter one of the parking lots near the buildings. You will want to find the science building.
Go to the top floor (4th) and as you exit the elevators you will see a sign leading you towards the greenhouse on the wall opposite the elevators. Follow the signs.
You can take the train to the red line T-stop, the JFK/UMass stop and there are free shuttle buses that bring you to UMass. They will drop you off at the new campus center or the stop in front of the administration building. Either way enter the buildings and go the 2nd floor and walk on the catwalk connecting all of the buildings to get to the science building.

Lab 7 Pre-Lab: Animal Diversity
Name:_____

1) Name one coelomate, one pseudocoelomate, and one acoelomate phylum from the lab on animal diversity.

Coelomate:

Pseudocoelomate:

Acoelomate:

2) Name one phylum from the lab on animal diversity that has a complete digestive tract and one with a gastrovascular cavity (same opening for mouth and anus).

Complete:

Gastrovascular cavity:

3) Name one protostome and one deuterostome phylum from the lab on animal diversity.

Protostome:

Deuterostome:

4) Name one phylum lacking symmetry, one with radial symmetry, and one with bilateral symmetry.

No symmetry

Radial symmetry:

Bilateral symmetry:

Lab 7 Animal Diversity

Objectives

Describe similarities and differences in the anatomy of representative animals.
Discuss how these similarities and differences may indicate phylogenetic relationships.
Discuss the relationship between body form and lifestyle of the organism.
Understand the relationship of cross sections to the whole organism and the terms used to describe anatomical direction.

Introduction

Phylogeny is the evolutionary history of organisms: their lines of descent, the branching of these lines, and thus the relationships between organisms. Much of our understanding of animal phylogeny has come from comparative studies of the anatomy and embryology of present-day animals. Our concepts concerning their ancestral history and relationships have been extended, refined, and sometimes changed as a result of physiological, cellular, or molecular studies. Just as our understanding of animal phylogeny benefits from a study of anatomy, our understanding of anatomy is enhanced by an understanding of evolutionary principles. The form and function of all features of an organism are determined by: 1) the selection imposed by the organism's environment, and 2) the genetic/morphological/physiological constraints imposed by the general architecture that the organism's lineage has developed over the course of its evolutionary history. Regardless of their particular phylogenetic group, all living animals have the same basic requirements and must perform the same basic functions. Animals may meet these problems in different ways because of differences is size, structure, and environment. Kingdom Animalia is a subgroup of the Eukarya Domain. Taxonomists further divide the animals on the basis of morphological characteristics such as body symmetry, type of body cavity (known as the coelom [pronounced "see-lum"]), and basic embryological difference including the number of germ layers and development of the digestive tract. However, results from research using molecular techniques have started to reform the traditional animal phylogeny based on body form. In many ways the phylogenies agree but in many ways they do not.

Before you begin become familiar with the following characteristics:

Symmetry-

Radially symmetrical animals have their body parts arranged around a central axis such that any imaginary slice through the central axis would divide the animal into mirror images. These animals have no right/left nor head/tail; they have an oral (mouth) and aboral (away from the mouth) side. Anemones are radially symmetrical.

Bilaterally symmetrical animals have right and left halves which are mirror images of each other. Only one imaginary cut would divide the animal into its mirror-image and right and left sides. Humans are bilaterally symmetrical.

Animals with *no symmetry* cannot be divided into mirror-image halves. Sponges are generally nonsymmetrical.

Tissue organization- Are cells organized into well –defined tissue layers (structural and functional units)? If so, how many distinctive layers are present ? In Metazoan animals, the process of gastrulation during development results in the formation of concentric layers of tissue called germ layers which give rise to the various tissues and organs of the body. Animals may have up to three layers: ectoderm, mesoderm, and endoderm. Animals with two layers are diploblastic and those with three are triploblastic. *Ectoderm*, the outermost layer, gives rise to the outer covering of the animal and in some phyla the central nervous system.
Endoderm, the innermost layer, gives rise to the lining of the digestive tract and organs derived from it (e.g., liver).
Mesoderm, the layer between the ectoderm and endoderm, forms the muscles and most other organs between the digestive tube and ectoderm.

Coelom (body cavity) – Most triploblastic animals can be assigned to one of three groups depending on characteristics of the body cavity or coelom.
Acoelomate animals have solid, three layered bodies without a body cavity. Mesodermic tissue completely fills the space between the endoderm (lining of the digestive tract) and the ectoderm (the body wall).
Coelomate animals have a cavity or space between the ectoderm and endoderm that is completely surrounded by the mesoderm. The mesodermal lining of the coelomic body cavity is known as the peritoneum.
Pseudocoelomate animals have a body cavity that is not completely lined by mesodermal tissue; instead, it is bordered by mesodermal tissue toward the outside of the body and endodermal tissue toward the inside of the body.

Digestive tract (gut) –
Openings into the digestive tract- Where does food enter and digestive waste leave the body? How many openings are there? Some animals have only one opening which serves as both mouth and anus known as the *gastrovascular cavity*. Others have separate openings for the mouth and anus, a *complete digestive tract*, sometimes referred to as a tube within a tube.

Protostome/deuterostome- Coelomates can be further divided based on the developmental fate of the embryonic blastopore (the opening in the gastrula). *Protostome* ("first mouth") - The blastopore develops into the mouth and the anus develops as a secondary opening on the end opposite the mouth. Protostomes also exhibit schizocoelous formation of the coelom in which the coelom forms from splits in the mesoderm.
Deuterostome ("second mouth") –The blastopore develops into the anus and the mouth develops as a secondary opening on the end opposite the anus. Deuterstomes also exhibit enterocoelous formation of the coelom in which the coelom forms from out pocketings of the mesoderm.

Cleavage-Pattern of cleavage divisions typically differs between protostomes and deuterostomes (although many exceptions exist).
Spiral cleavage- Most protostomes exhibit spiral cleavage in which cell division results in each tier of cells sitting in the grooves of the adjacent tier of cells.

Radial cleavage- Most deuterostomes undergo radial cleavage in which the tiers of cells sit directly on top of one another.

Where possible also look for:
Type of nervous system- Does the organism have a brain or nerve cord? How many nerve cords and in what location? What types of sensory organs are present? Where and how many?

Circulatory system-
Open circulatory system-blood flows through coelomic spaces where it mixes with interstitial fluid and bathes the organs directly.
Closed circulatory system- blood mainly flows through vessels separate from interstitial fluid.

Organs for respiration – Does the organism possess specific organs for the exchange of gases? Where does the exchange occur—skin, gills, lungs?

Organs for excretion- How does the animal get rid of nitrogenous waste?

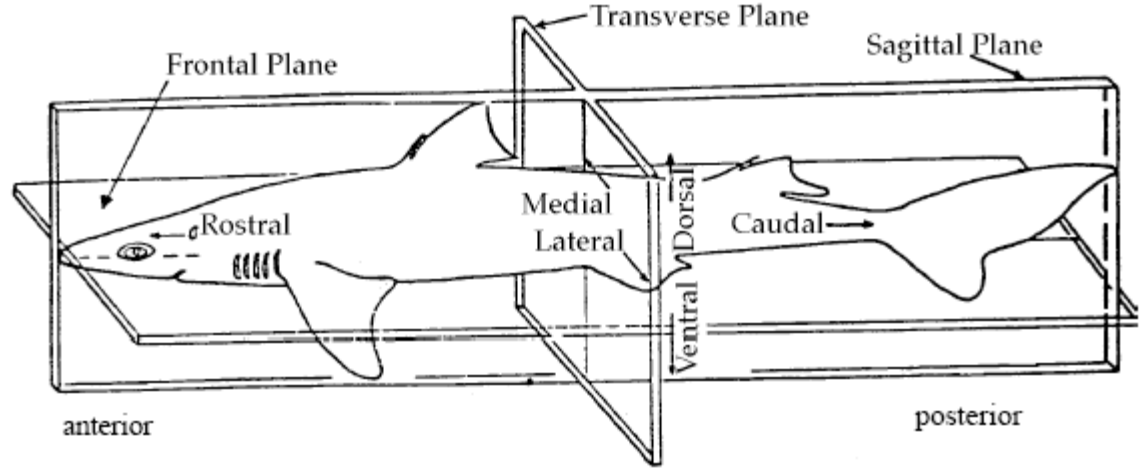
Support system- How does the animal support its body/ Is there a skeleton present-endoskeleton or exoskeleton? If the animal has no true skeleton, does it use a hydrostatic skeleton for support (fluid within and between cells and in body chambers such as the gastrovascular cavity or coelom)?

Habitat- terrestrial or aquatic

Anatomical glossary

- Anterior or rostral: towards the head end.
- Posterior or caudal: towards the tail end.
    - "Your nose is anterior of your belly button. Your chin is posterior of your nose. "
- Dorsal: toward or near the back.
- Ventral: toward or near the belly.
    - "Your belly button is ventral of your intestines."
- Medial: in or near the plane in the middle of the body.
- Proximal: near the base or site of attachment
- Distal : near the tip.
    - "Your fingernails are on the distal ends of your fingers."
- Sections through the body are called:
    - Sagittal: dividing the animal into left and right sides
    - Frontal: dividing the animal into dorsal and ventral parts.
    - Transverse: dividing the animal into anterior and posterior parts.

See this figure:



You need to bring your copy of Campbell for reference-extremely important for this lab.

Phylum Porifera

Phylum Porifera (Latin porus, pores; Greek fera, bearing) encompasses the sponges which split early from the main branch of animal evolution and has given rise to no other animal groups. The phylum contains approximately 9,000 species of sponges, all of which are aquatic and most of which are marine. Although adult forms are sessile, the larvae (immature forms) are motile. Sponge bodies consist of two cell layers, an outer epidermal layer and an inner layer of flagellated collar cells, but have no tissues or organs. Between the layers lies an acellular layer called the mesohyl which contains amoeba-like cells (amoebocytes) with various functions such as food storage, digestion, waste elimination, and formation of reproductive cells. Some amoebocytes secrete materials that form an endoskeleton that supports the sponge. These support materials include spongin, a fibrous protein, and spicules, a mineral crystal. Bath sponges, for example, contain fibrous endoskeletons with no spicules. Sponges generally lack anterior/posterior and left/right symmetry and often grow to fit the space in which they live. Sponges feed by filtering suspended food particles out of the water column (i.e., suspension feeders). Water flows through the numerous pores that perforate the sponge's body into the central opening called the spongocoel and then out of the sponge through a larger opening called the osculum. The central cavity or spongocoel is not a digestive tube or body cavity in the sense of a coelom but is only a channel for water. Moreover, the osculum is not a mouth but an opening used as an outlet for the current of water passing through the sponge. The flagellated collar cells (also called choanocytes) bring water into the sponge through the pores and the collar sieves out food particles such as microscopic algae, bacteria, and organic debris. Most sponges are hermaphrodites and can reproduce both sexually via sperm and eggs and asexually from fragments of a parent sponge.

Examine the section of sponge. Observe the pores for which the phylum is named. Be able to describe how sponges feed.

Examine the spicules. In addition to structure, what other function might these serve the sponge?

What would you hypothesize about the movement of oxygen and waste throughout the sponge body and into and out of the cells?

How would you describe the symmetry of a sponge?

Given that all sponges are filter feeders, why are all aquatic?

Do you see evidence of nervous or circulatory systems?

Do you see evidence of cells organized into tissues or organs?

Phylum Cnidaria

Phylum Cnidaria (Greek Knide, nettle; Latin aria, like) contains approximately 10,000 species, all aquatic and mostly marine. Cnidarians exhibit radial symmetry in two distinct body forms: (1) polyps, a primarily stationary or immobile form (e.g., sea anemones, corals, hydra), and (2) medusa, a free floating, mobile form (e.g., jellies). Some species display both body forms during their life cycle. Cnidarian bodies consist of two tissue layers, the outer epidermis and inner gastrodermis, separated by a gelatinous material, the mesoglea (not to be confused with mesoderm) that helps support the body. The central, sac-like gastrovascular cavity has a single opening which serves as both mouth and anus. Undigested food remains are ejected through the same opening as food is ingested. The water in the gastrovascular cavity also serves as a hydrostatic skeleton. Cells in the two tissue layers have bundles of microfilaments arranged into contractile fibers (note that true muscle develops from mesoderm, not found in cnidarians). The contractile cells work against the hydroskeleton to perform movement. A non-centralized nerve net coordinates movement of the contractile fibers and simple sensory receptors are distributed around the circumference of the body. Cnidarians use the tentacles around their mouth to capture prey. The tentacles contain specialized cells called cnidocytes which contain organelles called cnidae. Cnidae are capable of everting to entangle or sting a prey item or in defense. The forms of cnidae tipped with a stinging barb or spine are known as nematocysts. Some cnidae can inject poison as well.

Examine hydra whole mount and cross sections.

Sketch the longitudinal cross section and label the gastrodermis, epidermis, mesoglea, mouth, anus, tentacles, and gastrovascular cavity.

Why is radial symmetry adaptive for a sessile animal in an aquatic habitat?

Name a disadvantage of having one opening into the digestive cavity.

Examine the slide of the hydra nematocyst.

How does the hydra use the nematocyst?

Examine the slides of Obelia, a colonial cnidarian with both polyp and medusa stages.

Compare the slides to the diagram provided. Sketch and label feeding polyps, reproductive polyps, and medusa buds.

How does the medusa stage fit into the lifecycle of Obelia?

Which stages are haploid and which are diploid? Label the feeding polyps, reproductive polyps, and medusa buds as such.

Of what advantage is the colonial life adopted by Obelia?

If an animal is stationary what is the purpose of having a motile phase at some point in the life cycle?

Why is it advantageous to have sensory cell encircling the bell of the medusa?

Phylum Platyhelminthes

Phylum Platyhelminthes (Latin platy, flat; Greek helmis, worm) includes about 20,000 species. A dorsoventrally flattened body (i.e., thin between dorsal and ventral surfaces) characterizes these species. Like other bilaterally symmetrical animals, flatworms have three layers of tissue but have no body cavity or coelom. Most platyhelminthes have a digestive tract with one opening; although the parasitic cestodes or tapeworms lack a digestive tract. Flatworms lack organs specialized for gas exchange and circulation, and most nitrogenous waste diffuses directly out of the cells into the surrounding water. However, they do possess specialized cells, called flame cells that primarily help the organism maintain osmotic balance. Free-living flatworms such as planaria are in the minority, comprising less than ¼ of the species, compared to parasitic forms such as flukes and tapeworms. Flatworms live in marine, freshwater and terrestrial habitats and range in size from microscopic to over 20 meters long in some tapeworms!

Examine the Planaria slide whole mount.
Examine the body for a number of digestive openings (the stained planaria shows the digestive system). Observe the pharynx and mouth. The pharynx lies in a pharyngeal chamber inside the mouth. The proximal end of the pharynx opens into the dark-colored branched intestine. How do planaria rid themselves of solid waste?

Which end is the head? What led you to that conclusion?

Two auricles containing a variety of sensory cells (e.g., touch and chemical receptors) project from either side of the head or anterior end (blunt end.) Two pigmented eyespots, sensitive to light intensity and direction but unable to form images, lie between the auricles. The pigment cups contain the photosensitive end of retinal cells which extend from the brains. Two cerebral ganglia (the brain) lie beneath the eye spots, and two ventral nerve cords extend posteriorly from the brain. Transverse nerves connect the two nerve cords forming a ladder like nervous system.

How might bilateral symmetry be an advantage to a motile organism? What is cephalization? Under what circumstances would it be useful? Under what circumstances would it not be useful?

Look at planaria in cross section. The slide shows sections through three different regions of the body.
Do you see a body cavity or coelom? What word describes this condition? (The pharyngeal chamber and spaces in the gut are not a coelom – recall that the coelom is a space surrounded by mesoderm between the body wall (ectoderm) and lining of the digestive tract (endoderm)).

How many tissue layers can be detected?

What provides support for the body?

Diagram the flatworm as seen in a cross section at the level of the pharynx. Label the epidermis, muscle derived from the mesoderm, the lining of the digestive tract derived from endoderm, and the pharynx.

How do flame cells relate to the ability of flatworms to live in freshwater and terrestrial habitats?

Examine the tapeworm slide.

Adult tapeworms live in the intestine of numerous animals including humans. The scolex at the anterior end of the worm allows the animal to anchor itself to the intestinal wall to avoid being swept out by digestive movements. Posterior to the scolex is a chain of reproductive structure called proglottids each containing male and female reproductive organs. Mature proglottids loaded with thousands of eggs detach from the worm and leave the host's body with the feces. Tapeworms lack a digestive system and must absorb nutrients across their body surface directly from their hosts.

Sketch the tapeworm proglottid and label the uterus, ovary, testes, and genital pore.

Compare tapeworm and planaria anatomy in relation to their lifestyles (especially consider the proglottids, anterior structures, and lack of a digestive tract in tapeworms).

How does the flat body shape help with gas exchange and circulation in an animal without organs specialized for such functions?

<u>Phylum Nematoda</u>

Phylum Nematoda (Greek *nema*, thread,; *eidos*, form) contains about 90,000 identified species but may contain up to a million; indeed, nematodes may be the most abundant animals on earth. They live in virtually all habitats, including moist soils, beach sand, slat flats, ocean, hot springs, and lakes, and exhibit a great diversity of lifestyles. Although some of our most familiar parasites are nematodes (e.g., dog and cat heartworm, hookworm, roundworm, pinworm) most species are harmless or beneficial. These worms range from 0.1mm to 9m (a parasite in sperm whales) in length. These animals exhibit bilateral symmetry with three germ layers. Nematodes

have a complete digestive tract with two openings but no circulatory system or organs for excretion of gas exchange. Their nervous system consists of a ring of nervous tissue around the anterior end of the worm with one dorsal and one ventral nerve cord extending posterior from the ring.

Examine the slides of the longitudinal sections of male and female Ascaris.

Identify the digestive tract. How is food taken in and undigested wastes expelled? What are the advantages of a complete digestive tract (i.e., a gut with two openings)?

Look at the cross section of male and female Ascaris.

Note that the body wall is made up from the outside inward of the cuticle (noncellular), epidermis (cellular), and muscle fibers. The muscle derived from the mesoderm lies at the outer boundary of the body cavity. Locate the intestine (derived from endoderm).

Can you detect muscle tissue adjacent to the endodermal layer? What do we call a body space that is lined by mesoderm laterally and endoderm medially?

Most of the body cavity is filled with reproductive organs. Identify male and female reproductive organs.

Identify the nerve cords. How many are there and where are they located?

Sketch a cross section of a male Ascaris and label cuticle, epidermis, muscle fibers, intestine, body cavity (give specific name), testis, dorsal and ventral nerve cords.

Phylum Nemertina

Phylum Nemertina (Greek Nemertes, a sea nymph) contains about 900 identified species ranging from less than 0.5mm to 30m in length, one of the longest invertebrates known. Their common name of ribbon worms refers to their flat bodies and often vibrant color patterns. They are characterized by a long anterior proboscis used to capture prey, explore their environment, and defend themselves. They can rapidly evert their proboscis which may extend up to three times their body length. Nemertines possess a blood vascular system through which blood pumps and a digestive tract with two separate openings, one for the mouth and one for the anus. Some species may promote gas exchange through a vascularized foregut but most occurs through the epidermis. Like flatworms, these species also possess flame cells that regulate ions and water and perhaps dissolved waste. Their nervous system resembles that of flatworms with cerebral ganglia and longitudinal nerve cords with connecting nerves. They also possess numerous anterior sensory organs for chemical, tactile, auditory, and light reception. Nemertines possess three body layers but their categorization as to the status of a coelom remains somewhat controversial. However, molecular data and ultrastructural evidence strongly suggest that they indeed possess a coelom but one that has undergone significant modification into the blood vascular system, gonadal sacs, and cavity that houses the proboscis.

Examine the slides of *Cerebratalus* embryonic development.

Identify the type of cleavage. Sketch the 8-cell stage. Is this animal a protostome or deuterostome?

Identify the blastula and gastrula. Sketch the gastrula and label the blastopore and archenteron. Will the blastopore become the anus or mouth? What does the archenteron become?

Phylum Annelida

Phylum Annelida (Latin *annellus,* little rings) contains approximately 15,000 species including marine, freshwater, terrestrial members and both free-living and parasitic species. Earthworm and leeches are the most familiar examples and a quick examination of their bodies illustrates why they are referred to as segmented worms. However, the most specious group of annelids is the polychaete class, most of which are marine. The outer body segments coincide with internal compartments containing serially repeated nervous, muscle, and excretory systems. Body segments are filled with a fluid that serves as a hydrostatic skeleton against which the muscles contract to allow movement. In contrast to the relatively unspecialized nematode digestive tract, the earthworm digestive tract is divided into several different organs. At the anterior end are the mouth and pharynx, a muscular organ used to draw food into the mouth. The esophagus, a passageway between the pharynx and the crop (a temporary storage organ for food), follows. From the crop, food passes to the gizzard which grinds the food into smaller pieces. The intestine follows posteriorly and runs the remainder of the worm. Enzymatic digestion occurs in the intestine followed by absorption of nutrient molecules. Undigested material is expelled through the anus. A pair of cerebral ganglia (brain) lies anterior to the pharynx and connects to a ventral nerve cord with segmented ganglia. The closed circulatory system consists of dorsal and ventral blood vessels connected by segmental pairs of vessels some of which around the esophagus are muscular and pump blood. The excretory system consists of segmentally – repeated pairs of metanephridia that remove nitrogenous waste from the blood and coelomic fluid. Individual earthworms possess both male and female reproductive organs (i.e., hermaphroditic). Mating worms lay head to tail side by side and transfer sperm to each other. On each worm the clitellum, a specialized swollen section of segments, produces a mucous cocoon that surrounds the eggs and transferred sperm. The cocoon then slides off each worm's head depositing the mass in the soil. The embryos develop inside the protective cocoon.

Observe earthworms under the stereoscope. Note the segmentation, mouth, anus, clitellum (a structure specialized for reproduction), and setae (small bristles on each segment used for locomotion).

Examine the cross section posterior to the clitellum. Sketch and label the intestine, two muscle layers (one inside the skin and one on the surface of the intestine), coelom, ventral nerve cord, dorsal and ventral blood vessels, epidermis, and metanephridia. Which parts are derived from the endoderm, mesoderm, and ectoderm? Label these.

Gas exchange must take place across thin wet surfaces. How do you think gas exchange occurs?

Examine the composite cross sectional slide of the earthworm. Locate the brain and pharynx.

Examine the slide of the leech whole mount. Note the segmentation.

What structures adapt it to a parasitic (external blood sucker) life style?

Locate the mouth and anus.

Examine the cross section of the leech. Identify the ectoderm, mesoderm, endoderm, and coelom. What does the coelom look like?

Phylum Echinodermata

The phylum Echinodermata (Greek echin, spiny, Greek derma, skin) includes about 7,000 species. All live in marine habitat, and as adults all exhibit a radial, five-part appearance. Some sources refer to them as radially symmetrical while other sources cite certain anatomical features that render them not truly radially symmetrical. However, this radial appearance (symmetrical or not) is believed to be secondarily derived from a bilateral ancestor-the larvae of echinoderms are in fact bilateral. This phylum includes sea stars, sand dollars, sea urchins, and sea cucumbers. Echinoderms possess many unique adaptations. For example, they locomote by means of a water vascular system, a network of canals connected to the outside by pores through the epidermis. By using specialized contractile organs, echinoderms vary the water pressure in certain portions of the water vascular system causing hundreds of tube feet that project through the body wall to extend or retract; this allows the echinoderm to move, capture food, or cling to surfaces. Many sea stars represent important predators of clams and mussels and have an unusual way of feeding on them-the sea star wraps its tube feet around the shell and pulls constantly with them until it fatigues the muscles that hold the shells together. This causes a small opening in the shell (less than 1mm) that allows the sea star to evert its stomach and insert it into the shell where it digests the mollusk's soft body parts. Sea urchins and sand dollars have no arms; all are spherical or disk shaped. The body surface consists of epidermis covering an endoskeleton composed of calcareous ossicles, and all urchins and sand dollars are covered with movable spines (be sure to look at them at the NEAQ in a couple of weeks). The digestive tract of most echinoderms have an oral surface or mouth which faces the ventral side of the animal (i.e., toward the seafloor or substrate) and an aboral surface with an anus that points in the opposite direction. Echinoderms achieve circulation through hemal and perihemal coelomic systems, an array of canals and rings derived from the coelomic space. Nitrogenous waste diffuses from the coelom through the tube feet which, in some species, also serve respiratory functions. The nervous system consists of a nerve ring encircling the esophagus (in the central disc of the body) with nerve nets extending into the body. Echinoderms also have sensory receptors for light, chemical, touch, and balance. Many echinoderms can regenerate missing body parts.

Examine the pictures or samples of echinoderms. Note the radial appearance and five-part body plan. Understand why despite this they are included in phylogenies with bilateral rather than radial animals.

Do you see any evidence of a head or anterior end and a tail or posterior end?

Examine the cross section of a sea star arm.

Identify the coelom, tube feet, radial canal (part of the water vascular system), and gonads.

Examine the slides of sea star cleavage, blastula, and gastrula.

Identify the type of cleavage. Sketch the 8-cell stage. Is this animal a protostome or deuterostome?

Identify the blastula and gastrula. Sketch the gastrula and label the blastopore and archenteron. Will the blastopore become the anus or mouth? What does the archenteron become?

Phylum Chordata

Your textbook includes two subphyla of invertebrate chordates (animals without a vertebral column) and one subphylum of vertebrate chordates within the phylum Chordata (your textbook is a lumper). The Urochordata includes tunicates and sea squirts, and all are marine. The Cephalochordata include lancelets or Amphioxus, and all live in aquatic habitats. The vertebrates or craniata comprise the largest group of chordates with about 45,000 species. This group includes animals most familiar to humans - fish, birds, amphibians, reptiles, and mammals. All chordates, vertebrate or invertebrate, share common characteristics: a single dorsal hollow nerve cord, a notochord, gill structures and a post-anal tail.

For this part of today's lab, you will view images of cross sections of the human body. These images came from a project in which human bodies were preserved, frozen, cross sectioned in more than 150 locations along the body, and photographed. The images for this lab exercise were selected from this enormous undertaking. Note that all sections are viewed from below, looking toward the head. This corresponds to the way radiologists view sections of the body but not to the usual anatomical view of looking down toward the feet. Also, the left side of the body usually appears on the right of the photograph and vice versa.

On the outline of the human body (to be provided during lab for inclusion in your lab report), identify the approximate location of the selected cross sections. Where appropriate identify the images as male or female. Use figures from the Photographic Atlas for reference.

Using these images, identify and provide evidence for the following:
Type of body symmetry
Layers of embryonic tissue
Presence of coelom
Number of Digestive tract openings
Open or closed circulatory system
Organs of respiration
Organs of excretion
Type of support system

Position and complexity of nervous system

Lab report

- Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. All drawings must indicate size. Include a title page with the name and date of the lab and your name.
- Due next week at the start of the lab session you are currently in. 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 (Note that the lab manual has many more questions associated with the organisms you are examining that you do not have to officially answer for the lab report. However, your understanding of this material will benefit greatly if you give these questions due consideration):

(1) Drawings of each of the following organisms:

a. Hydra (whole mount)
b. Planaria (cross section at the level of the pharynx)
c. Ascaris (cross section of male)
d. Earthworm (cross section posterior to the clitellum)
e. Sea star arm (cross section)
f. Sponge

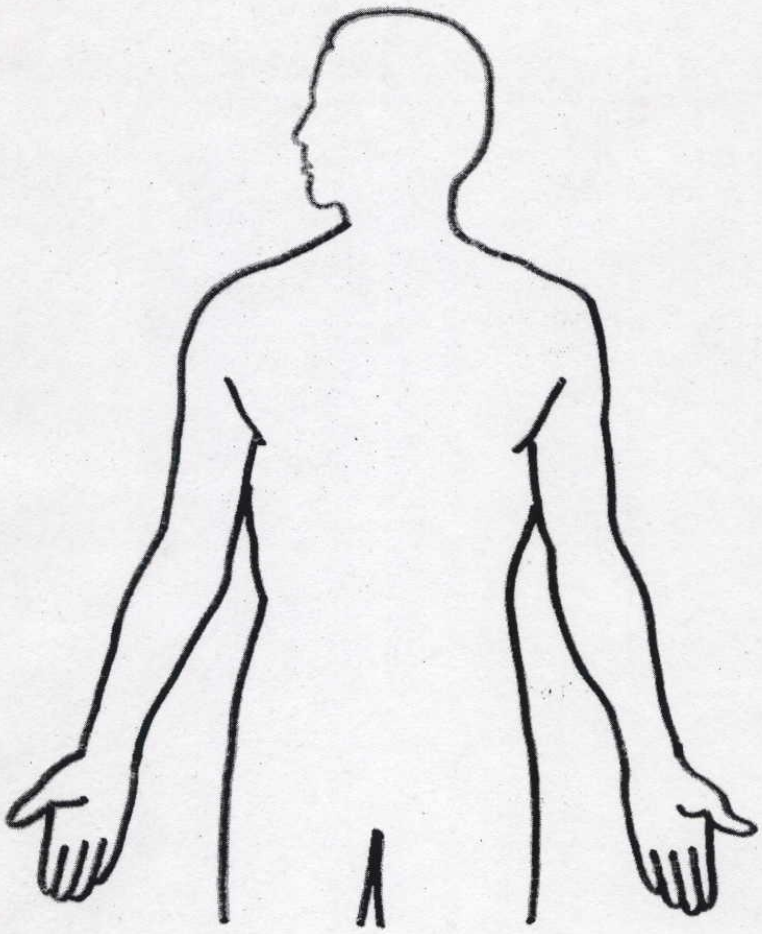
Label the structures indicated in the lab manual. For each drawing, provide the name of the organism, the phylum, and an indication of scale.

(2) Drawings of 8-cell stage and gastrula of embryo development for the following organisms:

a. Cerebratalus
b. Sea star

For each drawing, provide the name of the organism, the phylum, and an indication of scale. Label each according to the type of cleavage pattern exemplified and whether it is a protostome or deuterostomes. On the gastrula drawings, label the blastopore and indicate whether it will become a mouth or anus.

(3) Indicate on the human outline where each of the cross sections are located. If possible, indicate whether the cross section is from a male or female. Turn in the labeled human outline page with your lab report.



Lab 8 Pre-Lab: Phylogenetic Collection Lab
Name:_____

The pre-lab exercise for this lab is different in nature from the others, it has a physical component and you should read the entire lab exercise before starting the pre-lab. You should begin working on it as early as you can to give yourself time to collect specimens. Like all pre-lab assignments, it is very important to complete in order to understand the lab, but this one goes even further, you actually collect specimens to bring in and explain in the lab.

Instructions Between now and your lab meeting, **each student** must collect representatives of at least 5 different phyla. Fill out the chart of specimens that you are bringing in. All specimens must be from different phyla. Access the following URLs for phyla lists.

http://intro.bio.umb.edu/111-112/OLLM/112s99/phyla/animals.htm
http://intro.bio.umb.edu/111-112/OLLM/112s99/phyla/bacteria.htm
http://intro.bio.umb.edu/111-112/OLLM/112s99/phyla/fungi.htm
http://intro.bio.umb.edu/111-112/OLLM/112s99/phyla/plants.htm

Specimen chart

					Where it lives	
Kingdom	**Sample #**	**Phylum**	**Name**	**Where you found it**	**Geography**	**Habitat**
			common name or genus, species name	(beach, supermarket, etc.		
	1					
	2					
	3					
	4					
	5					

If you collect more fill this in:

	6					
	7					
	8					
	9					
	10					

.

Lab 8 Phylogenetic Collection

This is an introduction to the idea of Phylogenetics and the practice of comparing specimens. There is much detail and information involved and this exercise is meant to get you thinking about how all life is similar and not by comparative means. This one lab is not meant to have you master all phyla but to help you start viewing the living world in a more descriptive and comparative way.

Objectives

- to connect the diversity of organisms described in class with the real world.
- to connect particular phyla of organisms with their characteristic habitats.
- to compare & contrast organisms within the different phyla.
- to show that most of "nature" that you usually see belongs to only a few phyla.
- to have you look at the world in a different way.

Assignment

Between now and your lab meeting during the week listed on the syllabus, each student must collect representatives of 5 different phyla.

Note that you must have collected your specimens **before** this lab meeting!!!

Specifically:

2. Your phyla must be listed in Campbell.

3. In lab each student will present and discuss his or her collection.

4. In order to get credit for a particular phylum, you must bring in something that is clearly recognizable as a member of this phylum to show to your instructor. It can be a whole organism or a piece of an organism, but it must be clearly recognizable as a member of that phylum. For example, a dog hair is clearly from a mammal (the only animals with hair) and since mammals are chordates, this is clearly a member of the phylum chordata. You can use a microscope to show your instructor any microscopic samples. It is nice to have specimens that represent more of the entire organism, a small branch from a tree would be good. If you bring in dog hair, a picture of the dog would be a very nice thing to have as well.

5. You can obtain samples from any source including the supermarket, the outdoors, in your backyard, a beach or a park. You may find items with 2 or 3 good specimens growing together but from different phyla. You should read about the different kingdoms and their phyla first, and try to envision what you will be able to collect or find in the outdoors or a supermarket. It is best to know some of the major differences to look for before you go to physically collect them.

6. In order to get credit, you must also specify where each of your samples came from. You must specify both geography (part of the world) and habitat. Note that, if you get

your sample from other than its natural habitat (greenhouse, supermarket, etc.), you must specify where this organism originally came from. For example, if you include dried krill that you got at Star Market or a market in Chinatown, you'd have to say where it originally came from (geography: probably where it was processed) and from the open ocean (habitat). However, do not bring in food items that need to be refrigerated. Go for dry if you can or canned if you have to; live is nice but only if it can stay alive.

You must be prepared to *defend* your selections. That is, it is up to you to prove to your TA that a particular organism is what you say it is and that it belongs in the phylum you say it does.

Procedure

• You can get samples from anywhere. Some suggestions:

– marshes	– supermarket	– fish store
– in your house	– in your neighborhood	– ethnic markets
– off of docks	– bait shop	– a greenhouse
– farm	– forest	– sea shore

• You can consult any sources you need outside of lab (you will need to consult outside sources).

– the library	– your instructor	– the internet

• You will need to preserve some of your specimens. You can try freezing, drying, or putting them in a mixture of 2 parts rubbing alcohol (isopropanol) to 1 part water (keep this in a tightly closed container!) and store at room temperature. If you are freezing things use a cooler to transport in and out of lab.

THIS WILL TAKE A LONG TIME; DON'T WAIT UNTIL THE LAST MINUTE!

In lab during the week listed on the syllabus:

• Each student should bring in their collection with the completed list as described below.
• Your instructor will check off the various organisms and collect your lab reports for grading.
• Your instructor will then go phylum by phylum and ask "does anyone have a …".
• The class will then discuss what they have found, where they found it, etc
- Additionally, you will classify 25 specimens provided by your instructor and fill out the chart below as it applies to each specimen. Use your text for reference.

Kingdom	**Sample #**	**Phylum**	**Name**	**Where you found it**	**Geography**	**Habitat**
	1			UMass		
	2			UMass		
	3			UMass		
	4			UMass		
	5			UMass		
	6			UMass		
	7			UMass		
	8			UMass		
	9			UMass		
	10			UMass		
	11			UMass		
	12			UMass		
	13			UMass		
	14			UMass		
	15			UMass		
	16			UMass		

	17			UMass		
	18			UMass		
	19			UMass		
	20			UMass		
	21			UMass		
	22			UMass		
	23			UMass		
	24			UMass		
	25			UMass		

Lab Report

You should choose one phylum of organisms that was represented in your or your classmates' collections (it need not be a phylum that you brought in, but it must have been brought in by somebody). In a report of no more than 1-1.5 double-spaced pages, answer the following questions about the specimens of your phyla that you and/or your classmates brought in. Your report may only deal with organisms that were presented by you or your classmates. Include a title page with the name and date of the lab and your name.

1. Which organisms are you talking about in your report (a minimum of 3) and to which phylum do they belong?
2. What is similar about these organisms? Be specific about body plan, habitat, etc.
3. What is different about these organisms and how do differences in their habitat, food source, 'life style', etc. explain these differences?

Lab 9 Field Trip II:
New England Aquarium

Note – There is no pre-lab for this lab. The website for the aquarium is www.neaq.org

Objectives

- To examine the diversity of water-dwelling organisms and to consider the adaptations required for aquatic habitats.
- To observe living organisms (as opposed to the dead ones at the HMNH) in their habitats as they interact with other organisms.
- To observe live ecological systems.

Introduction

Living in water as opposed to on land changes strategies for locomotion, gas exchange, light capture, feeding, reproduction, temperature regulation, defense, and many other functions. Water can support animals that are too large and too structurally weak (for their size) to survive on land; water changes the ability of these animals to maintain body temperature economically. The diminishing of light with depth limits where photosynthesis can occur and also changes the wavelengths available. Aquatic animals may obtain oxygen either from surface air, using lungs or directly from the water, using gills. Although life began in the water and moved onto land, some land animals "returned to the water"; you will see some of them.

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 Aquarium**:

1. Read up on classification systems in Campbell and familiarize yourself with terms like kingdom, phylum, etc.
2. Look up all the names listed in question (7) and make a few notes about what an organism in this group would look like - that will make it a lot easier to find these organisms. You should use Campbell as reference.
3. Think about how you will answer each of the questions & make some notes to help you look.

Tickets to the Aquarium will be given out in lab. You can go to the Aquarium anytime; your instructor will be there on_____. The Aquarium is a short walk from Aquarium Station on the MBTA's Blue line.

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 written with the same care and thoroughness as any other lab report.

You should pick up a map for reference.

Lab report:

- Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine. Include a title page with the name and date of the lab and your name.
- Due at the start of the lab session you are currently in during the week indicated 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 following questions. Retype the questions with the answers and number the questions.

General notes on answers to lab report questions:

When asked to "name an organism", you must always:

1. choose an organism found in the aquarium
2. give the common name as well as the genus & species names; the aquarium's web site: http://www.neaq.org has a virtual tour that lists many species' names.
3. give the name of the tank or exhibit where you found it

(1) Give a method of locomotion used by both land and aquatic animals. Name an organism that uses it.

(2) In the giant ocean tank, you will notice that different **fish** use different fins to swim. There are three major types of swimming motions; describe them. What is the most common type?

(3) What method of feeding is found in the ocean but not on land? Name an organism that uses it.

(4) Various morphological adaptations have evolved for different animal species to blend into their habitat ("cryptic morphology"). Describe an example of this cryptic morphology (name and describe how the animal blends in to its habitat) from each of the following habitats:

i) sandy bottom

ii) rocky intertidal zone

iii) Some animals show "anti-camouflage" (aposematic coloring) – that is, they are colored to be especially visible so that they are **avoided** by predators. Give an example of an organism in the aquarium that is colored in this way. How does this coloring strategy confer a selective advantage on this organism?

(5) Give two examples of mutualistic or commensal interactions between organisms of different species in the Aquarium. You should look up these terms in Campbell; good examples can be found in the Tropical Tank.

(6) Give three different methods of obtaining oxygen and one aquatic creature from the Aquarium that uses each.

i)

ii)

iii)

(7) For each of the groups of organisms below, find a water-dwelling example found in the Aquarium.

Group	**Example**
turtles	
cnidarians	
gastropods	
cephalopods	
bivalves	
echinoderms	
birds	
mammals	

(8) For one of the animals in the groups in question (7) that descended from land-dwelling ancestors, describe two of it's adaptations to an aquatic habitat.