Biology 0861 & 0871 Course Manual

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Table of Contents

Using this manual

Welcome to Biology 0861 & 0871! This course manual is designed to supplement your lab, field and classroom activities. You will probably not do *every* activity or assignment in this manual; your instructor will tell you which ones to print out and bring to class. In general, you can expect to use the Ecology, Evolution and Microbiology & Fungi sections for Biology 0861, and the Algae & Plants and Animals sections for Biology 0871. The order in which you cover the topics within each course will also depend on your instructor.

We strongly recommend that you prepare for lab and field activities by reading over the relevant pages of the lab manual ahead of time, and by looking up any unfamiliar terms. Familiarizing yourself with the safety information in the Appendix is also highly recommended. Coming to class prepared will help you to use your time efficiently and to learn as much as possible.

This course will introduce you to much of the diversity of life on Earth, as well as some of the very important core concepts in biology – we hope you enjoy it!

Ecology

Learning objectives

Energy flow:

- Distinguish between producers and consumers, and describe how each of these acquires energy. Be able to describe the 5 types of consumers.
- Construct a simple food chain and food web and describe how an increase or decrease in the population of one species would affect other species in the food chain/food web.
- Distinguish between grazing and detritus food chains.
- Identify the trophic level of organisms in a food chain and food web.
- Describe the pyramid models of energy, biomass, and abundance of organisms.
- Explain the 10% rule and apply it to explain why large carnivores are relatively rare, and are absent from some ecosystems.

Water and nutrient cycles:

- Compare water and nutrients cycles to energy flow.
- Describe the water cycle.
- Describe the carbon cycle, and be able to list the processes that add and subtract carbon dioxide from the atmosphere. Explain why the amount of carbon dioxide in the atmosphere is increasing.
- Describe the nitrogen cycle and the role of bacteria and plants in the cycle.
- Describe the phosphorous cycle.
- Explain nutrient limitation.

Climate and biomes:

- Explain the factors that affect climate.
- Describe the greenhouse effect.
- Describe the cause of global warming.
- Describe the major biomes of the world.
- Interpret a climatogram, and be able to describe the challenges that plants and animals would face in a given biome based on its climatogram.

Biotic and abiotic factors:

- Distinguish between abiotic and biotic factors of an ecosystem.
- Describe how abiotic factors affect where organisms are found, and where they are most abundant.
- Identify and describe biotic interactions among organisms, and be able to give an example of each type of biotic interaction.
- Explain what a niche is, and why two organisms cannot occupy the same niche in the same habitat.

Aquatic ecosystems:

- Describe and compare the various types of wetlands.
- Explain the challenges faced by organisms that live in a bog, and describe adaptations of bog plants that help them to cope with these challenges.
- List the abiotic factors that are important in aquatic ecosystems, and describe how these differ among different types of aquatic ecosystems.
- Describe differences between the photic and aphotic zones of the ocean.
- Explain what the intertidal zone is, and what challenges organisms in that zone face.
- Describe where kelp forests and coral reefs are found, and the importance of each of these.
- Describe the open ocean (oceanic zone) and benthic zone, and the major types of organisms found in each one.

Succession:

- Compare primary and secondary succession.
- Describe the stages of primary succession that eventually lead to a forest.
- Describe the stages of secondary succession following a forest fire.
- Describe the characteristics of pioneer species and later colonists.

Natural resources:

- Distinguish between renewable and non-renewable resources, and be able to give examples of both.
- Explain what is meant by “sustainability” and give two examples of sustainable land-use practices.
- Explain the cause and significance of soil erosion, deforestation, overfishing, air pollution, and acid rain.

Biodiversity:

- Explain the importance of biodiversity.
- Define the 3 types of biodiversity.
- Distinguish between species richness and evenness, and be able to compare simple ecosystems in terms of these factors.
- Describe global patterns of biodiversity, and be able to list at 3 reasons that the tropics tend to have higher diversity than other regions.
- Describe the criteria for identifying a biodiversity hotspot, and be able to name at least 2 regions of the world that are considered biodiversity hotspots.
- Describe at least 3 ways that human activities threaten and/or reduce biodiversity.

Field trips:

- Use a dichotomous key to identify native plants of B.C.
- Identify the abiotic and biotic components of an ecosystem.
- Describe biotic interactions occurring in bog and forest ecosystems.

Field notes

Writing field notes

You may be asked to take field notes on field trips. Bring a clipboard or some other hard writing surface, copies of the sample field notes journal pages included in this course supplement, and a pen or pencil. You might also bring a clear plastic bag so that you can protect your notes in the field.

How to Write Your Field Notes

Before each field trip:
You may need to print several copies of the field notes journal pages found in this course supplement in order to have enough for each field trip. Note that there is a space to write the page number in the upper right corner. Number your pages consecutively, and do not start over for each trip.

On the field trip:
Record general environmental observations of habitats, weather, temperature, terrain, and dominant vegetation.

As you move along, describe what you do and what you observe in as much detail as you can. Remember to name plant species when possible, name trails when you change locations, and describe all activities, including experiments.

Sketch plants and other interesting features.

Log the time in the margin throughout the trip, especially when you change locations, habitats, or activities.

At the end of the trip:
Write down the time, location, and conditions.

After the field trip:
Write the heading Species List and make a list of each species (by common or scientific name) that you identified on the trip.

Write the heading Summary and write a final paragraph that lists the total number of species seen, the changes in habitat you experienced, and any outstanding or unusual experiences you had or unusual species you saw.

How your field notes will be marked:
See the “Marking Rubric for Field Notes” following the field notes journal pages.

Your full name: page #___
Date:
Park name:
City, Province:

Field notes journal

Write the time in the column below approx. every 20 min:	Main goal for trip:
	Habitat of study:
	Weather:
	Temperature:
	General Description of your area at the start of your note-taking. Describe the terrain and name the dominant plants or other organisms you see. Where are they in relation to each other and you? Approximately how many are there?
	Exact location of the starting point (*e.g.* trail name):
	Now start to walk along the trail or in the site. As you go, note the time in the column on the left, and write detailed notes of **everything** below that you see, hear, and do. Describe everything. Also make at least 1 sketch of an unknown plant – your sketch should be ~¼ page large and be detailed (height/colour/style of leaf) so you can try to identify the plant later using an identification book

Your full name: page #___
Date:
Park name:
City, Province:

Time:	Notes continued:

Marking rubric for field notes

	Forgot to:
	write on only one side of page
	put name on each page
	number each page
	numbers pages consecutively from last field notes submission
	put date, month, year on each page
	write "JOURNAL" and trip location at the top of each page
	write purpose
	write down specific trail head name/location
	note ecosystem/habitat
	note weather
	note temperature
	wrote at least 2 pages while on trip
	wrote detailed description of trail head (species present, numbers, etc)
	wrote time in left column on at least 3 occasions/page
	estimated distances to plants, heights, numbers
	used descriptive language
	noted species by name
	gave location a context for each species noted
	described a species that cannot be identified
	included a detailed drawing of an unidentified species
	noted change in activities
	noted change in location/trail name
	*when doing an experiment, included hypothesis for experiment
	*when doing an experiment, included materials and methods of experiment
	*when doing an experiment, included results of experiment
	noted time & location of trip end
	*when continuing experiment next class, included post-field observations
	*following experiment, discussed possible meaning of experimental results
	included map, marked trails walked (and noted experiment location)
	include species list at end of notes
	included summary of whole trip
	*** (2) impressive effort
key: 1 = you lost 1 mark for leaving this out… √ = you did well	

Modified by M. MacKenzie from Biology 061/071 Manual by P. Ballin

Name:_____

Stanley Park Forest

DUE DATE: _____ Your score (out of 20): _____

We will meet at the main bus loop for Stanley Park, near the Stanley Park Pavilion. From there we will walk through the Rose Garden and across Pipeline Road and follow South Creek Trail toward Beaver Lake.

Part 1: Field notes (5 marks)
When we arrive at our study site, spend a few minutes making observations and taking notes. Attach your Field Notes Journal to this assignment when you hand it in. See "Writing Field Notes" for more detailed instructions.

Part 2: Tree survey (10 marks)
Work in a group of 2-3 students. Choose a tree as your starting point. Identify this tree, then walk along the trail and identify the *next 10 trees* you encounter (within about a meter or so of the trail) in each habitat type. Record the species of each tree below. In the column marked "C/D" indicate whether each tree is coniferous (cone-bearing with scale-like or needle-like leaves) or deciduous (with broad leaves) with a "C" or a "D", respectively.

Table 1. Tree survey data

Tree #	Riparian/Lake Species	C/D	Tree #	Forest Species	C/D
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		

** After the field trip: make a graph using these data and hand it in on a separate page**
Your graphs should indicate / compare species in the two habitat types.

Follow the graphing instructions given in class, and note the following requirements:
Use colour coding to indicate deciduous (broad-leaf) and coniferous (needle- or scale-like leaf) trees. Be sure to include:

- a proper figure legend with the date and place your tree survey took place, and information about the colour coding of the bars
- axes with titles
- the scientific names of the trees, using correct scientific nomenclature

The graph may be made on a computer (preferred) or neatly drawn by hand on graph paper. For more information, see "Making a Bar Graph" in the Appendix.

Part 3: Biotic interactions (5 marks)
Identify an interaction that is happening in the forest (remember that an interaction is between living organisms).

1. Name and describe the interaction, including the names (common names are fine) of the organisms involved.

2. Explain how you can guess that this interaction is happening - what clues can you see?

3. Describe how you could do a field study to find out if the interaction is really happening.

What to hand in:

- This worksheet
- Graph
- Field notes journal

Name:_____

Pacific Spirit Park: Camosun Bog and Forest

DUE DATE:_____ **Your score (out of 40): _____**

We will meet at 16th Ave and Camosun St, in front of Queen Elizabeth School. You can take bus #25 or #33 to this spot, or take the #99 to Sasamat and walk from there. From our meeting point, we will walk to Camosun Bog; the entrance is near 19th Ave and Camosun St.

Part 1: Camosun Bog(16 marks)

1. Describe the role of *Sphagnum* moss in the bog ecosystem.

2. Describe the abiotic factors in a bog that make it challenging for plants to live in this habitat.

3. Identify 4 species of bog plants and fill out the table for each one. *Do not copy your sketches from the informational signs – draw what you can actually see! The plants may look quite different from the signs, depending on the season.*

Table 1. Identification and adaptations of plants at Camosun Bog

a. Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

b. Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

c. Common name: Scientific name:
Adaptations for living in a bog:

Sketch, with distinguishing features labelled or described:

d. Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

Part 2: Pacific Spirit tree survey (14 marks)

Work in a group of 2-3 students. Choose a tree as your starting point. Identify this tree, then walk along the trail and identify the next 20 trees you encounter (within about a meter or so of the trail). It is fine (and expected) that there will be many of the same species – just record what you see rather than looking for 20 different species. Record the species of each tree below. In the column marked "C/D" indicate whether each tree is coniferous (cone-bearing with scale-like or needle-like leaves) or deciduous (with broad leaves) with a "C" or a "D", respectively.

Table 2. Tree survey data

Tree #	Species	C/D	Tree #	Species	C/D
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

4. After the field trip, make a bar graph of these data, following the same format as for the Stanley Park field trip. Hand in your graph on a separate page.

Follow the graphing instructions given in class, and note the following requirements:

Use colour coding to indicate deciduous (broad-leaf) and coniferous (needle- or scale-like leaf) trees. Be sure to include:

- a proper figure legend with the date and place your tree survey took place, and information about the colour coding of the bars
- axes with titles
- the scientific names of the trees, using correct scientific nomenclature

The graph may be made on a computer (preferred) or neatly drawn by hand on graph paper. For more information, see "Making a Bar Graph" in the Appendix.

Part 3: Understory species (10 marks)

We will walk to an area of the forest where the trees form a relatively closed canopy, and a nearby area with a more open canopy.

5. Compare the abiotic factors between the two areas (closed and open canopy); then describe and compare the understory species (i.e. ferns and shrubs) found in the two areas. Explain the pattern in understory species using what you know about abiotic factors and biotic interactions, as well as your observations from the field trip.

What to hand in:

- This worksheet
- Graph
- Field notes journal

Name:_____

Pacific Spirit Park: Camosun Bog (bog only)

DUE DATE:_____ Your score (out of 16): _____

We will meet at 16th Ave and Camosun St, in front of Queen Elizabeth School. You can take bus #25 or #33 to this spot, or take the #99 to Sasamat and walk from there. From our meeting point, we will walk to Camosun Bog; the entrance is near 19th Ave and Camosun St.

1. Describe the role of *Sphagnum* moss in the bog ecosystem. (2)

2. Describe the abiotic factors in a bog that make it challenging for plants to live in this habitat. (2)

3. Identify 4 species of bog plants and fill out the table for each one. *Do not copy your sketches from the informational signs – draw what you can actually see! The plants may look quite different from the signs, depending on the season.* (12)

Table 1. Identification and adaptations of plants at Camosun Bog

Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

Common name: Scientific name:
Adaptations for living in a bog:

Sketch, with distinguishing features labelled or described:

Common name: Scientific name:
Adaptations for living in a bog:
Sketch, with distinguishing features labelled or described:

Richmond Nature Park

Objectives:

1. Observe the causes and effects of ecological succession.
2. Identify microhabitats, plant species and associations, plant habitats and other members of the biological community.
3. Practice an ecological sampling technique.
4. Interpret the results of a scientific field study.

What to bring:

- Rubber boots or light hiking boots or running shoes
- Clothes to suit the weather conditions, including a hat. Consider rain pants and jacket if there has been rain, since you will likely brush vegetation.
- Field Notebook, with relevant Manual pages
- *Plants of Coastal British Columbia* by Jim Pojar and Andy MacKinnon or *Trees, Shrubs and Flowers to Know in B.C. and Washington* by C.P. Lyons and Bill Merilees
- Binoculars, camera

Notes:

- No plant collecting at Richmond Nature Park
- Rubber boots are highly recommended unless the weather has been dry.
- Prepare for this trip. Complete the labs *Richmond Nature* and *Wet Deserts and Green Carnivores* on pages IV-24-30 and the assignments *The Natural History of Bogs in British Columbia* and *Ecological Succession and Bogs* on pages III- 40-51. Write your hypothesis and methods for our experiment in your Field Notebook. Examine our class collection of bog plants. Form study teams of two or three students.

How to Get There:

From campus, drive (carpool if you can) south (right) on Clark. Follow it as it turns into Knight. Observe the Fraser lowlands and the former island of Tsawwassen as you go down the hill towards the Knight Street Bridge. Cross the Fraser River into Richmond. Continue south (do not turn-off) until you reach the end of Knight, and turn west (right) onto Westminster Highway. Follow it past the Auto Mall, over the highway. After you pass the signals at No. 5 Road, turn right into the Richmond Nature Park.

Field Methods:

Areas 1 and 2: The trip begins with an interpretive walk through the bog forest and the birch forest. Here we become more familiar with the story of bog succession, the organisms that live here, and their relationships to one another. Record your observations and pertinent information in your Field Notebook. Sketch the plants to get to know them better. Make your own bog plant identification book! *If you visit without the class, obtain a pamphlet, available at the park, which directs you on an interpretive tour around the Time Trail.*

Area 3: After emerging from the forest we collect data. We will sample an area of the open bog to more objectively assess the story of succession (see map). Be clear on the hypothesis we test: we want to observe whether or not there is a sequence of plant species up a hummock that approximates the order in which we expect succession to occur in this bog.

The independent variable is water content of the soil, which in turn affects other conditions such as pH, microclimate, and microbes. We will record dominant plant species, which become the dependent variable. In other words, water content of the soil, the cause, leads to an effect: differing plant species compositions.

After you write your hypothesis and methods in your Field Notebook, note the specific location where you collect your data, perhaps on a map of the area. Write about conditions and observations you consider relevant. For instance, you might note other plant species nearby, animals, microclimate, or questions that come to mind.

A sampling method enables us to gather representative data about the community without measuring all of it. Consider how to choose where you sample. Ideally, ecologists choose random samples for measurement. This way they avoid bias. That may be difficult to do, so make careful notes about bias in your selection of samples, because it may affect your data. For example, you may choose to sample near a trail, which may influence the undisturbed pattern. Or you may notice a climax tree, and use that as an endpoint in following a path of succession. Sometimes ecologists exercise biases such as this intentionally, and make it part of their methodology.

The sampling method we use is a type of grid system that looks like a rope ladder. Each section of the sampling grid is 10 cm x 30 cm. Lay one end of the grid in a low area and drape the rest of the grid up a hummock. Record on the data sheets the dominant species in each section of your grid until you reach the top of the hummock. Stop at the top; do not go down the other side. If a hummock continues rising past your last grid section, flip the grid up the hummock and continue sampling. Take care to run the grid parallel to the slope of the hummock. Some hummocks rise higher than others, so expect differences in the number of grid sections from sample to sample. Bog shrubs make it difficult to get the sampling grid near the ground; take care that your team agrees on which species dominates.

Form a group of two or three and record one sample for practice. Discard this data (why?). Your data may look like this:

Group # Sample #

top

labrador tea
bog laurel
bog blueberry
bog cranberry

bottom

Now take a control sample. Choose as flat an area as possible. Why do we do this? What pattern do you expect to find? Mark this sample *control* on your first data sheet.

Now proceed with your experimental samples. Take as many as time permits. Consider your bias in sampling (why did you pick that hummock?). Fill in your data sheets, numbering each and identifying your team. If you require more than one sheet to complete a sample, label it 1a, 1b, etc. Since your entire hummock is based on *Sphagnum*, do not count it as dominant unless little else is growing. Make notes around your data; for instance, you might note other non-dominant species, animals, humidity, or...? Think about the effects of uncontrolled variables on your results.

Submit your data sheets to the instructor. On each of your data sheets, identify your research team. Make very sure that your data is clear--it needs to make sense later. Each member of your team should have a backup data set. Write many notes for clarification. Bring your notes to class. The instructor will collate our data and distribute it in class. We will then decide how to assess it, since data alone do not complete a study. We must now interpret the results.

Interpret Your Data:

What do your data mean? How do you know if your data support or refute your hypothesis? If the order of plant species matches the predicted order, you have no problem with your answer. But how close a match counts as “support”? Will you allow a pattern with one out-of-sequence species to support your hypothesis? Two? Then, how far out of sequence will you allow? Scientists establish criteria for making such decisions, and so should you.

Once you decide upon a criterion, score the classes’ samples. A simple system of yes-it-does support the hypothesis/no-it-doesn’t, will suffice. What percentage of yes scores do you require to support the hypothesis that ecological succession in the bog proceeded as predicted?

Area 4: After our sampling session, we continue around the Bog Forest Trail to visit an area that was burned in the fall of 1974. Here we observe the plants that have invaded the site of this one-acre fire, which was sparked by a train.

If you are unable to join the class, obtain a sampling grid from the instructor. View the videotape in the library. If possible, plan to go to RNP with other students. Remember that the Nature House and park naturalists are resources for you. If you phone the park (718-6188) to make arrangements, you may be able to join a naturalist-led tour. Go the Richmond Nature Park website http://www.geog.ubc.ca/richmond/rnp/

Think and Link:

Is water content of the soil the appropriate independent variable? Which other variables could be the independent variable? How would you know if it were one or several of them together?

Compare this experimental field study with an experimental laboratory study that you have completed. How are they similar? How do they differ? Discuss your ability to control variables in the two situations.

Locate another area that demonstrates ecological succession, such as the shore of a pond, the side of a road, a logged area, or the edge of a playing field. Devise a sampling method to describe succession in the area. Carry out a field investigation.

Follow plant species changes up a nearby mountain. Correlate changing species associations with changes in altitude, soil, temperature, and precipitation.

Name: _____

Jericho Marsh

Part 1: Field trip

We will meet at the parking lot on the east side of Jericho Beach Park, just west of Wallace St. on West 2nd Ave. The closest stop on the #99 bus route is at 10th and Alma.

1. An instructor will demonstrate how to use the various equipment for measuring abiotic factors. Record your measurements in Table 1. Indicate your sampling locations on the map (Fig 1).

Table 1a. Abiotic factors at Jericho Marsh

Factor	**Value (with units if applicable)**
Air temperature	
Water temperature Near shore At surface near centre Below surface near centre (note depth)	
Secchi depth	
Oxygen concentration At surface near centre Near bottom (note depth)	
pH	
Ammonia concentration	
Nitrate concentration	
Phosphate concentration	

Table 1b. Abiotic factors at Jericho Marsh (continued)

Factor	**Description**
History (circle one)	Natural / human-made

Character of shoreline at water testing location (circle all that apply)	Rocky / boggy / sandy / muddy / meadow / wooded
Character of watershed (circle all that apply)	Mountainous / hilly / rolling hills / flat / swampy / wooded / open / cultivated / uncultivated
Strength of water current	Mild / medium / fast
Principal tributary streams (number and size)	
Pond substratum type	Mud / silt / clay / peat / detritus / hard pan / gravel / bedrock

Figure 1. Map of sampling locations at Jericho Marsh. © Google

2. Use field guides to identify some of the biotic components of the marsh ecosystem. Record them in Table 2. Show the location(s) for each species on the map (Fig 1).

Consider how these organisms might be connected - you will be using your observations to create a food web and to describe how changes in abiotic factors might affect the organisms you observed.

Table 2. Plants and animals observed at Jericho Marsh.

Plant, fish, bird, mammal, or invertebrate?	Species	Where found	Abundance (very common, common, occasional, rare)

5. Collect a sample of pond water as instructed. We will examine these samples back in the lab to find microscopic organisms.

Interpreting your Jericho Marsh water testing results

Secchi depth / Turbidity (Note: *Light penetrates to a depth 2-3X the Secchi disk depth)*:	
0-2 m	Eutrophic conditions. Algae growth and particulates may be too high for healthy water. Water too cloudy for best plant growth. Particles catch in gills.
2-5 m	Mesotrophic conditions. Algae growth is kept in check.
Oxygen	
0-4 mg/L	fish gasp for air at surface
4-6 mg/L	tolerable levels for short times, especially adults
8 mg/L	tolerable for young fish
10 mg/L	optimal level by most organisms in Pacific Northwest
12 mg/L	maximum possible in 7°C water
pH	
< 5	impairs fish smell and prevents eggs from hatching
5+	water safe for fish, amphibians, snails and many insects
6+	mayflies, stoneflies, and caddisflies cannot survive in water below pH 6
9+	impairs body functions of most organisms
Ammonia	
0mg/L	best reading is 0 if bacteria actively converting NH_3 to nitrate
Nitrate	
0-5 mg/L	oligotrophic conditions? Water may not have enough nutrients for plant life
5-7 mg/L	mesotrophic conditions. Pond communities thrive.
> 7 mg/L	eutrophic conditions? May encourage too much algal growth.
10 mg/L	maximum safe level for humans to drink (American EPA limit)
25 mg/L +	water no longer safe for pond life
Phosphate	
0-0.03 mg/L	Oligotrophic conditions? Water may not have enough nutrients for plant-life
0.03-0.05 mg/L	Mesotrophic conditions. Pond communities thrive.
0.1 mg/L	Water no longer safe for human consumption

Name: _____

Part 2: Pond life lab

1. With your partner, set up a compound microscope and a dissecting microscope (see "Using a Microscope" in the Appendix for further instructions). Collect a small dish of pond water, a well slide and coverslip, a dropper, and a watch glass (a small glass dish). Work to find as many different organisms as you can and identify them using the guides provided in lab. Record your observations in Table 3.

Table 3. Microscopic pond life collected from Jericho Marsh

Algae, protozoan, or animal?	Species	Description / sketch / observations

Table 3 (continued). Microscopic pond life collected from Jericho Marsh

Algae, protozoan, or animal?	Species	Description / sketch / observations

2. On a separate page, create a food web that includes organisms from Jericho Marsh - microscopic organisms you observed today and the larger organisms you saw on the field trip.

3. Choose TWO abiotic factors that we measured in the field and explain how changes in these factors would affect your food web.

Lighthouse Park

Objectives:
Identify plants using a field guide.
Describe features of the old-growth forest community
Compare different sub-biomes and microhabitats

What to bring:
- Light hiking boots or solid running shoes
- Clothes to suit the weather conditions (bring warmer clothes than you need for the city; the forest can get cold and you can always remove layers if you are too warm)
- A map of Lighthouse Park available online at: http://www.lighthousepark.ca/wp-content/uploads/2014/01/lhp_brochure_map.pdf
- The handout *Lighthouse Park Plant List,* the handout *Some Plants of Lighthouse Park,* field note sheets, clipboard, a plastic bag to protect notes from the rain, and these pages.
- Lunch or snack; water or drink
- Optional:
  - a detailed plant identification book. You can find the following in the library:
    - *Plants of Coastal British Columbia* by Jim Pojar and Andy MacKinnon
    - *Trees, Flowers and Shrubs to Know in B.C.* by C.P. Lyons and Bill Merilees
  - Binoculars, camera

Notes:
- We will walk down a fairly steep rocky trail that might be wet from rain.
- No plant collecting at Lighthouse Park!

How to Get There:
If you are driving from campus: drive west (left) on Great Northern, north (right) on Main, west (left) over the Georgia viaduct, then, after finding Georgia Street, cross the Lion's Gate Bridge. Stay left and take Marine Drive west. The scenic drive nears the park when it winds up a hill. You will know you are close when you see the gas station on the right and the Anglican church on the left. When you reach the 5000 block of Marine Drive, you will finally see a bus stop on the left and a large wooden sign that says "Lighthouse Park". *Be careful* when turning left: visibility is limited and you turn into a one-lane road. *Drive down the lane slowly*. The parking lot is on a hill. Park at the bottom of the hill. We will meet at the bottom of the parking lot near the west-side trail marker for "Juniper Loop" trial.

To take the bus: Take bus #250 from downtown to Lighthouse Park (stop at Beacon Lane) or check online at http://tripplanning.translink.ca/ for your best route.

Field Methods:

Prepare to enter an ancient forest, never logged, and compare its complexity to Pacific Spirit Park, logged about 1900. The climate on the coast of Lighthouse Park resembles that of the Gulf Islands and the east coast of Vancouver Island, thus contrasting with the moister forest where we start our trip. In addition, the rugged topography provides many different microhabitats, furthering the diversity of life in this small area, so close to an urban center.

Area 1: an ecotone. In the lower parking lot, identify two plant species, either by looking up a plant you find (easier if you make it a tree or shrub), or by finding a plant you look up, from the Lighthouse Park Plant List. Then find someone else who has done the same and each-one-teach-one. Next you two find another two, and now you may have eight plants identified. Continue the process. We will come together to review common species.

Area 2: an ancient forest. Enter the trail head of **Juniper Loop** and walk a short distance to examine community structure in an old growth forest.

Start taking field notes here: Note the time in the margins of your notes every 15-20 minutes, write down all you see and hear, identify the plants, animals, and so forth by species name if you can. Use your handout to help you. Be sure to describe how many of each species you see, where they are, and what they look like, focus on identifying native species.

Continue walking along Juniper Loop Trail until you reach a fork in the trail. Keep right at the fork and follow the sign for **Shore Pine Trail**. Look for the hanging root and consider how it formed so high above ground. Also look for examples of wildlife trees. Can you find wildlife trees in different stages of deterioration? Which organisms prefer each stage you see?

Area 3: transitions. We continue on the Shore Pine Trail. Keep taking your notes of all you see and hear, identifying the species by name as you go.

Stop on the hill by the huge boulders and note the unique species living here. *What is different about the light here? About the soil?*

Continue down the hill and stop when the path passes between the halves of an old, felled tree. Note how close you are to the ocean and describe this new ecosystem.

Continue once again on Shore Pine Trail until you reach the trail marker for **Shore Pine Point/Jack Pine Point.** Note the time and new trail name. Turn right here to walk to the ocean-front of the Georgia Straight.

Area 4: Shore Pine Point. We stop to assess this dry habitat, identify plants adapted to reduced water availability, and have lunch. Look up for eagles!

Back on the trail, we re-join **Shore Pine Trail** and follow it up the hill. Turn left when you reach the trail sign for **Songbird Trail**, make a note of the change and follow Songbird Trail up another short hill to a large open clearing called **Salmonberry Meadow**.

Area 5: Salmonberry Meadow. Here, we review our plant identifications of the most common native species and examine soil characteristics.

To complete our trip, continue in the same direction to find the large, gravel trail. This is **Beacon Lane Trail** and it leads up a hill to the parking lot. Make note of the trail and activity change and walk along the path up the hill. At the top of the parking lot, we will make a final note of the time and conclude our field notes. We will review our notes in class next day.
Now head for home! *I hope you enjoyed your time in this rare, old-growth forest.*

Plant Collection Project

Digital Plant Collection Project

DUE DATE: _____

Objectives:

1. Become familiar with native plants of B.C.
2. Learn how to identify plants using field guides.

Plant collection requirements:

- At least 10 tree, fern, or shrub species (NO grasses or mosses)
- All species must be native (not invasive) to BC
- Photos must be taken by you, not from internet sources
- Each photo MUST have a metric ruler clearly visible in the image, beside the plant specimen
- The specimen must be clearly visible and identifiable – consider bringing both black and white paper to use as background, and make sure your pictures are in focus
- Submit your digital collection via email as a **.pdf** document.
- Name your document: **Lastname_Firstname_Plant Collection.pdf**
  Note: DO NOT just name it "Plant Collection"!!!!

How your collection will be marked:

Collection contains ≥10 native species of plants	10 points; -1 point/missing or non-native.
Species correctly identified	10 points; -1 point/misidentification
Required information given for each species	20 points; -1 point/missing piece of info
Neat and tidy, and in the correct format	10 points
Total	**50 points**

Assignment details:

Whenever possible, stems, leaves, flowers, fruits, and seeds should all be photographed. For smaller plants, this may involve taking pictures of the whole specimen, or multiple whole specimens if not all structures are present or visible on a single specimen. For larger species, taking several pictures of separate representative parts (branches with leaves, bark, etc.) in addition to a zoomed-out image of the whole tree (or as much of it as possible) is a good idea.

Hints:

- Take several pictures of each specimen to make sure that you have a high-quality image to submit. Use your camera's Macro mode to get a clear image. Do not submit blurry pictures for your project!
- Don't forget to include the same metric ruler in all of your photos! This is important both for scale and to prove that the photos are yours!

Specimen data:

Each specimen you collect should be accompanied by the following data:

- **date** of collection (when) in the format : **YYYY / MM / DD**
- geographical **locality** (where)
- a **description** of the surrounding **habitat/ecological conditions**, and
- a specific description of the specimen itself
  include its **common name + scientific name** with **family name**

While in the field, data should be collected in a field notebook. To keep organized, each specimen should be assigned a unique collector number in your field notebook. It may be helpful to include a small sheet of paper with the specimen number in each photograph so that you can keep track of which notes belong with each photograph. Note that the identifying features should be those you used to identify it - so don't mention flowers if there are none visible in your picture!

Sample specimen card:

FAMILY NAME: Snapdragon Family (Scrophulariaceae)
SCIENTIFIC NAME: *Orthocarpus attenuatus*
COMMON NAME: White Owl's Clover

HABITAT:
Foothill woodland, in association with annual grasses, Blue Oak, Interior Live Oak, Gray Pine, and assorted spring wildflowers.

IDENTIFYING FEATURES:
Height: 15-25cm
Leaves: alternating; lance-shaped; little bit of hair

LOCATION: 200m East of Taylor Road, 500m North of King King Road, Vancouver, BC.
COLLECTED BY: Bret Moore NO: 12
DATE: 2013-05-13

Pressed Plant Collection Project

DUE DATE: _____

Objectives: To become familiar with native plants of B.C., and learn how to identify plants using field guides.

Plant collection requirements:

- Between 10 and 20 tree, fern, or shrub species (NO grasses or mosses)
- All species must be native (not invasive) to BC
- Species must include a section of stem and several leaves. You could also include cones and flowers.

How to do the assignment:

1. Arrange your own collecting trip(s)
    - go alone, or with classmates.
    - *visit natural, legal areas*
        - gardens and city streets are not natural. Your identification books work only for native plants, not for *exotics* (imported plants native to other areas).
        - it is illegal to collect in designated parks
2. Gather your materials
    - plant identification book or books, preferably
        - *Plants of Coastal British Columbia* by Jim Pojar and Andy MacKinnon
        - *Trees, Flowers and Shrubs to Know in B.C.* by C.P. Lyons and Bill Merilees
        - Your handouts, "Plants of Lighthouse Park" or "plants of Richmond Nature Park"
        - Field notes
    - plastic bags for your specimens
    - clippers or pocket knife or scissors
    - specimen labels (you may copy more; cut them to individual labels)
3. Collect your plants
    - you may collect plants observed on our field trips. **You may not collect plants on our field trips.**
    - **identify your specimens in the field**

- *much* easier than at home
- do not collect protected species!! Your plant ID book will note if a plant is protected.
- complete your label
    - specimen number
    - common name
    - scientific name
    - specific location where you found it
    - description of habitat where you found it, list of neighbouring species and environmental conditions
    - date collected

4. Prepare your collection
    - at home, press and dry your specimens as quickly as possible. A telephone book works well if you don't have a proper press. If you are delayed, place your specimens in your refrigerator.
    - glue your plants to a white sheet of paper; glue the label at the bottom right side. You can slide pages into page protectors to protect your specimens. Alternatively, you could mount your plants on photo album pages (you may use both sides of the page, one species to a side).

- suggestion: collect more than twenty plants when you are in the field as some insurance for misidentifications
- another suggestion: start by looking at your field trip notes and your plant handouts to *search* for specific and common plants

How your collection will be marked:
Note that you will only be given marks on the 10 best samples as:

Species correctly identified	10 points
Required information given for each species	30 points
Collection is neat, tidy, and well-presented	20 points
Total	**60 points**

Specimen cards. Please print out and use for the assignment.

Specimen #
Common Name
Scientific Name
Specific Location
Habitat description:
Date collected

Specimen #
Common Name
Scientific Name
Specific Location
Habitat description:
Date collected

Specimen #
Common Name
Scientific Name
Specific Location
Habitat description:
Date collected

Supplementary Readings

Natural History of Bogs in B.C.

What is a bog? How did bogs become such unique wetlands? The history of bogs in British Columbia is linked to the history of the land itself. And the land itself actually immigrated to what is now British Columbia, followed by microbes, plants, and animals. Fill in the blanks below to discover the abiotic and biotic factors that influenced the evolution of the bogs of British Columbia.

What is a bog?

A bog is defined as an _____ mossy, peat-covered or peat-filled wetland that develops in open terrain with restricted drainage. One percent of British Columbia is peatland. Sphagnum bogs form distinct wetland communities featuring specialized plants. The plants we find here are often called _____ remnants because we find the same kinds of plants way up north. The Arctic-like conditions accompanying the retreat of the glaciers led to the establishment of cold-adapted plants, which were supplanted by _____ species as the climate moderated. The acid, _____, _____-_____ and relatively cold conditions in the bog allowed the specialized plant community here to remain and out-compete the new wave of temperate plants. Nowhere else in temperate biomes but in bogs do we find this unique assemblage of plants. In more northerly latitudes, and in eastern and maritime Canada, bog vegetation becomes increasingly common. Vast stretches of northern bog take the name muskeg; in northern Europe, they are called heaths, mires, and moors.

Words for filling in the blanks: Arctic; temperate; acid; wet; nutrient-poor

Water is a very important feature of bogs. _____ exceeds evaporation. The water table lies at or near the surface for much of the year because of poor _____, whether due to water below, compressed soils, or frozen ground (permafrost). The enormous water retention capacity of peat and live Sphagnum furthers these wet conditions. Sphagnum absorbs water through pores in hollow cells. Many bogs, called _____ bogs, gather all of their water, with the minerals dissolved in it, from precipitation.

Cool temperatures characterize bogs. Water _____ from the surface, taking heat with it. Thus even during the summer bogs remain relatively cool.

Words for filling in the blanks: drainage; precipitation; evaporates; ombrotrophic

What preceded bogs?

Geology helps us understand the rich biodiversity we find in British Columbia. _____ years ago no British Columbia existed west of where the Rocky Mountains now lie: it was ocean! Later, the continent began moving west, and smashed into island blocks of land called _____, eventually to be scrunched into a series of mountain ranges. By 120 million years ago, the western ranges of the Rockies emerged; by 100 million years ago, volcanic ranges along the coast; by _____ years ago, the eastern Rockies and their foothills. But the landscape kept changing as all of these mountains kept moving in complex patterns. From 55 to 36 million years ago intense _____ _____filled valleys. Various parts of B.C. have been shaped by volcanic eruption until recently. The cascade volcanoes, including Mount Garibaldi and Mount Meager, were born only _____ years ago.

Words for filling in the blanks: terranes; volcanic eruptions; 200 million; 60 million; 5 million

Most of the recent geological history of British Columbia involved ice: four _____ occurred between 1 million and _____years ago. The weight of the glaciers depressed the level of the land as much as 300 meters. When the glaciers retreated, the vast quantities of water released by the glacial melt created lakes and waterfalls and rivers. They raised the sea level as much as 200m along the coast; so much so, that ocean extended up the Fraser Valley all the way to New Westminster and up the Skeena Valley to Terrace. The depressed land rebounded to near its present elevation when the ice left. The river deltas formed recently from a combination of till and outwashings from the retreating glaciers, and marine deposits. As the _____ _____ deposits sediments below the water surface, its delta front continues to push _____m into the Strait of Georgia each year. Lulu Island, where we find the Richmond Nature Park, and Delta, home of Burns Bog, were formed by these silty depositions about _____ years ago.

Words for filling in the blanks: 5000; 10,000; Fraser River; glaciations; 2.5

How did ecological succession create bogs?

Ecological succession describes the process of ecosystem change that culminates in a self-sustaining _____ _____. Where glacial depressions or poorly drained marshes created _____ (oxygen-depleted) lakes and ponds, Sphagnum moss colonized. There the Sphagnum pioneered the basis of its own climax community: a bog. Other plant species that found the conditions suitable moved in, and the open water transformed into a wetland. If the climate becomes warmer and drier, or if people drain them, more _____ plants may invade and ecological succession may proceed to a forested climax community. Forests typical of their biogeoclimatic zone represent the terrestrial climax communities of British Columbia below the treeline.

Words for filling in the blanks: terrestrial; climax community; stagnant

Where do we find bogs in British Columbia?

Bogs are wet, so look for them in wet places. Mountain ranges greatly influence our _____: both _____ and precipitation. Air flows predominantly eastward from the Pacific Ocean. Our mountain ranges run roughly north/south. The mountains keep moisture from the air on their western flanks, forming _____ _____, which leave areas to their east dry. Where precipitation is high, soils are usually poor in _____, and bogs are nutrient-poor. Bogs are most common on the West Coast, where they constitute the most abundant wetland class, and in the Interior wet belt in the Cariboo, Monashee, and Selkirk Mountains. The colder continental temperature on the _____ side of the Rockies makes the Fort Nelson Lowlands another good area for bogs. Here, soil underlying glacial depressions, frozen much of the year, keeps water from draining away.

Words for filling in the blanks: temperature; nutrients; rain shadows; east; climate

What kinds of bogs do we find in British Columbia?

The Canadian Wetland Classification System recognizes eighteen forms of bogs. The most common in British Columbia are basin, flat, slope, domed and shore. Camosun Bog of Pacific Spirit Park and Rithets Bog in Victoria, lying in glacially scooped depressions where they receive water from their immediate surroundings and precipitation, are examples of _____ bogs. These two bogs are treed (with shore pines or shore pines and western hemlocks). Mossy basin bogs show more herbaceous vegetation. Flat bogs, also called blanket bogs, occur in broad, poorly defined depressions, often on the rock that glaciers scraped. Trails on the West Coast of Vancouver Island often pass through flat bogs, and they cover extensive areas of the Queen Charlotte lowlands. On tilted landscape on our open ocean coasts, we find _____ bogs. Burns Bog and Richmond Nature Park in the Fraser Lowland, large bogs with convex surfaces rising several meters above the surrounding terrain, are examples of _____ bogs. Low shrubs dominate these bogs. Domed bogs seem to have evolved from basin or flat bogs. Burns Bog in Delta is the largest domed bog in western North America, accounting for 80% of the total bog area of the Lower Mainland. Shore bogs line the shores of lakes, but rise above the lake level so that the plant roots are not affected by lake water. Tiny "pocket" bogs can occur in poorly drained depressions. Peatlands in our mountains, often along the shores of lakes or ponds, suggest another classification: montane bogs.

Words for filling in the blanks: basin; domed; slope

Why is Sphagnum moss so important to a bog?

Sphagnum mosses (of which there are about 30 species in B.C.) largely determine the distinctive nature of bog communities. Although only the top few centimeters are alive, the entire plant may be thousands of years old, growing upon its dead sections below, which become part of the underlying peat. This underlying tangle of partially decomposed moss accumulated and was compressed over thousands of years, preserved by the cool, acid and largely bacteria-free waters. The stems of bog shrubs support Sphagnum to form little hills called _____. This peat moss is a virtual sponge, able to absorb up to thirty times its weight in water; the bog remains wet.

Sphagnum creates acid water, with a low _____, and very soft water, with a low_____ content, approximating that of rainwater. Sphagnum absorbs _____ ions (which bogs are especially poor in), and secretes _____ ions, which create acid conditions. Humic acid, which arises mostly from decaying plant material with the help of bacterial enzymes, also maintains the acid surroundings of the bog, serving as a good buffer between pH4 and pH5. Acid environments lead to retarded bacterial activity, as may the lack of calcium and low dissolved organic carbon, thus slowing decomposition (well-preserved humans over 2000 years old have been found in peat bogs!). The absence of certain bacteria reduces the availability of nitrogen in the form of _____. Almost all of the plants living in the

bog must use nitrogen in the form of _____ ions. The more acid the waters of a bog, the lower the species diversity.

Words for filling in the blanks: mineral; ammonium; nitrate; hummocks; calcium; hydrogen; pH

What adaptations must plants have to live in a bog?

Many bog plants show adaptations to conserve _____. This may seem paradoxical, but apparently the bog water is difficult for plants to absorb because of its acidity. Consider some adaptations of these dominant bog plants:

shore pine: needles cylindrical, waxy, sunken stomata
labrador tea: leaves waxy, edges rolled, fuzzy underside
cranberry: leaves waxy, small

Low nitrate availability means plants must use _____ _____(NH4+) as a nitrogen source. Almost all of the shrubs in the bogs are in the heath (heather) family, which can not only absorb ammonium but also require abundant iron, which is more available in acid than in neutral or alkaline environments.

Another strategy to obtain nitrogen, used by a little plant called the sundew, is to be _____. Unable to process ammonium, this plant digests the proteins of the insects it captures to obtain its _____. Its victims are essentially sources of fertilizer, not energy, as the sundew is a green, photosynthesizing plant. In northeastern B.C., find carnivorous pitcher-plants.

Some (if not most) bog plants have _____, mutualistic fungal-root relationships that aid the plants in the absorption of vital nutrients.

Words for filling in the blanks: mycorrhizae; carnivorous; water; ammonium ions; nitrogen

What community relationships typify bog vegetation?

Decomposition: the most common decomposers in the bog are _____.

_____: Rust fungus causes the lumps on the lodgepole (shore) pines. They kill the trees.

_____: Lichens do not harm the shore pines they hang from, but benefit from growing on them.

_____: The lichens themselves are symbiotic relationships between fungi and cyanobacteria. Both organisms benefit from the relationship.

Words for filling in the blanks: parasitism; fungi; mutualism; commensalism

For Further Investigation

1. Bogs constitute one of several freshwater wetland classes of British Columbia. Characterize each of the following: bog, fen, marsh, swamp, and shallow water. What makes them similar? What makes them different? What wetlands occur in our region?
2. Bogs and other freshwater wetlands are frequently threatened. Investigate histories of wetlands or former wetlands in our region. What threatens their existence? What led to their elimination?
3. Where else in Canada do we find bogs? Where else in the world do we find bogs? Use the World Wide Web to track down bogs. How do they differ? What makes them similar?
4. Where is the bog closest to where you live? What conditions favour the presence or absence of bogs near your home? Relate this to the biogeoclimatic zone in which you live.
5. Find examples of symbiotic relationships in other wetland communities in our area.
6. Write a synopsis, a brief to-the-point paragraph that describes a bog.

Ecological Succession and Bogs

What is ecological succession? Find out more about this process of community change and how it formed bogs. Fill in the blanks below, and then re-enact the story of bog succession. See also the labs Richmond Nature and Wet Deserts and Green Carnivores on pages IV-24-30. Consider the effects of habitat disruption.

What Is Ecological Succession?

Ecological succession is a process whereby one type of plant community replaces another until a self-perpetuating plant community exists. This "final", self-maintaining plant association is called a _____ _____.

Replacement by another community usually occurs only through major environmental disturbance, as from fires, flooding, landslides, volcanic eruptions or climatic change. Humans can eliminate a natural community by clearing existing plant communities for agricultural, industrial or urban development. Other interference results from emissions that produce acid precipitation, global warming and toxic depositions.

The first plants to invade areas devoid of vegetation are called _____ species. Each successive type of plant community is called a _____ _____.

The entire pattern of succession to a particular climax community is called a sere. Climate limits the type of climax community in an area.

Ecological succession in areas previously devoid of life usually proceeds slowly, especially in its early stages, often taking _____ of years. Often, however, very noticeable changes occur within ten to twenty years after habitat disruption in lower elevations in southern and coastal B.C., more slowly in colder interior regions and at higher elevations. Although succession is commonly presented as being very predictably progressive, it sometimes goes backwards (consider the dam work of a beaver) or doesn't appear to follow the predicted order.

Words for filling in the blanks: thousands; seral stage; climax community; pioneer.

What Causes Succession?

Plants themselves cause ecological succession. Seral plant communities modify their environments by changing the soil and the _____ (the very local atmosphere) in such a way that the environment becomes less favorable to the species already there and more favorable for the invasion and growth of plants not yet common there. When plants die, bacteria and fungi _____ their remains, and this alters such soil factors as water retention capacity and _____ _____. As plants grow, they change such microclimatic factors as _____, _____, and sunlight intensity. Seeds are always being deposited from all over, and now some, previously not competitive, may germinate and find conditions suited to their growth and reproduction. They out-compete the offspring of the residents. These new plants thus successfully invade and replace the earlier plant community.

Dominant species and others typical of their particular community are called _____ _____. Climax plants will normally continue to dominate because their offspring can grow in their presence and are better _____ to the prevalent conditions than other plants.

Words for filling in the blanks: indicator species; adapted; temperature; humidity; nutrient composition; decompose; microclimate

What Kinds of Succession Are There?

When succession "starts from scratch" in a previously uninhabited area, such as rock recently uncovered by glaciers or new lava beds, we call it _____ _____. Initial colonization and early succession proceeds very slowly, because bare rock must yield soil in order for any but the smallest plants to establish themselves. The climax community may not appear for many thousands of years, especially if winter snow and ice cover the area for much of the year. When ecological succession begins in uninhabited open waters it progresses much faster than on bare rock. Succession that occurs after habitat disruption, whether by humans or natural events, is called _____ _____. Some types of disruption that can set the stage for this kind of succession include: _____, _____, hurricanes, _____, _____ and _____.

Words for filling in the blanks: primary succession; secondary succession; logging; fires; floods; farming; animals.

You can see such successionary changes prompted by human interference at the Richmond Nature Park at the burn area on the Bog Forest Trail (fire from a spark from a passing train in 1974), and the birch forest near the highway (clay fill in the early 1960's).

Where Do Bogs Fit Into the Pattern of Ecological Succession?

Bogs usually arise from stagnant lakes and ponds. In stable climates, they form their own climax community. If the climate becomes warmer and drier, or if people drain them, more terrestrial plants may invade the bog and ecological succession may proceed to the climax community of the biogeoclimatic zone.

How Did Ecological Succession Form the Fraser Lowland Domed Bogs?

The Fraser River periodically dumped silt onto the growing delta islands, including Lulu Island, where we find the Richmond Nature Park, between 4000 and 1500 years ago. The land was low, flat and wet with occasional shallow pools. These conditions fostered the growth of _____vegetation: grasses, sedges and rushes, such as cattails, cotton grass and wiregrass.

The growth of these plants, further siltation from the river, and poor drainage reduced circulation in the shallow water. Dissolved _____ levels dropped. The debris from the deaths and seasonal die-downs of the plants decomposed, providing food for_____, whose activities further reduced the oxygen level of the water, leading to _____ conditions. The rate of _____greatly decreased due to a combination of the cold climate and the replacement of aerobic bacteria with much slower-acting anaerobic bacteria. Dead plants decomposed only partially and were compressed to form sedge peat. This material released _____ _____, which stained the water brown and created _____ conditions, with a pH between 3.5 - 4.5. Only plants and bacteria specialized for the cold and acid conditions could survive here.

Words for filling in the blanks: bacteria; anoxic; marsh; acid; humic acid; oxygen; decomposition

By approximately 3500 years ago shrubs and bushes had invaded some parts of the marsh. They grew in the sedge/grass _____ that had accumulated along with more silt from the river. At that time, the elevation of the land was higher than today and conditions were _____ than in the former marsh.
It seems that a straightforward pattern of succession did not occur. Wetter conditions returned much of the area to marsh and the stagnation cycle discussed above resumed. _____ _____ invaded these inhospitable (to most plants) wetlands 3000 years ago and filled the watery spaces between other plants. Sphagnum also grew outward over open water from footholds on pond edges and formed floating mats, which later thickened to form more or less stable substrates. This process formed the basis of the lower mainland domed bog today: a bed of Sphagnum peat that is sometimes seven meters thick. As larger shrubs colonized bogs, Sphagnum grew up on their stems, creating a gradient from wetter to drier. These topographical features led to a variety of _____, increasing the variety of species in the bog.

Words for filling in the blanks: drier; peat; Sphagnum moss; microhabitats

What Keeps A Bog, A Bog?
Sphagnum maintains the acid, nutrient-poor conditions of the soil and water, thus enforcing a bog climax community. Fires also help maintain the bog. During long, hot, dry spells, the surface Sphagnum becomes tinder and supports combustion from lightening strikes or human carelessness. Bog fires pose danger for humans because they can go underground. The fire smolders in the oxygen-poor environment just above the _____ _____, then rises to the surface unpredictably. The lodgepole (shore) pines contain highly flammable turpentines in their barks that spread the fires. Their thick barks usually protect the trees from extensive damage. The pines are actually promoting their own best interests: fires open up their cones to release their seeds, erase the

_____ for their seedlings, and add nutrients to the soil for them. At the same time, shrubbery is cleared and more light reaches the surface of the Sphagnum, promoting growth of plants typical of earlier _____ stages of the bog. As long as precipitation exceeds evaporation, drainage remains limited, and nutrient-rich waters do not intrude, the bog will remain a bog.

Words for filling in the blanks: competition; seral; water table

Common Bog Plants:

Introduced in their approximate order of habitat preference, from wetter to drier:

waterlogged:

yellow pond lily (*Nuphar polysepalum*)	Nyphaeaceae: waterlily family
wire grass or common rush (*Juncus effusus*)	Juncaceae: rush family
cotton grass (*Eriphorum polystachyon*)	Cyperaceae: sedge family

on the *Sphagnum*:

at least three species of *Sphagnum*	Sphagnaceae
bog cranberry (*Vaccinium oxycoccus*)	Ericaceae: heath family
cultivated cranberry (*V. macrocarpon*)	Ericaceae: heath family
sundew (*Drosera rotundifolia, D. anglica*)	Droseraceae: sundew family
cloudberry (*Rubus chamaemorus*)	Rosaceae: rose family
hair-cap moss (*Polytrichum* sp.)	Polytrichaceae

on prominences that dry out:

crowberry (*Empetrum nigrum)*	Empetraceae: crowberry family
lichens such as cariboo lichen (*Cladina)*	Cladoniaceae

higher on the *Sphagnum*:

bog rosemary (*Andromeda polifolia*)
bog blueberry (*Vaccinium uliginosum*)
bog laurel (*Kalmia polifolia*)
velvet-leaved blueberry (*V. myrtilloides*) — all Ericaceae: heath family

further up, even higher on the *Sphagnum*:

labrador tea (*Ledum groenlandicum*)
cultivated blueberry (*V. corymbosum*) — both Ericaceae: heath family

Characteristic Plants of Later Seral Stages:

topping the hummocks:

shore pine (*Pinus contorta*)	Pinaceae: pine family

moving in when soils become drier and richer in nutrients above the *Sphagnum*:

salal (*Gaultheria shallon*)	Ericaceae: heath family
bracken (*Pteridium aquilinum*)	Dennstaediaceae: hay-scented fern family
evergreen blackberry (*Rubus laciniatus*)	Rosaceae: rose family
mountain ash (*Sorbus aucuparia*)	Rosaceae: rose family
hardhack (*Spirea douglasii*)	Rosaceae: rose family
fireweed (*Epilobium angustifolium)*	Onagraceae: evening-primrose family
red-berry elder (*Sambucus racemosa*)	Caprifoliaceae: honeysuckle family
willows (*Salix* sp.)	Salicaceae: willow family
aspens *(Populus tremuloides)*	Salicaceae: willow family
western white birch (*Betula papyrifera*)	Betulacaeae: birch family

Plants of climax communities:

Western hemlock (*Tsuga heterophylla*) at lower elevations in the wetter biomes, spruces (*Picea)* in the north and at altitude. These conifers (Pinaceae:pine family) can grow in the shade of birches or aspens and thus will eventually grow over them and shade them out.
Look for other plants as well, because the diversity increases as we leave bog conditions.

Other bog areas of interest:

Burns Bog, North Delta: "the last reasonably intact major domed bog on the West Coast of North America". Burns Bog Conservation Society, P.O.Box 328, Delta, B.C. V4K 3Y3

Camosun Bog, Pacific Spirit Park (UBC Endowment Lands), 19th and Camosun, Vancouver: succession from a pond--but it is small and threatened. Undergoing restoration. Lots of sundews. Greater Vancouver Regional District, 492-6350

Thanks to Margaret Flaherty, Marilyn Ratcliffe, Peter Woods, and L.Keith Wade for expert and thoughtful editing, and authors of early interpretive literature for the Richmond Nature Park, upon which much of this exercise is based.

Bog Plant Adaptations

A Desert in a Bog?

In the midst of abundant water, many bog plants exhibit adaptations to conserve it. Why should that be? Furthermore, unlike most plants, bog plants must tolerate the combination of acid, cool, oxygen-poor and nutrient-poor soil.

The **acid** (low pH) and **soft** (low calcium) bog water imposes a condition on many bog plants reminiscent of that sailor in Samuel Coleridge's *Rhyme of the Ancient Mariner*, who, lost at sea without fresh water, says: "Water, water, everywhere, and nary a drop to drink." The liquid is there, but the plants can't absorb it effectively. Consequently, bog plants, like desert plants, display **morphological** (structural) **adaptations** to water limitation, such as:

1. **Thick cuticle**: The waxy or leathery cuticle covers the leaf's upper surface. The cuticle helps conserve water in two ways. It helps retard water loss through **transpiration** and reduces the absorption of sunlight, thus slowing photosynthesis and the demand for water. A shiny, waxy cuticle reflects sunlight; an indented, leathery cuticle diffuses it.
2. **Rolled leaf edges:** Many species exhibit an inwardly and downwardly rolled leaf margin. This reduces leaf area, particularly on the underside where the **stomata** are located. The roll also gives the underside an inverted cup shape, which may increase humidity and retard airflow around the stomata. When some plants have lost too much water, their leaves roll or fold to protect their stomata.
3. **Pubescence (hairiness):** A dense covering of tiny hairs may be found on one side of the leaf. Still, moist air trapped in these hairs can reduce water loss.
4. **Small leaves:** Small surface area reduces transpiration and light absorption. Bogs are open areas, so sunlight doesn't limit growth. Lessened light absorption slows the photosynthetic machinery and diminishes the water demand. If plants have thin leaves, they are often long and narrow, exposing little surface area.
5. **Non-horizontal leaf positions:** By pointing leaves up or down the plants minimize water loss. Horizontally positioned leaves absorb light and heat maximally, which accelerate photosynthesis and increase water requirements.
6. **Increased lignification of cell walls: Lignin** is a very strong substance that many bog plants use to harden their tissues. This allows them to stand upright even when they have lost so much water that they would otherwise wilt.
7. **Anthocyanins:** The name of these pigments means "blue flowers", but the low pH in the sap of bog plants turns anthocyanin red. The red leaves reflect the warmer, longer wavelengths of light, thus reducing leaf temperature, transpiration and water demand.
8. **Small size:** Relatively short plants lie in the high humidity zone generated by the usually wet *Sphagnum*. They also grow sheltered from drying winds and require less water than larger plants.

Examine bog plants for their specific **adaptations to water limitation**. Use the RNP plant collection and photos in a plant field guide. Fill in the data table below for each species. Place a checkmark in the column(s) that apply. Total the checkmarks for each row and each column. Calculate the percentage of species that exhibit each adaptation, and the percentage of morphological adaptations used by each species.

Species name	Thick cuticle	Rolled leaf edge	Hairy leaf	Small leaf	Leaves point up and down	Lig-nified	Red color	Small plant size	Total	% of adapt-ations
Total										
% of species with this adaptation										

1. Which species shows the highest number of water conservation adaptations? Predict where you will find it on the bog field trip.
2. Which morphological adaptations are most common?
3. How does each adaptation function to help the plant conserve water?
4. Why do you suppose that a given plant does not use all of the possible morphological adaptations to water limitation?

Nutrient levels in the bog:

Water conditions in bogs make it difficult for the plants to absorb nutrients as well as water. The nutrient nitrogen is one of 17 elements essential to plant growth. All plants require nitrogen as a building block for making protein, DNA, ATP, vitamins and other chemicals of life. But nitrogen is not readily available in bogs. The absence of **nitrifying bacteria** eliminates **nitrates (NO_3^-)**, the usual nitrogen source for plants. **Nitrogen-fixing bacteria** convert atmospheric **nitrogen (N_2)** into **ammonium ions (NH_4^+)**, and almost all of the bog plants absorb their nitrogen in this form**. Ammonifying bacteria** also produce ammonium ions, from decaying organic material—a slow process in bogs. Some bog plants, however, cannot use any of these nitrogen sources. They also cannot absorb nitrogen from the air, so they resort to the same source as we do: animals! In this exercise examine special adaptations of a carnivorous plant to the nutrient limitation of the bog. Formulate your hypotheses:

If plants are to capture animal food, then they should be built this way…because…. See how many possibilities you can think up.

Carnivorous Plants?

Bog plants adapt to nutrient limitation. Carnivorous plants have adopted a curious habit: they eat animals! You don't have to worry, because these small plants focus their predation on insects. Some 600 species and subspecies of carnivorous plants have evolved different strategies for capturing their prey.

Carefully examine the **sundew** in the RNP collection. The instructor may furnish you with other carnivorous plants. Sketch the plant and label specific adaptations for insect-eating. Compare what you see with the following descriptions of carnivorous plants.

Sundew (round-leaved: *Drosera rotundifolia*: great: *D. anglica*)
Sundews live in all of B.C.'s bogs. The highly modified hairs secrete a drop of clear red sticky fluid that attracts insects such as mosquitoes, midges and gnats. When insects get stuck, the hairs bend inward, further ensnaring the victim. Glands on the leaf secrete adhesive compounds that hold the prey and digestive enzymes that render the prey into chemical soup. The sundew then absorbs the essential nutrients it requires.

Butterwort (common: *Pinguicula vulgaris*; hairy: *P. villosa*)
Butterworts live on the edges of mountain bogs. Their greenish-yellow leaves attract insects and trap them in a sticky slime. The leaf margins roll inward to contain insects with the digestive juices that dissolve them.

Bladderwort (greater: *Utricularia vulgaris*; flat-leaved: *U. intermedia*; lesser: *U. minor*)
These free-floating aquatic plants (over 210 species) trap aquatic insects and crustaceans in tiny air bladders. Each bladder is closed at the narrow end by a water tight, valve-like door. This door opens when an aquatic insect or crustacean triggers four stiff bristles on the outer surface. When the door opens, the partial vacuum inside the bladder is released, the bladder walls expand and water rushes in with the victim (kiss the air and you'll get the idea). The door closes within 1/30 of a second and digestion begins.

Common pitcher-plant (*Sarracenia purpurea*)
In B.C., pitcher plants live only in the muskegs of the far northeast. These carnivorous plants employ no moving parts to capture their prey. The insects fall into a cauldron of water mixed with digestive juices secreted by the plant and enzymes manufactured by mutualistic bacteria. Any attempts to crawl out of the plant are countered by gravity and downward pointing hairs. Some species of pitcher plants employ wetting agents and insect narcotics to subdue their prey.

Venus fly trap (*Dionaea muscipula*)
These common plant "pets" are endangered in their native southern North Carolina. The leaves secrete nectar attractive to insects. When an insect repeatedly touches hairs on the jaw-like leaves, it triggers their collapse into a death cell. At first the grip of the leaves is loose, but the more the prey struggles, the more times it touches the trigger hairs, and the tighter the grip gets. The closing mechanism involves a release in turgor pressure at the hinge of the two leaves. The leaves remain closed for several days as digestion proceeds. Upon re-opening, a drained, dry exoskeleton is all that remains.

5. Why do plants need nitrogen?
6. Why can't plants utilize atmospheric nitrogen?
7. Compare the nitrogen cycle in bogs with the nitrogen cycle in your garden or on agricultural land. What are the similarities? What are the differences? Describe what causes the differences.

8. Connect and explain these observations:
    - bog waters contain few bacteria
    - bacteria require nitrogenous nutrients
    - bacteria live in the crops (first stomach) of deer, where they break down the cellulose of plant cell walls in the deer's food
    - does drink their fawns' urine (and that of people and dogs too!)
    - deer have been observed licking bank swallow droppings, which include uric acid (the dry white excretory waste of most birds)
    - decomposition in bogs occurs very slowly

9. All carnivorous plants photosynthesize in spite of their meals of insects. Explain. Are carnivorous plants autotrophs or heterotrophs?

For Further Investigation:

Check out Barry Meyers-Rice's website, The Carnivorous Plant FAQ, for photos and information: sarracenia.com/faq.html

Thanks to Professor Jolie Mayer-Smith for permission to adapt her bog plant adaptation exercise.

Wildlife Trees in BC

by Peter Ballin

What is a wildlife tree?

Any standing dead or live tree with special characteristics that provides valuable habitats (places) for the conservation or enhancement of wildlife. Snags often make good wildlife trees.

Why are wildlife trees important?

Forested ecosystems depend upon death and decay of trees. Tree death may rival tree life for promoting biodiversity. After death, trees experience changes which eventually return most of their substance to the forest ecosystem, providing important nutrients to foster new plant growth. Along the way, they provide a portion of the life support system for many species of plants, animals, fungi, and bacteria. Some of their uses include nesting, feeding, communication (drumming, marking), roosting, shelter, and over wintering. Altogether, more than 90 animal species in British Columbia depend on dead or deteriorating trees.

What are the signs of a good wildlife tree?

Given the large number of wildlife tree-dependent species and wide range of wildlife uses of these trees, there can be no simple system for determining which trees provide the best habitat for wildlife. The most significant indicators of wildlife tree quality include:

height and diameter location cause of death
decay stage and degree of deterioration distribution

These features contribute to a diversity of habitats for wildlife:

natural cavities branching loose bark
primary cavity excavation (cavities animals have created)
feeding holes heart rot spike tops
chimney effect perching snags
secondary cavities (modified primary cavities)

What makes one wildlife tree more valuable than another?

The value of any particular tree as wildlife habitat depends on a variety of attributes, including, structure, age, condition, abundance, species, geographic location and surrounding habitat features.

What makes a wildlife tree?

Time, weather, insects, fungi, and fire.

Trees pass through life stages, death stages, and after-death stages. Decades, even centuries, may pass for a tree to mature and die and go through the stages of decay.

What is the goal of wildlife tree management in bc?

Maintain sufficient habitat necessary to support viable populations of animals that are dependent upon wildlife trees. The long list of wildlife tree users includes some rare and endangered birds and mammals. Failure to protect wildlife trees decreases abundance and diversity of wildlife and may contribute to the eventual loss of some species.

Who uses wildlife trees?

The largest group of wildlife tree users is cavity nesting birds, such as owls, woodpeckers, and some ducks. Approximately 18% of the bird species known to breed in British Columbia nest in tree cavities. Some mammals, reptiles, and amphibians, many invertebrates, and countless fungi and microbes use wildlife trees for foraging and homes.

Which mammals use wildlife trees?

Bats are perhaps the mammals most dependent upon wildlife trees. Black bears den-up in hollow trees. The mountain caribou's staple winter food is arboreal lichens, which grow on the branches of old and/or dead trees. Small and medium-sized mammals may nest, shelter, and/or forage in wildlife trees. Larger mammals may use them as marking posts to advertise their presence.

What are primary cavity excavators, and who are they?

Primary cavity excavators chisel out holes in the decaying wood of trees. Woodpeckers and sapsuckers and some species of chickadees and nuthatches are primary cavity excavators. They depend on the availability of dead or defective trees for nesting, and often for roosting, foraging and communicating sites as well.

What are some uses of the cavities?

Through their excavations, primary cavity excavators provide other wildlife with nesting, roosting and feeding opportunities…the secondary cavity users. They also provide sites for insect attack and fungal infection. Ultimately, they accelerate the rate of tree decomposition and nutrient cycling in forest ecosystems.

Who are secondary cavity users?

Secondary cavity users cannot excavate their own holes. Birds such as small owls, swallows, bluebirds, and wood ducks, as well as a variety of mammals such as martens, raccoons, flying squirrels, deer mice, and bats are secondary cavity users.

Who are the open nesters?

Great blue herons, bald eagles, ospreys and the largest hawks and owls are open nesters. They build large, heavy nests on the tops or on high branches of large trees or snags that can support their bulk. These open nesters are named as protected species under Section 35 of the *Wildlife Act*.

Which wildlife tree users are threatened or endangered?

Some threatened or endangered animals use wildlife trees. Red-listed species are those under consideration for legal designation as Endangered or Threatened by the B.C. Ministry of Environment (1993) under the *B.C. Wildlife Act*. Blue-listed species are considered vulnerable and/or sensitive and at risk because of low or possibly declining populations.

What is the ecological and economic significance of wildlife tree users?

Wildlife tree-dependent species have a number of ecological roles in B.C. forests, some of which we deem economically positive, some negative. We will probably never understand the complete ecological significance of all, if any.

One of the most important and well-documented roles of wildlife tree users is their impact on forest pest populations. Each year, B.C. forests are subject to damage from a variety of pest species, including bark beetles, spruce budworm and Douglas-fir tussock moth. These pests kill trees and reduce tree growth and vigor, thereby reducing the economic potential of our forests. The average loss of timber to insect pests between 1986 and 1990 was estimated at 5.6 million m^3 annually, which represents $43.4 million in stumpage revenue and over $400 million in direct provincial gross domestic product.

What impact do wildlife tree users have on forest pest species?

Wildlife tree users eat forest pest species and therefore reduce the damage incurred by these pests. Some of the best evidence for this type of control comes from the bark-foragers:

Three-toed, black-backed, and hairy woodpeckers eat mainly insects and in winter, they specialize on wood-boring beetle larvae. They use their chisel-shaped bills to drill beneath the bark and then extract the larvae with their unique tongues. Three-toed woodpeckers show impressive rates of consumption using this feeding technique. During a spruce beetle outbreak, their stomachs contained an average of 915 beetles per bird, with each bird filling its stomach to capacity several times a day. Many studies show that woodpeckers can reduce beetle populations; they respond *directly* to beetle outbreaks by including more beetles in their diet and by aggregating in outbreak areas, especially in winter.

Woodpeckers also increase beetle mortality *indirectly* through their feeding activities. The process of excavating beneath the bark alters the microhabitat of the beetle larvae, making them more susceptible to temperature extremes, desiccation, and attack by parasitic or predaceous insects. Other predators (e.g., brown creeper, red-breasted nuthatch) are also drawn to “woodpeckered” bark where they can access beetle larvae. Both the direct and indirect effects of woodpecker feeding activity contribute to the biological control of wood-boring beetles.

How do cavity-nesting birds regulate insect pest populations?

Cavity-nesting birds generally play an important role in maintaining insect pests at low levels by preventing or delaying the onset of an insect outbreak and accelerating its decline. The feeding habits of aerial-foraging bats suggest that they too play a significant role in controlling insect pests. Maintaining healthy populations of all of these predators makes good biological and economic sense.

What important role do rodents play?

Recent research reveals an important role rodents play in a complex cycle integral to the health of forests. Some 90% of plant families and virtually all commercially valuable trees in B.C. (e.g., pine, fir, spruce, larch, hemlock) depend on root-inhabiting fungi (mycorrhizae means “fungus-root”) to absorb adequate nutrients and moisture for growth. Many rodents eat mycorrhizal fungi, and consequently disperse their spores.

What other materials do wildlife tree users transport?

Wildlife tree users play a significant role in the transport of other materials within forest and near-forest ecosystems.

Small mammals and ground-foraging birds collect and eat several kilograms of seeds annually. Many seeds pass unharmed through the digestive tract, some even requiring this journey in order to germinate.

Substances contained in rodent pellets (e.g., yeast, nitrogen-fixing bacteria, fertilizer) encourage seedling establishment and growth. In the process of digging, small mammals mix soil layers and improve the properties of the soil for seedling establishment. Birds and bats effectively disperse nutrients. Nitrogen rich bat feces contribute to the nutrient content of roost trees and entire forest ecosystems.

Forest birds and mammals have been implicated in the transport of tree pathogens (e.g., dwarf mistletoe, needle casts, blights and rusts), and the impact on forest health requires further investigation.

How are wildlife trees classified in BC?

Class 1, 2

Healthy, live trees may show signs of deterioration such as dead branches or physical injuries but may not contain any decay yet. However, the first stages of decay often begin in the living tree. Bacteria, fungi, or wood-boring beetles lead the invasion. Wildlife trees that are living or in the early stages of decay attract birds that build large open nests, such as ospreys, bald eagles, and great blue herons. Woodpeckers often build nest cavities in live hardwoods. Occasionally a live tree may not show external signs of decay.

Class 3, 4

The tree has died, and decay continues. Woodpeckers will chisel out nesting cavities because the outer shell of sapwood is still hard, protecting eggs and nestlings. As time passes, the tree continues to rot and soften.

Classes 5, 6, and 7

When the tree reaches these stages, weaker excavators, such as nuthatches and chickadees, can make their nest holes. Branches often break off, and slabs of bark loosen from the trunk. Decay is advanced in the upper portions of the trunk. The loss of tree limbs creates knotholes and natural cavities, many soon converted into homes by a variety of animals. Figure n shows cavities in live or partly dead trees. Over the years, the tree gets shorter. Often the whole top of a tree snaps off at a weak point. Throughout stages 6 and 7, chunks of bark and sapwood slough off. Once the softer heartwood is exposed, wildlife trees are used less by woodpeckers and more by other animal species.

Classes 8, 9

In the final phases of decay, all the sapwood is gone, and the heartwood is completely rotted through. The stump and the mound of woody debris that surrounds it become an ideal site for new plant growth, providing a ready supply of moisture and nutrients elevated above competitors. It now offers suitable habitat for amphibians, such as the Clouded Salamander, that require moist, sheltered environments.

Evolution

Learning objectives

Darwin's Theory of Evolution

- Describe Darwin's observations and ideas that led to developing the concept of natural selection.
- Describe the process of natural selection and be able to describe an example of this process.
- Explain why individuals cannot evolve, and why evolution does not lead to "perfect" organisms.
- Explain how fossils form.

Evolution of Populations

- Define the gene pool, a population, and microevolution.
- Explain how genetic variation is produced and maintained in a population.
- Define gene flow and genetic drift.
- Explain how the bottleneck effect and founder effect influence microevolution, and how bottlenecks threaten the survival of some species.
- Distinguish among stabilizing, directional, and disruptive selection. Describe an example of each.
- Name and explain the 5 conditions under which genetic equilibrium will be maintained.

Speciation

- Define species and speciation.
- Explain how geographic isolation can lead to speciation.
- Explain how speciation can occur without geographic isolation, and describe an example.
- Describe the adaptive radiation of the Galápagos finches.
- Explain how a small body size might evolve in a species that has just migrated to a small island.

Early Earth and the Origins of Life

- List the major eras of life on earth. For each one, be to name its time range, and which type of life was most abundant. Name the key events that serve to divide these eras.
- Describe the conditions on the surface of the early Earth.
- Describe the experiments of Miller & Urey, and their significance in understanding how life might have first evolved on Earth.
- Describe the origin of single-celled organisms, the origin of multicellular organisms, and the colonisation of land.
- Explain the significance of the earliest photosynthetic bacteria.
- Describe how eukaryotic cells could have arisen from prokaryotic cells (endosymbiotic theory).

Mechanisms of Macroevolution

- Describe how Earth's continents have changed over the past 250 million years. Explain the consequences of these changes for life on Earth.
- Explain how mountains, volcanoes, and earthquakes result from plate tectonics.
- Describe the causes, frequency, and consequences of mass extinctions over the last 600 million years.
- Explain how and why adaptive radiations occur.
- Define convergent evolution and coevolution, and describe an example of each process.
- Define and describe examples of paedomorphosis.
- Distinguish between gradualism and punctuated equilibrium.
- Explain why evolutionary trends do not reflect "directions" or "goals."

Phylogeny

- Distinguish between homologous and analogous structures and provide examples of each. Describe the process of convergent evolution.
- Describe the goals of phylogeny. Define the terms cladogram, clade, monophyletic groups, derived characters, ingroup, and outgroup.
- Explain how molecular biology is used as a tool in systematics.
- Be able to interpret a cladogram.

Microbiology and Fungi

Learning Objectives

Bacteria

- Describe the roles of bacteria in the human body, and in natural and commercial systems.
- Distinguish between Domain Archaea (Kingdom Archabacteria) and Domain Bacteria (Kingdom Eubacteria).
- Describe the ways that various prokaryotes acquire energy.
- Explain what it means to be an obligate aerobe, obligate anaerobe, and facultative anaerobe.
- Describe binary fission, conjugation, and endospore formation.
- Describe the 2 ways that pathogenic bacteria can disrupt the host's body functions.
- Distinguish between vaccines and antibiotics, and explain how each one works. Explain how antibiotic resistance can evolve in bacteria.
- Describe 3 ways of controlling bacterial growth and/or killing bacteria. Explain the goal of aseptic technique.
- Explain the goal and overall process of the Gram stain procedure, and what the results indicate about cell wall composition.
- Be able to calculate the size of an object under a compound microscope.

Viruses

- Explain what a virus is, and describe the basic structure of a virus.
- Describe the function of the capsid.
- Give a detailed explanation of the process of lytic and lysogenic viral infections.
- Explain how retroviruses differ from other viruses.
- Compare viruses to living organisms, explaining which features of living organisms viruses have and which features they lack.
- Describe virus-like particles - viroids and prions - and explain how they differ from viruses.
- Give a step-by-step explanation of how vaccines work.

Eukaryotic cells

- Describe the structure and function of the nucleus.
- Describe the structures and organelles involved in protein synthesis.
- Describe the functions of the endoplasmic reticulum, Golgi apparatus, lysosomes, vacuoles, mitochondria, and chloroplasts.
- Describe the structure and function of the cytoskeleton.
- Be able to label the major structures on a diagram of a plant cell and an animal cell.

Protozoans- Kingdom Protista

- Explain what a protist is, and how the major groups of protists are classified.
- Name and describe the 4 phyla of animal-like protists. Be able to identify the phylum of a given protozoan.
- Identify the major structures of the protozoans *Ameba* and *Paramecium* on a model or diagram, and describe the functions of these structures.
- Describe the process of conjugation.
- Describe the life cycle of the protozoan that causes malaria.
- For one other disease (besides malaria) caused by a pathogenic protozoan, name the protozoan that causes it, and describe the transmission, symptoms, and treatment/prevention of the disease.

Unicellular Algae and Fungus-like protists

- Name and describe the 4 phyla of unicellular algae.
- Recognize *Euglena* as a unicellular alga and be able to identify its major structures on a diagram. Describe the function of these structures.
- Describe 2 ways in which unicellular algae are ecologically significant.
- Compare cellular and acellular slime molds.
- Describe the process of aggregation in slime molds.
- Compare slime molds and water molds in terms of their habitat, specialized structures, aggregation, and dispersal stage.

Fungi

- Describe how fungi obtain energy.
- Describe the structure of multicellular fungi, including the fruiting body, hyphae, and mycelium. Explain the function of each of these structures.
- Describe the general life cycle of fungi.
- Explain how fungi disperse their spores.
- Name and describe the 4 phyla of fungi. Be able to name at least one example member of each group.
- Describe the process of fermentation, and be able to name the phylum of fungi to which yeasts belong.
- Describe the importance of fungi as decomposers in natural ecosystems.
- Describe 2 examples of parasitic fungi.
- Describe 2 examples of mutualistic symbiosis that involve fungi. Explain the advantage to each organism involved in the relationship.
- For each fungus observed in lab, be able to identify the phylum to which it belongs, and what life stage or part of the life cycle it represents.

Labs

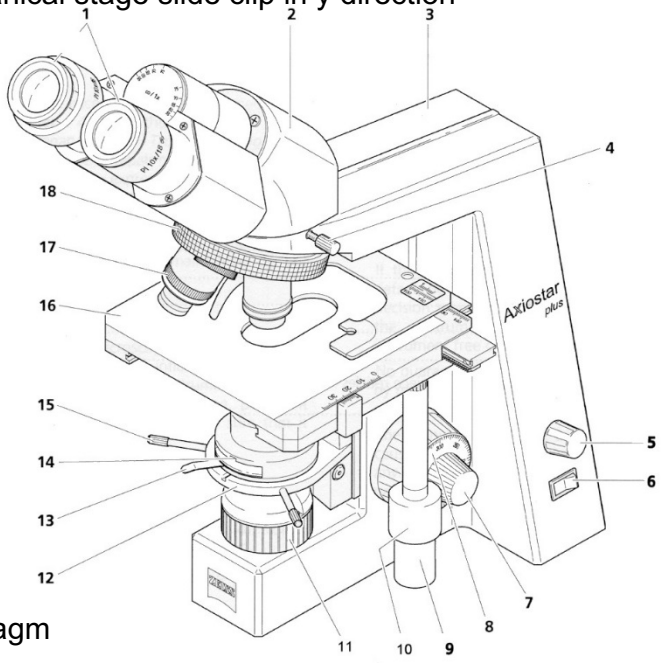
Microscope lab

Important reminders:

- Always carry with two hands!!!
- Dry the stage a.s.a.p. if it accidentally gets wet.
- Never use the 100x objective (longest of 4 lenses, has black ring around bottom of lens) unless instructed to do so

Parts of a Microscope

1. Eyepieces
2. Binocular tube
3. Microscope stand or arm
4. Knurled screw for tube locking
5. Brightness control
6. On/off switch with integrated signal lamp
7. Fine focusing drive (two-way)
8. Coarse focusing drive (two-way)
9. Drive for adjusting mechanical stage slide clip in X direction
10. Drive for adjusting mechanical stage slide clip in y direction



11. Luminous field diaphragm
12. Condenser carrier
13. Lever for adjusting iris diaphragm
14. Condenser
15. Centering screw for condenser (two-way)
16. Mechanical stage with specimen holder (slide clip)
17. Objective
18. 4-position nosepiece

Practice using the microscope before viewing a slide:

1. *Before you turn it on or insert a slide*, make sure the **low power** (shortest, 4 or 5X) **objective lens** (on rotating wheel) is clicked in place closest to you.

2. Clean all the lenses with **lens paper**.

3. Plug in the microscope, find the light switch, and turn on

4. Look through the **ocular lenses** and reduce the light until it is comfortable for your eyes.
   Now swing in or out the ocular lenses (eyepiece lenses) until you see only 1 circle of light.

5. Find the lever for the **iris diaphragm**.
   Slide left and right to further adjust the amount of light.

6. Find the large **coarse focus** wheel.
   Turn towards yourself and watch the stage from the side. What happens to the stage?

7. Find the small **fine focus** wheel.
   Turn towards yourself. What happens to the stage?

Now you are ready to view a slide:

8. Obtain a slide of *Aurelia* (baby jellyfish) and clean it with **lens paper**. Place it on the stage. (*You will have a silver-coloured **slide holder** to help you drop and hold the slide in the proper location. The slide should click into place.)*

9. Check that the **low power** objective lens (4 or 5 X) is still in place, and look at the magnified jellyfish through the ocular lens.
   Use the coarse focus wheel to focus on the cells.
   Adjust the focus using the fine focus wheel.
   Adjust the light reaching your eye using the iris diaphragm.

10. Use the side arms with rubber turn-wheels to move the slide left/right and forward/back until you see the jellyfish in the center of the **field of view** (circle of light).

11. Rotate the objective lenses until the next (middle length, 10X) lens clicks in place closest to you.
    Center the jellyfish
    Adjust the focus using the **fine focus** wheel to better see the cells. *Important tip: Only use the fine focus when looking at slides under mid- or high-power magnification.*

12. Use a circle on the next page and inside that circle, sketch what you see. These circles represent the field of view, the circle of light you see. Make sure your drawing is done to scale. Note the magnification next to your sketch. (e.g. 10X objective with 10X ocular = 10·10 = 100X total magnification). Also write the sample name next to your drawing.

13. Rotate the objective lenses until the next (40 or 50X length) lens clicks in place closest to you.
    Center the jellyfish part of interest
    Adjust the fine focus to better see the cells

NOW YOU ARE READY TO VIEW A SLIDE OF BACTERIA:

14. Repeat steps 7-11 to view a pre-prepared and stained sample of cocci and a sample of *E.* coli. Remember that you must start with the **low power objective lens** each time. *Note that the cells will only look like a mass of coloured dots at first. You will need to view these cells at high magnification before any details start to come in to view.*

15. Now swing the high-power objective partly out of line and place a single drop of oil onto the middle of the slide. *If you look carefully at the slide from the side, you can see where the path of the light passes through. Place you oil drop here.*

16. Rotate the highest power objective lens into place (it has a black ring around its base and is marked with 100x) to view the bacteria.

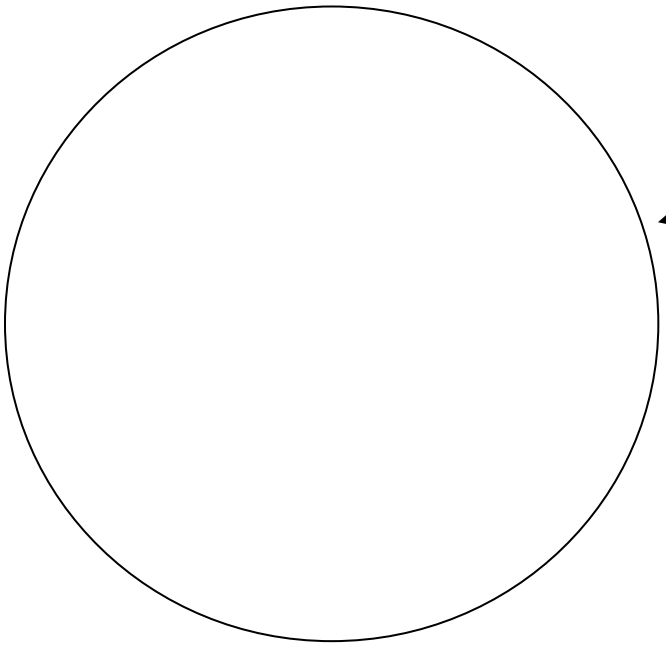
17. Use two other the circles on the next page to sketch a few cells from what you see. Note the sample name and magnification next to each sketch.

When you are finished:

1. Remove oil from slides with lens paper.
2. Put the slides back in their holders
3. Clean the microscope lenses with lens paper
4. Loosely coil the electrical cord and replace it in the cupboard
5. Cover the microscope with the plastic slip and replace it carefully in the cupboard
6. Wipe down your work area and wash your hands

Microscope Lab –Sketching cells

1. Organism name: _____



(Field of view)

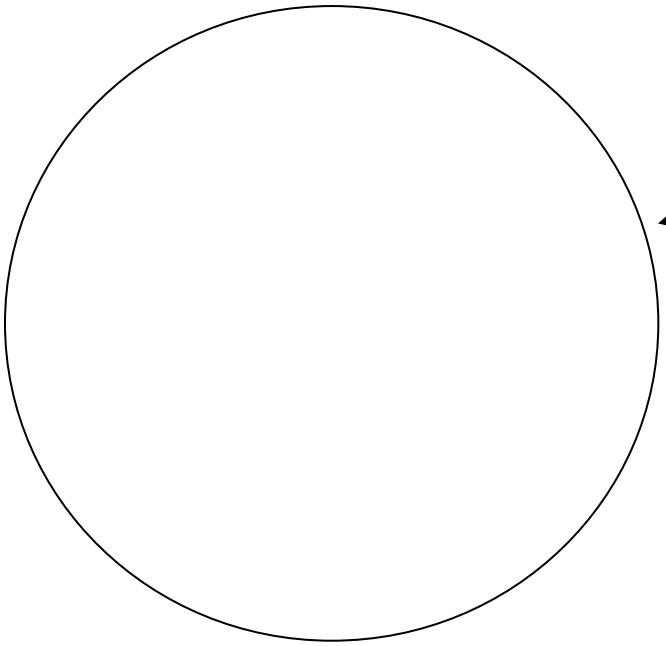
Microscope magnification:

Objective magnification: ____ X

Ocular magnification: ____ X

Total magnification: = _____ X

2. Organism name: _____



(Field of view)

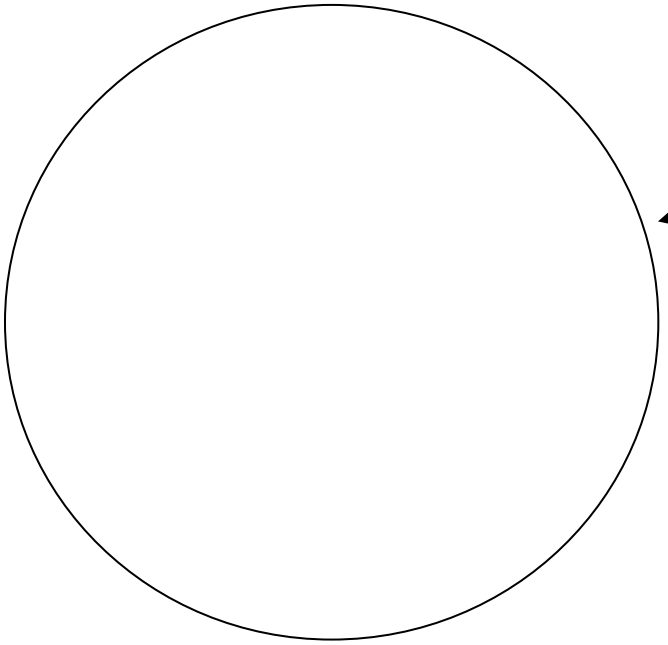
Microscope magnification:

Objective magnification: ____ X

Ocular magnification: ____ X

Total magnification: = _____ X

3. Organism name: _____



(Field of view)

Microscope magnification:

Objective magnification: ____ X

Ocular magnification: ____ X

Total magnification: = _____ X

Name: _____

Bacteria lab

Day 1: Culturing bacteria

Culturing bacteria:

We will grow bacteria from two sources: (1) prepared cultures of known bacterial species, and (2) the college environment. We will grow them in Petri dishes on a culture medium called nutrient agar. The agar culture medium is derived from seaweed and is rich in nutrients that support bacterial growth.

To prepare for this lab, read this handout and review your class notes on bacteria and aseptic technique. All techniques will be demonstrated in class before you begin.

Safety

Refer to the appendix for detailed safety information for this lab. Please review these sections prior to the lab:

- Use of Bunsen Burners
- Chemical safety
- Biohazards
- Spills

We will discuss related safety procedures as part of the pre-lab demonstration.

1) Bacteria from prepared cultures
   - Obtain a Petri dish. Do not open it until it is time to inoculate it.
   - Use a wax pencil to label the Petri dish with your name, the date, and the bacteria species. Label around the edge of the dish, not across the centre. Make sure you are labelling the side of the Petri dish that contains the agar, and not the lid!
   - Use an inoculating loop to collect bacterial culture from the culture flask. Streak the plate by lightly applying the loop to the culture plate, without breaking the surface of the agar.
   - Place your plate upside down in the incubator (i.e. agar side up) in order to prevent condensed water from dripping onto the agar. The warm, constant temperature in the incubator encourages rapid bacterial growth.

   Bacteria species you are growing: _____

2) Bacteria from the college environment

- Obtain another Petri dish. Do not open it until it is time to inoculate it.
- Use a wax pencil to label the lid of the Petri dish with your name and the date, and the base (agar side) of the dish with two lines that cross to divide the dish into 4 equal areas:

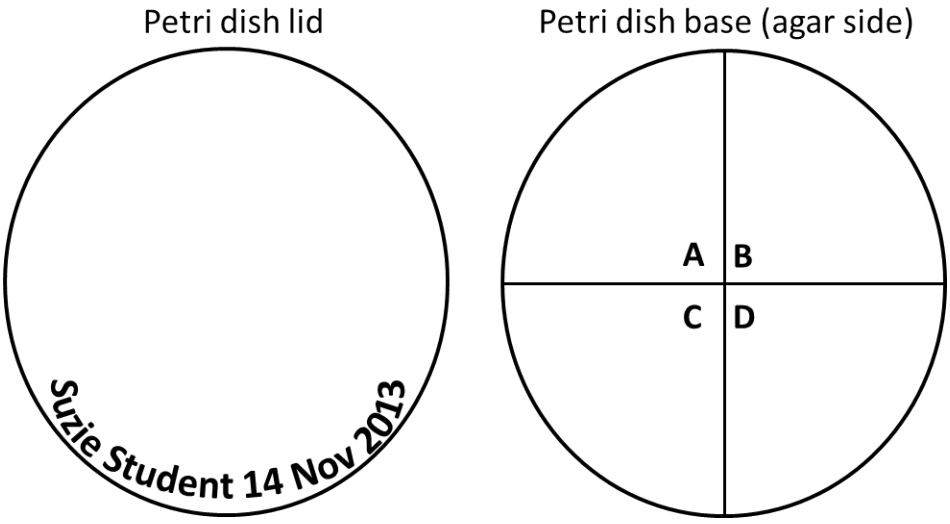


Fig. 1. Labelling your Petri dish

- Take two sterile cotton swabs. Don't open the packages until you are ready to collect samples, and don't touch the ends of the swabs!
- Using one end of each swab for each collection, transfer bacteria from each of three surfaces to each of the three sections of your dish (B, C, and D). Leave section A blank as a control. Collect from anywhere in the college environment EXCEPT bathrooms and bodily fluids (including saliva). Record where you collected each sample in Table 1.
- Tape your culture dish shut.
- Place your plate upside down in the incubator (i.e. agar side up).

Table 1. Bacteria sample collection locations at Vancouver Community College.

Sample	Collected from
A	(control sample - just the swab straight out of the package)
B	
C	
D	

1. What measures did we take in this lab to prevent contamination?

2. Which of your samples do you expect to grow the greatest diversity of bacteria, and why? Which do you expect to grow the least diversity of bacteria, and why?

3. Why might your samples not reveal the true diversity of bacteria in the college environment?

Day 2: Staining and observing bacteria

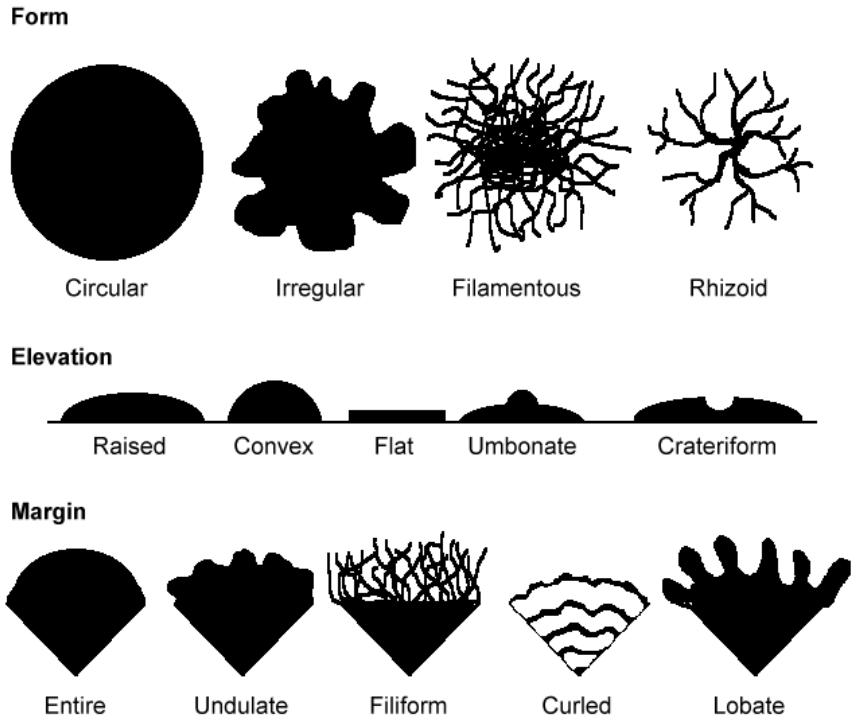
In today's lab, we will observe the bacteria we cultured on Day 1 in two ways:

1) under the dissecting microscope to observe features such as size, shape and colour of the colonies (known species and environmental samples)
2) under the compound microscope to observe cell shape and whether they are Gram-positive or Gram-negative (known species only)

To prepare for this lab, read this handout and review your class notes on bacteria, aseptic technique, and identifying bacteria.

** Remember: to keep plates sealed shut (especially those with unknown bacteria from the college environment) in case you happened to culture a harmful (pathogenic) species!! **

Observe the growth your Petri dishes and record your observations in Tables 2 and 3. Use the diagrams in Fig. 2 to help you describe the colonies.



Opaque: not permitting light to pass through (hold plate up to light to check)
Translucent: some light passes through

Fig. 2. Properties of bacterial colonies. Image from sciencebuddies.org

Table 2. Observations of bacterial colonies from prepared cultures

Species	Colony size (mm)	Colour	Form	Elevation	Margin	Opaque / translucent

Table 3. Observations of bacterial colonies from the college environment

	# of types visible	Colony size (mm)	Colour	Form	Elevation	Margin	Opaque / translucent
A							
B							
C							
D							

1. Was your prediction (from Day 1) correct regarding which area of the college would have the most and least bacterial diversity? Explain.

2. Did anything besides bacteria grow on your environmental swab plate? Describe.

3. Compare your plate with at least one other group. Describe differences and similarities between the two plates.

Gram Stain:

We will examine bacteria from the prepared cultures using the Gram Stain procedure. The Gram Stain procedure allows us to differentiate bacteria into gram positive or gram negative groups. This has practical application as a step in identification of bacteria, as well as significance in terms of cell composition & structure. Bacteria will stain as either **gram positive** (purple or dark blue) or **gram negative** (red or pink) depending on the composition of their cell wall.

Gram positive cell wall: Gram negative cell wall:

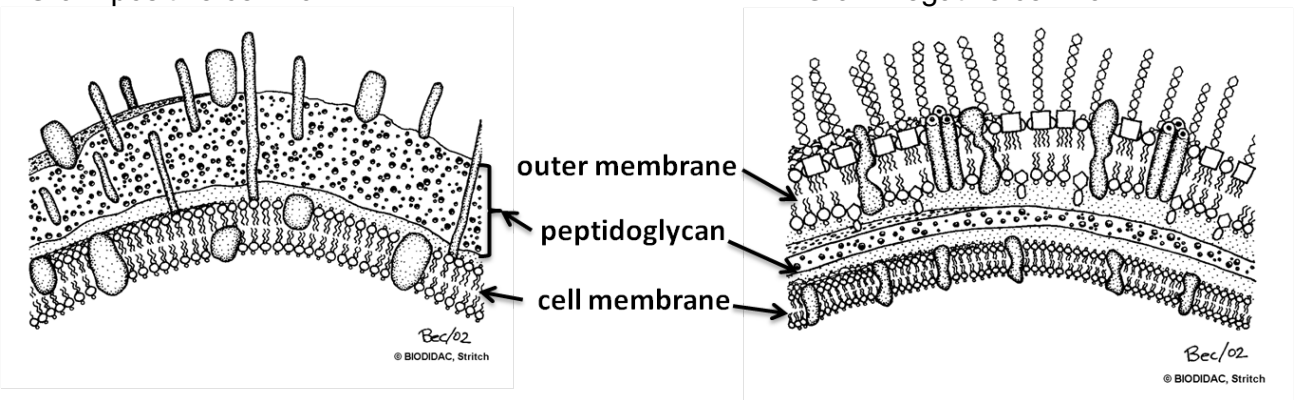


Fig 2. Gram-positive and gram-negative cell walls.

Gram Stain Procedures:

Slide preparation:

1. Label a slide with initials using a wax pencil
2. Hold slide with a clothespin while working through procedures and draw a circle (approx. 1 cm in diameter) in the middle of the slide using the wax pencil.
3. Using an inoculation loop, smear bacteria culture within the boundaries of the circle. Dilute smear with a drop of water to ensure an even consistency if necessary.
4. Allow to air dry.
5. Fix the smear by passing quickly through flame 3-5X. Do not over-heat.

Staining Procedure:

1. Place slide on screen over waste collection vessel.
2. Cover the smear with 1-2 drops of **crystal violet** and allow to react for 60 seconds
3. Rinse the slide gently with **deionized water**, taking care not to spray water directly on smear. To do so, introduce a gentle stream of water at one end of slide and allow it to rinse across the smear. Collect run-off in waste vessel.
4. Add 1-2 drops of **Gram's iodine** and allow to react for 60 seconds
5. Rinse the slide again gently with **deionized water**, taking care not to spray water directly on smear. Allow run off to collect in waste vessel.
6. Decolorize the slide with **ethanol (95%)**. Continue dropping ethanol on one end of slide and allow it to run across the smear and into waste vessel. Continue until the

run-off is clear (no more purple stain is being washed away). This may require several dropper squirts. Do not over de-stain.

7. Rinse the slide again gently with **deionized water**, taking care not to spray water directly on smear.
8. Add a drop of **Safranin-O** and allow to react for 60 seconds.
9. Do a final rinse of the slide gently with **deionized water**, taking care not to spray water directly on smear.
10. Blot the slide carefully using paper towels to dry. Do not rub the smear.
11. Examine on microscope at 400X or 1000X (Oil immersion), no coverslip required.
12. Observe and record whether your specimen is **gram positive (blue or purple)** or **gram negative** (pink or red). Record the shape of the cells as well (spheres (cocci), rods or spiral shaped). Create a diagram to illustrate what you see, including estimates of cell size.

Clean Up:

- Slides should be placed in the biohazard sharps disposal container
- Work surfaces should be wiped down with disinfectant wipes or 70% ethanol
- Wash your hands well with warm water and soap

All techniques will be demonstrated in class before you begin. Additional information on Gram Stain and Oil Immersion techniques will be provided in class - follow these very carefully to avoid damaging equipment and contaminating samples, and of course in order to obtain the best results!

Table 4. Observations of Gram-stained bacteria

Bacteria species	Gram-positive or Gram-negative?	Drawing of cells - include shape and estimate of cell size

4. What does the Gram stain result indicate about the cell composition and/or structure of bacteria?

Name: _____

Protist lab

Prepared slides:
Set up your compound microscope and obtain prepared slides of *Amoeba, Paramecium*, *Euglena* and one other protist of your choice.

1. View the prepared slide of *Paramecium* at high power (400x). Make a detailed scientific drawing (with labels of all structures you can see, a scale bar, and a proper title). This drawing should be based on what you actually see under the microscope and not copied from your textbook or class notes.

2. View the prepared slide of *Amoeba* at high power (400x). Make a quick sketch of what you can see and label the structures used for movement.

3. View the prepared slide of *Euglena* at high power (400x). Make a detailed scientific drawing (with labels of all structures you can see, a scale bar, and a proper title). This drawing should be based on what you actually see under the microscope and not copied from your textbook or class notes.

4. For another protist of your choice (not *Paramecium*, *Amoeba* or *Euglena*)

a) What is it called?

b) Is it an animal-like, plant-like, or fungus-like protist? How do you know?

c) Draw a quick sketch of it, labelling any features you can see.

Live protists:

Follow the instructions given in lab to make depression slides of two different live protists. Compare them in the Table 1.

Table 1. Comparison of live protists viewed in lab.

	Structures visible on live specimen	Description of movement / other observations
Protist: Phylum:		
Protist: Phylum:		

Name: _____

Fungi lab

Mushroom

Phylum:_____

What is the mushroom called in the fungus life cycle, and what structures does it produce?

Grasp the cap firmly with one hand and twist the stem until it breaks away from the cap. Pinch the stem between your fingers until it breaks into long pieces; gently pull these pieces apart. What are these hairlike filaments called? _____ Examine these under the dissecting microscope.

Now look at the underside of the cap. Each gill is lined with thousands of basidia, the spore-producing structures. Gently grasp one gill with forceps, near where it attaches to the cap, and pull it loose. Place it on a microscope slide, add a drop of water and a coverslip. Examine the slide with the compound microscope to find the finger-shaped basidia, and see if you can see any spores. Draw what you see:

View a prepared slide of a mushroom cap. Draw or describe where the **spores** and basidia are located.

Yeast

Phylum: _____

Put a drop of the yeast mixture under onto a slide, and add a coverslip. Examine it under the compound microscope. You should be able to see cell division. What is this process called? _____ Is it sexual or asexual reproduction?

_____

Now look at a prepared slide of yeast (*Saccharomyces cerevisiae*) and draw a quick sketch of a yeast cell.

Mold

Phylum: _____

Observe the mold in a culture dish under a dissecting microscope. Look for **hyphae** and **sporangia**. Draw (and label) a sketch of what you see.

Examine a prepared slide of bread mold (*Rhizopus*) using a compound microscope. Look at the hyphae and a sporangium up close.

What does the sporangium produce?

Is the bread mold classified as a parasite or a decomposer? Why?

Lichen

What two types of organisms form a lichen?

What is this type of relationship called?

How does each species benefit from the relationship?

Look at the lichen under the microscope. Draw a sketch of the lichen and label the fungal and algal components.

Research paper

Microbiology in the News

DUE DATE: _____

For this assignment, you will find **two** related news articles about a bacteria, virus, or protist. The articles should come from a printed newspaper (such as The Vancouver Sun, The Globe and Mail or The New York Times), or a major online news service (such as cbc.ca, cnn.com, bbc.co.uk) with full-length articles. Free daily newspapers with very short articles (e.g. Metro) are not appropriate for this assignment.

Your paper will consist of:

- summaries of **two** related articles
- your comments on how the two articles compare to each other and how they are related
- a glossary of scientific terms from the articles

Details:

1) Choosing articles
At least one of the news articles you choose should have been published in the past 12 months. It must be about a bacteria, virus, or protist. It should be a news article, and not simply an informative one - for example “New mutations in HIV discovered”, not “Why you should get a flu shot”. The second article should be related to the first one but can address a different aspect of the same bacteria, virus, or protist. An informative article (as opposed to a news article) is acceptable for the second article, as long as the first article is a news article. Check with your instructor if you are not sure about the articles you have selected. Include a copy of both articles along with your written report.

2) Writing summaries
Each article summary should be about 300-400 words long (for a total of 600-800 words). You may need to include some background information from other sources (such as your textbook) in order to explain your articles; if so, be sure to properly cite the source that you used to find this information. The summary should be in your own words; it is not enough to simply change a few words from the original article (that’s still plagiarism!). Do not include quotes from the articles.

3) Commenting on the articles
After summarizing the articles, discuss how the two are related. For example: how does reading both articles change your perspective on the issue? Do the articles agree with each other, or present different viewpoints? Does either article seem to have a certain bias? Is one a “better” article, and how? This section should be about 200-300 words long (about one page, double-spaced).

4) Creating a glossary
While reading the articles, you should make a note of any unfamiliar words and look them up. Use this list to create a glossary of at least 5 “biology” terms to accompany your paper. If you are familiar with all of the words in the article, choose 5 that you think are important for anyone reading the article to know, and provide definitions for these words. Be sure to properly cite the source that you used to find these definitions. Your textbook or other biology textbooks may be good resources for this.

5) Listing your references
All of the sources you use should be cited in-text and listed at the end of your paper under the heading “references”. Use Harvard format (not APA, MLA or another format – see “Formatting References” in the Appendix).

How you will be marked:
Summary: 10 points (5 points per article)
- article topic and source are appropriate for the assignment
- includes enough relevant background information
- accurate reflection of the article
- well-written: correct grammar, sentences and paragraphs flow logically
- double-spaced and appropriate length

Comment: 4 points
- discusses importance or relationship between articles
- reasonable, well-thought-out discussion
- well-written
- double-spaced and appropriate length

Glossary: 3 points
- 5 terms
- good choice of terms
- terms correctly defined
- source(s) for definitions properly cited

References: 3 points
- follows Harvard format

-1 per news article not attached

Avoid plagiarism:
This paper MUST be in YOUR OWN WORDS. Direct quotes are not acceptable. Do not directly copy or cut and paste text from any source. Changing a few words is also not sufficient - take notes in your own words and then write from those notes rather than reading from another source as you write your paper. Copying from another source, only slightly changing the wording, or failing to cite sources, is considered plagiarism and is a serious offence that will result in a grade of “0” for this paper.

Plagiarised assignments will result in a grade of “0” for the assignment and may result in failing the course and/or further disciplinary action.

Disease Report

DUE DATE: _____

Select a human disease that is caused by bacteria or a virus. Write an essay that describes the pathogen, its life history, and the cure (if known) for the disease it causes.

Read this entire assignment description before you begin!! Get started early - it's almost impossible to write a good essay the night before it's due.

How to begin:

- Go to the library to find articles on your disease
- You can use textbooks, scientific journals, or the internet for your information sources. Be sure to focus your research on the causes of the disease and the pathogen involved.
- If you are using internet sources, stick to government websites, or large health care resources such as the Mayo Clinic - not about.com, webmd.com, or personal websites!
- As you take notes, make sure you write down the page numbers and bibliography information of the book, journal, etc., or note the address (url) of the website.

Content:

Introduction

A very general paragraph on the topic including the name of the pathogen, the people affected by it, and the severity of the disease.

Type of Pathogen

A paragraph to describe the pathogen: its kingdom or virus family name, its scientific name (using binomial nomenclature, e.g. *Staphylococcus epidermis*), and a description of the pathogen (shape, Gram-negative/positive if applicable, whether/how it moves).

Life History of Pathogen

One (or several) paragraphs to describe the process of the infection. Answer at least 3 of the following questions:

- How does the pathogen get transmitted to new hosts (people)?
- Which body organ(s) does the pathogen inhabit?
- How does the infection make people sick?
- How long does the infection last?
- How severe is the infection?

Cure for Pathogen
A paragraph that describes any currently known cure or treatment for this disease.

Summary
A 3-4 sentence that summarizes your whole report.
References
List **all** the information you used in your essay. You must:

- List them alphabetically by the primary author's name
- Use Harvard format (not APA, MLA or other formats) - see "Formatting References" in the Appendix for more information.
- List all the references that you cited in the body of your essay
- List at least 3 references

How to present your report:

- Type and double-space your essay. Use 12-point font and choose an easy-to-read simple font like Times New Roman, Arial or Calibri. Use the standard margin size in your word processing program.
- Your report should be 2-4 pages long (double spaced). An extra page is allowed for your list of references.
- Include a heading for each section: Introduction, Type of Pathogen, Life History of Pathogen, Cure for Pathogen, Summary, References
- Use parenthetical referencing in the body of your essay:
    - After each sentence, you should write in parentheses the last name of the authors of the book, article or website where you got the information for that sentence, and the year the book/article was published. For example: Vaccines are injected into the body in order to stimulate the body to produce immunity so that it can fight the disease (Miller and Levine, 2008).
- Check your essay carefully before you hand it in: does it contain all of the required content? Does it make sense? Is the grammar perfect? Have you cited all of your sources? Ask a friend to read through it for you to double-check the grammar and that it all makes sense.

Avoid plagiarism:
This paper MUST be in YOUR OWN WORDS. Direct quotes are not acceptable. Do not directly copy or cut and paste text from any source. Changing a few words is also not sufficient - take notes in your own words and then write from those notes rather than reading from another source as you write your paper. Copying from another source, only slightly changing the wording, or failing to cite sources, is considered plagiarism and is a serious offence that will result in a grade of "0" for this paper.

Plagiarised assignments will result in a grade of "0" for the assignment and may result in failing the course and/or further disciplinary action.

Algae and Plants

Learning Objectives

Algae

- Describe the 3 major taxonomic groups of multicellular algae.
- Describe the function of chlorophyll and accessory pigments.
- Be able to draw and label a sketch of a kelp and describe the function of each structure.
- Define alternation of generations.
- Describe/diagram the life cycle of multicellular algae, including where meiosis, mitosis and fertilization take place, and which stages are haploid and diploid.
- Be able to list at least two ways that humans use algae.
- Describe the ecological importance of algae.
- Be able to identify algae that you see in lab as unicellular, colonial, or multicellular (and know what these terms mean!).
- List adaptations of algae that you see in lab to environmental conditions such as deep water, strong currents or waves, and exposure to air.

Introduction to plants / Bryophytes

- List 4 requirements of all plants.
- Describe 2 trends in the evolution of plants.
- Explain why mosses are called non-vascular plants.
- Explain why mosses are only found in moist, shaded habitats.
- Be able to draw and label a sketch of a moss, and identify whether each structure belongs to the sporophyte or gametophyte stage.
- Describe/diagram the life cycle of moss, including where meiosis, mitosis and fertilization take place, and which stages or parts are haploid and diploid.
- Compare mosses with algae in terms of life cycle and dependence on water.

Introduction to vascular plants / Pterophytes

- Explain the function of vascular tissues in plants.
- Compare the two types of vascular tissue in terms of their structure and function.
- Define roots, stems, and leaves. (We will cover these structures in more detail in another lecture)
- Describe/diagram the life cycle of a fern, including where meiosis, mitosis and fertilization take place, and which stages are haploid and diploid.
- Be able to identify a fern prothallus and know where it fits into the life cycle of the fern.

Introduction to seed plants / Gymnosperms

- Define seeds, and describe their function. Explain how seeds allow seed plants to live in a wide variety of habitats.
- Describe pollination and know where pollen grains fit into the life cycle of seed plants. Be able to identify a pollen grain under a microscope.
- Explain how conifers are adapted to dry conditions.
- Be able to identify cones as male (pollen cones) or female (seed cones).
- Describe/diagram the life cycle of a conifer, including where meiosis, mitosis, pollination and fertilization take place, and which stages are haploid and diploid.

Angiosperms

- Define flowers and fruit, and know the function of each and where they fit into the life cycle of angiosperms.
- Compare characteristics of monocots and dicots.
- Be able to identify the parts of a flower on a model, a diagram, and a real flower. Know which of the reproductive parts are male, and which are female.
- Describe/diagram the life cycle of an angiosperm, including where meiosis, mitosis, pollination and fertilization take place, and which stages are haploid and diploid.
- Describe endosperm and double fertilization.
- Describe the process of germination.
- Conduct an experiment on seed germination and write up a formal lab report including appropriate background information, a graph and description of your results, and discussion of what your results mean.

Roots, stems, and leaves

- Describe the structure and function of dermal, vascular, and ground tissue.
- Describe the functions of roots, stems and leaves. Be able to tell whether a cross-section of a stem belongs to a monocot or a dicot.
- Label the major structures of a tree trunk, and know the functions of these structures.
- Be able to identify the major structures in a cross-section of a leaf, and know the functions of these structures.

Plant adaptations

- Describe the 3 categories of plant responses. Give an example of each type of plant response.
- Explain how plants defend themselves against insects.
- Explain the process of preparing for winter dormancy in plants.
- Name 5 types of habitats that are “challenging” for plants to live in. For each one, describe: why it is challenging, and how some plants are adapted to deal with that challenge.

Name:_____

Algae lab

***Chlamydomonas*:**
Single-celled, colonial, or multicellular? _____
How can you tell?

Observe the using a compound microscope. Draw a sketch of *Chlamydomonas* and label any structures you can identify.

Volvox:
Single-celled, colonial, or multicellular? _____
How can you tell?

Observe the specimen using a compound microscope. Describe the movement of *Volvox*. If you can't see what structures are causing it to move, make an educated guess.

Draw a sketch of *Volvox* and label the **chloroplasts** and any structures or features that you would use to identify it.

***Spirogyra*:**
Single-celled, colonial, or multicellular? _____
How can you tell?

Observe the specimen under low power on a compound microscope, then move on to higher magnification. Draw a sketch of *Spirogyra* and label the **chloroplasts** and any structures or features that you would use to identify it.

Ulva:
Make a wet mount (slide) of a small piece of *Ulva* and examine it under high power on the microscope. What structures are visible? Draw and label a diagram of one or two cells.

Another marine alga of your choice: _____
Phylum: _____
Single-celled, colonial, or multicellular? _____
How can you tell?

Draw a sketch of the marine alga.

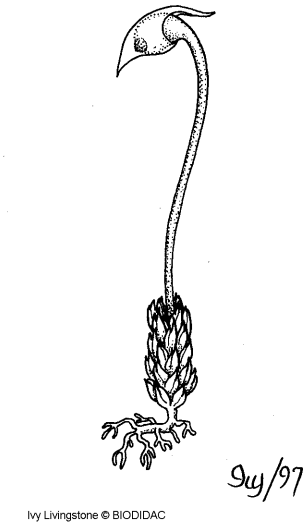
This alga lives in the intertidal zone is sometimes exposed to the air. How do you think it copes with being out of the water?

Name:_____

Moss and fern lab

1. Moss

Gently separate out one moss plant from the clump of moss and compare it to the diagram below; are all structures on the diagram also visible on your specimen? Label the diagram, including the sporophyte, gametophyte, stalk, and capsule. Where are the spores located?



Remove a single moss "leaf" using the forceps and examine it. Is it shiny or dull? Moist or dry? Soft and flexible, or stiff?

Make a wet mount of the moss "leaf". Observe it under low power on the compound microscope and make a drawing of what you observe.

Now focus the microscope at high power. What are the green structures you can see?

Obtain prepared slides of *Mnium* (a moss genus) **archegonia** and **antheridia**. Examine these at high power. What life stage (sporophyte or gametophyte) of moss do these represent?

Sketch both below, and label an antheridium, an archegonium, and an egg on your drawings.

2. Fern

Is the fern you are examining the sporophyte or gametophyte stage?

Examine the fern frond. Compared to the moss, is it shiny or dull? More flexible, or stiffer than the moss?

What type of tissue is present in the fern and not the moss?

Examine the **sori** (singular = sorus) on the underside of a fern. Each sorus consists of a cluster of rounded **sporangia**. Carefully scrape part of a sorus (i.e. some of the sporangia) onto a slide and make a wet mount. Examine this under the microscope and draw a sporangium.

Obtain a prepared slide of a fern prothallus. What life stage is this? Is it haploid (n) or diploid (2n)?

Examine the prothallus under a dissecting microscope. Draw a sketch of the prothallus and label the antheridia, archegonia, and rhizoids.

Examine the prepared slides of fern antheridia and archegonia if these structures were not clear on the prothallus slide. You will need to examine these at high power. How does their structure compare to the moss antheridia and archegonia?

Name: _____

Flower, fruit and seed lab

1. Flower dissection:

Collect the following materials: one flower, a scalpel, a watch glass, and a dissecting microscope.

a) Before dissecting the flower, make a sketch of the whole flower and label the **stigma**, **style**, **stamen, petals**, and **sepals** (if present).

b) What is the function of brightly-coloured petals?

c) Now make a longitudinal cut down through the flower. Be careful to cut down the middle of the ovary. Add the dissected portion to your flower drawing, and label the **anther**, **filament, ovary**, and **ovules**. Note the locations of seed development and pollen formation on your diagram.

2. Fruit:

a) Look at the fruits on display. Can you see any remnant of the flower on the outside of any of the fruits (perhaps a small, withered sepal)?

b) Look at a cross-section of an apple. On the diagram below, label the **seeds** and the old **outer membrane of the ovary** (this membrane is tough and separates the "core" from the rest of the apple).

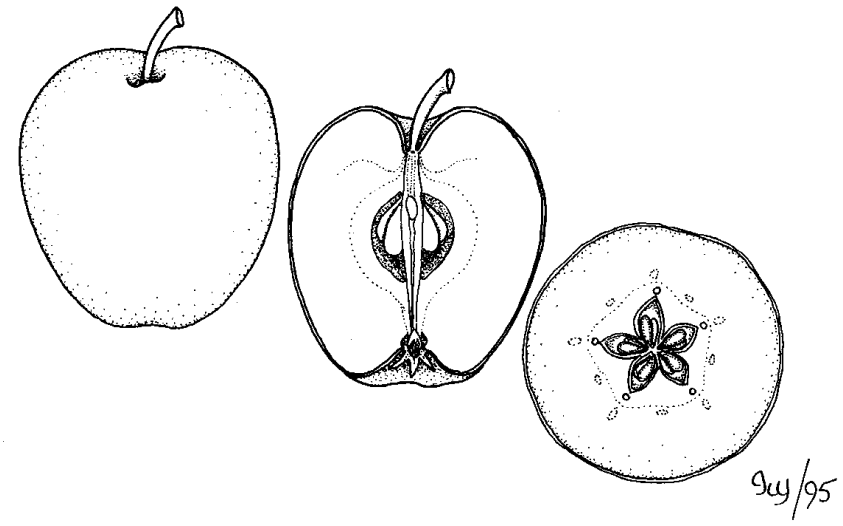


Image © BIODIDAC

c) Is an apple tree a monocot or a dicot? How can you tell from looking at the apple?

d) What is the function of fruit?

3. Seeds:

Collect the following materials: one bean seed that has been soaked overnight, a scalpel, a watch glass, and a dissecting microscope.

a) Carefully remove the **seed coat** of the bean seed. What is its function?

b) You should now be able to see the two **cotyledons**. Is the bean a monocot or a dicot?

c) Lift the cotyledons apart to find the part of the plant embryo that will become the stalk, and the part that will become the root. Make a quick sketch of the bean seed and label these structures. Also locate the **endosperm** and label it on your diagram.

Name: _____

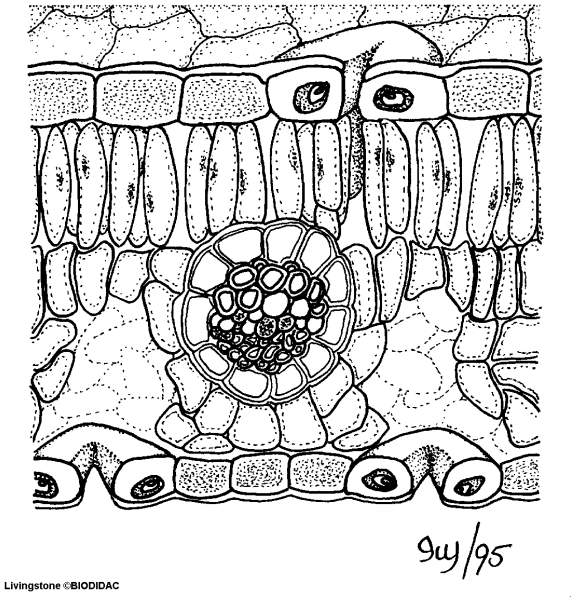
Leaves, stems, and roots lab

You will need a compound microscope, and prepared cross section slides of: a leaf, corn (*Zea mays*) stem, sunflower (*Helianthus*) stem, buttercup (*Ranunculus*) root.

1. Leaves:

Examine the prepared slide of a leaf cross section under high power (remember to start at low power, focus, then move into high power without changing the coarse focus).

a) Find the **cuticle, epidermis, mesophyll, stomata,** and **vascular tissue** on your slide and label them on the diagram. Note any differences between the diagram and what you see on the slide.



b) What is the function of the stomata?

2. Stems:

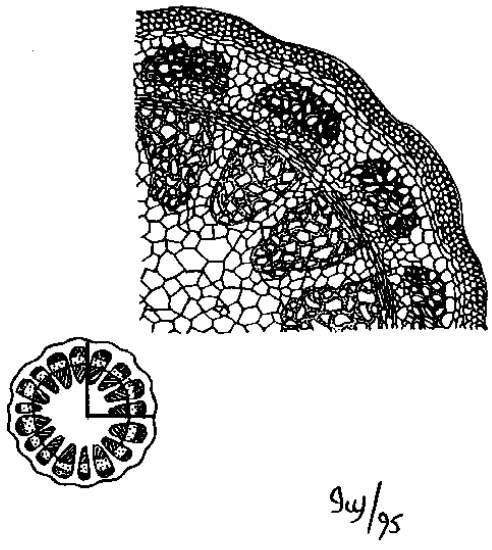
Examine the slide of a corn stem (*Zea mays*) cross section under low power.

a) How are the vascular bundles arranged? Is this typical of a monocot, or a dicot?

Examine the slide of a sunflower stem (*Helianthus*) cross section under low power.

b) How does the arrangement of vascular bundles compare with that of corn? Is this arrangement typical of a monocot, or a dicot?

c) Label the **xylem**, **phloem**, **dermal tissue**, and **ground tissue** in the diagram of a *Helianthus* stem cross section below.



Livingstone, © BIODIDAC

Look at the large cross-section of a tree.

d) What tissues make up the **bark**?

e) Find the **heartwood**. What type of tissue is it made up of?

3. Roots

Examine a cross section of a buttercup (*Ranunculus*) root. Draw a quick sketch of it and label the **epidermis**, **cortex**, **xylem** and **phloem** on your diagram.

a) Can you see root hairs on your slide? What is their function (even if not present on your slide)?

Seed germination lab report

Name: _____

Pre-lab assignment

We will be conducting an experiment to test the effects of temperature on seed germination. Each group will study a different type of seed so that we can compare the results. Use your textbook and/or other resources to answer the questions below.

**** Complete this assignment as homework and bring it to the next class ****

1) Describe the process of seed germination.

Where you found this information: _____

2) What time of year do seeds normally germinate? What are the conditions like in that season?

Where you found this information: _____

** You will need to use Harvard format for citing references in your final report, so keeping track of where you found the information (and all of the necessary bibliographic information like author, year, title, etc.) at this stage will save you some work later!!

Name: _____

Hypotheses

1) For your group's experiment, identify the:
a) dependent variable: this should be what we are specifically going to measure or count.

b) independent variable: this should be what we are going to vary in order to test its effects.

c) factors we will keep constant?

2) Write out your hypothesis for your group's experiment. Use one of the two following formats (not both).

Option 1:
I predict that as _____ increases, _____ will _____.
(independent variable) (dependent variable) (increase/decrease)

Option 2:
Alternatively, you might predict a non-linear relationship between the variables, i.e. the middle value of the independent variable might result in the highest value of the dependent variable. In that case you would write your hypothesis as follows:

I predict that _____ will be greatest at _____ and lower at
(dependent variable) (one level of independent variable)
_____.
(other levels of independent variable)

3) Explain why you think your hypothesis is right. Use information from your textbook or another reference to back it up.

Where you found this information: _____

4) By using data from the whole class, we will be able to add another independent variable: seed type. Write out your hypothesis for the class experiment… but… it doesn't make sense to use the same format because seed type is a category, not a numerical variable. Instead, try this format: I predict that among _____ ,
(list all seed types your class is using)

_____ will have the highest _____ and
(one type) (dependent variable)

_____ will have the lowest _____.
(another seed type) (same dependent variable)

5) Explain why you think your hypothesis is right. Use information from your textbook or another source (such as a plant book or website) to back it up.

Where you found this information: _____

Name: _____

Methods

1) With your group, make an ordered list or a flowchart of all the steps you will take to conduct your experiment.

2) Why is it important that everyone in the class follows the same procedure? (You do not need to include this in your formal lab report)

Name: _____

Data sheet and observations

Table 1. Raw data for your group.
Seed type: _____ # of seeds per replicate started on Day 1:___

	Temp: ____ºC		Temp: ____ºC		Temp: ____ºC	
Replicate	# on day 3	# on day 8	# on day 3	# on day 8	# on day 3	# on day 8
1						
2						
3						
Average						

Observations: Make notes/drawings about what you see on each day of the experiment. On Day 1, take a look at the seeds of other groups so you can see how yours compare.

<u>Day 1</u>
<u>Day 3</u>

Day 8

Name: _____

Results

1. If you haven't done so already, calculate the average # of seeds germinated per replicate on Day 3 and on Day 8 by adding up all the values from the 3 replicates, and dividing the number by 3. Enter the averages in Table 1.

2. Fill out Table 2 using data from your group and the other groups in the class.

Table 2. Average number of seeds per replicate germinated by Day 3 and Day 8 - class data

	Temp:	____ºC	Temp:	____º C	Temp:	____ ºC
Seed type	# by day 3	# by day 8	# by day 3	# by day 8	# by day 3	# by day 8

4. You will be making 2 graphs - one of your group's results for Day 3 and Day 8 at all temperatures, and one of the whole class' results for Day 8 at all temperatures. Make rough sketches of both graphs below. Include labels for the axes, but the graph itself does not have to be accurate at this stage (you will make accurate graphs for your report).

5. Describe your group's results. For example, which temperature resulted in the highest percent germination? Had any seeds germinated by Day 3? How about Day 8? Did you notice anything about the seeds that germinated, or about those that did not? Don't include any explanations of WHY you think you got these results yet, but just summarize what you observed.

6. Now compare your results to those of other groups. For example, did more or fewer of your seeds germinate than others in the class at each temperature? Did more of your seeds germinate by Day 3 than others? How did the appearance (size, shape, colour) of your seeds compare to those of other groups? Again, leave out the explanations here but summarize what you observed.

Name: _____

Discussion

At this stage, you have gathered information that will help you to write the Introduction, Methods, and Results. Now work with your group to answer the following questions - and make good notes, because this will help you to write your Discussion. **You MUST use references to support your statements in the Discussion – this is very important! Make sure you address the questions listed below in your lab report.**

1. Look back at your hypothesis for your group's experiment. Did your results support your hypothesis?

2. Based on what you have learned about plant biology, do your results make sense? If yes - explain the biology - why do seeds germinate better under certain conditions? How does that help them to survive as seedlings? If no - explain what results you were expecting, and why those results would have made sense (basically provide the same information as you would if "yes"). Then explain why you think you got different results. Use references to support your statements.

Where you got this information: _____

3. Now check your second hypothesis, relating to the class data. Did the results support this hypothesis?

4. Based on what you have found out about the types of seeds germinated by different groups, do the results make sense? Explain the biology - why do some seeds germinate faster than others? Is there an advantage to germinating quickly? Slowly? Think about what seedlings need in order to survive. Why might some seeds germinate better at different temperatures than others? Again, use references to support your arguments (don't make things up!).

Where you got this information: _____

Name: _____

Lab report rubric

If you have done all of the assignments related to this experiment, then you have gathered most of the information you need to write your lab report! Here's how you put it together:

**** Attach this sheet to your report when you hand it in ****

Title, etc: (doesn't have to be on a separate cover page)
____/1 □ An informative title □ Your name □ Names of your group members □ Date

Introduction: 1-2 pages long (double spaced)
___/8 □ Purpose of experiment (1)
Background: □ Describe seed germination (2)
□ The best season/conditions for seed germination (1)
□ References are cited appropriately (1)
□ Two hypotheses with support from references (2)
□ Written in paragraph form, using full sentences (1)

Methods: (also in paragraph form)
____/3 □ Written in past tense and in the active voice (1)
□ Accurate, brief description of what we did, including relevant numbers and without excess detail (2)

Results: (no need to include data tables, just text and your graph)
____/8 □ Summarize your numerical data & patterns in sentence form (1.5)
□ Describe your observations (1.5)
□ No interpretation of results - just facts (1)
□ Two accurate graphs, both mentioned in text of paper (2)
□ Both graphs with clear and complete figure legend under each graph (1)
□ Graph axes are labelled correctly (1)
Note: hand-drawn graphs are acceptable but they must be on graph paper

Discussion: (also in paragraph form)
____/10 □ State whether the results support your hypothesis (1)
□ Relate your results to plant biology and explain what they mean (6)
(see Discussion worksheet for suggested topics - VERY important!!)
□ References are cited appropriately (1)
□ Suggest a way the study could have been improved (1)
□ Propose one related experiment that could be done (1)

References:

____/3 □ Includes textbook (0.5)
□ Includes at least one other source (0.5)
□ Listed in alphabetical order by author's last name (0.5)
□ Follows Harvard format - see References handout (1.5)

Overall presentation:

____/2 □ Grammar and spelling are correct (2)

All experiment-related assignments completed:

____/5

□ Pre-lab □ Methods
□ Data/observations □ Results
□ Discussion

Subtotal: _____/40

Deductions:

Marking rubric not attached: -1
Late: -2 marks per day: _____
Copied: -50 to 100%: _____

Total mark out of 40:

Animals

Learning objectives

Animals: overall learning objectives

- List and describe the life functions of all animals.
- For each group of animals we study, identify how it accomplishes each of the life functions.
- Describe 4 trends in animal complexity and how they apply to each phylum of animals that we have studied

Ph. Porifera

- Draw a labelled diagram of the basic body plan of sponges.
- Describe the function of the specialized cell types found in sponges.
- Describe how sponges acquire food.
- Explain how respiration, circulation, and excretion occur in sponges.
- Describe the life cycle of sponges.

Ph. Cnidaria

- Draw a labelled diagram of the 2 basic body plans of cnidarians - medusa and polyp.
- Describe how cnidarians acquire food.
- Explain how respiration, circulation, and excretion occur in cnidarians.
- Describe the nervous system of cnidarians, including the types of sensory organs found in some groups of cnidarians.
- Describe how cnidarians move.
- Explain the life cycle of cnidarians.
- Recognize the 4 classes of cnidarians and be able to name an example member of each one.
- Describe the ecological significance (i.e. why they are important) of one group of cnidarians.

Ph. Platyhelminthes

- Draw a labelled diagram of the basic body plan of a free-living (non-parasitic) flatworm.
- Describe how free-living and parasitic flatworms acquire food.
- Explain how respiration, circulation, and excretion occur in free-living flatworms.
- Describe the nervous system of free-living flatworms, including the types of sensory organs present.
- Describe how free-living flatworms move.
- Describe how free-living flatworms reproduce.
- Describe 3 groups of flatworms: turbellarians, flukes, and tapeworms.
- Describe the life cycle of a tapeworm.

Ph. Nematoda

- Draw a labelled diagram of a cross-section of a nematode, showing the tissue layers and body cavity.
- Describe at least 2 different feeding modes found in nematodes.
- Compare the digestive tract of nematodes to that of flatworms and cnidarians.
- Explain how respiration, circulation, and excretion occur in nematodes.
- Describe the nervous system of nematodes.
- Describe how nematodes move.
- Describe how nematodes reproduce.
- Describe one parasitic nematode that causes disease in humans: how it is transmitted to humans, where it lives, and what effects it has on the human host.
- Identify the parts of a dissected nematode and describe the functions of each part.

Ph. Annelida

- Draw a labelled diagram of a cross-section of an annelid, showing the tissue layers and body cavity.
- Describe the basic body plan of annelids. Include segmentation in your description.
- Describe at least 2 different feeding modes found in annelids.
- Explain how respiration, circulation, and excretion occur in annelids.
- Describe the nervous system of annelids.
- Compare movement in earthworms and marine annelids.
- Describe how hermaphroditic annelids reproduce.
- Describe the 3 major classes of annelids.
- Identify the parts of a dissected earthworm and describe the functions of each part.
- Compare annelids with nematodes in terms of their external features, body cavity, cephalization, digestive system, circulatory system, and reproductive system.

Ph. Mollusca

- Draw a labelled diagram of a basic mollusc body plan, showing the foot, mantle, shell, gills, and visceral mass. Identify these major features on a snail, clam, and squid.
- Describe the 3 major classes of molluscs.
- Describe at least 2 different feeding modes found in molluscs.
- Explain how respiration and excretion occur in molluscs.
- Describe the two different types of circulatory systems present in molluscs.
- Compare the nervous systems of bivalves and cephalopods.
- Describe movement in snails and cephalopods.
- Describe the larval stage found in all aquatic molluscs.
- Identify the parts of a dissected clam and describe the functions of each part.

Ph. Arthropoda

- Describe the advantages and functions of the exoskeleton of arthropods.
- Describe at least 2 different feeding modes found in arthropods.
- Compare respiratory structures of aquatic and terrestrial arthropods.
- Describe the circulatory systems of arthropods.
- Compare excretion in aquatic and terrestrial arthropods.
- Describe the nervous system of arthropods.
- Describe how muscles work with the jointed exoskeleton to allow arthropods to move.
- Describe reproduction and molting in arthropods.
- Identify the parts of a dissected crayfish and describe the functions of each part.
- Identify external features of a grasshopper.
- Identify 3 major groups of arthropods (Subphylum Crustacea, Subph. Chelicerata, and Subph. Uniramia) and describe the distinguishing features of each one. Be able to name two example members of each one.
- Describe at least 2 different feeding modes found in insects.
- Describe the sense organs of insects.
- Describe at least 2 ways that insects communicate with each other.
- Compare complete and incomplete metamorphosis of insects.
- Describe how societies of social insects are organized.

Ph. Echinodermata

- Describe the basic body plan of echinoderms.
- Compare body symmetry of adult and larval echinoderms.
- Describe the structure and functions of the water-vascular system.
- Identify the 5 major classes of echinoderms (common names are okay)
- Describe at least 2 different feeding modes found in echinoderms.
- Explain how respiration, circulation, and excretion occur in echinoderms.
- Describe the nervous system of echinoderms.
- Identify the parts of a dissected sea star and describe the functions of each part.
- Describe the ecological significance (i.e. why they are important) of one group of echinoderms.

Ph. Chordata: Invertebrate chordates

- Describe the 4 features that all chordates have, and be able to label these on a diagram of a tunicate or a lancelet.
- Recognize tunicates and lancelets as two groups of invertebrate chordates.

Ph. Chordata: Subph. Vertebrata (general)

- Compare feeding and digestion in fishes, amphibians, reptiles, birds, and mammals. Be able to label a diagram of the digestive system of each group.
- Compare respiration in fishes, amphibians, reptiles, birds, and mammals.
- Describe the vertebrate brain, and compare the structure of nervous systems among fishes, amphibians, reptiles, birds, and mammals. Be able to describe the specialized sensory organs of each group (e.g. lateral line of fish, ampullae of Lorenzini in sharks, Jacobsen's organ in reptiles, and others)
- Compare heart anatomy among fishes, amphibians, reptiles, birds, and mammals.
- Compare the skeletons of various vertebrate groups and describe how their function relates to their structure.

Ph. Chordata: Subph. Vertebrata: Fishes

- Describe feeding and digestion in fishes. Be able to label a diagram of the digestive system.
- Describe respiration in fishes.
- Describe the structure of the nervous system of fishes, including the brain and specialized sensory organs. Be able to label a diagram of the brain.
- Describe the circulatory system of fishes.
- Identify the major organs and organ systems on a dissected fish.
- Describe trends in the evolution of fishes.
- Explain the importance of jaws and paired fins.
- Compare jawless fishes, cartilaginous fishes, and bony fishes.

Ph. Chordata: Subph. Vertebrata: Cl. Amphibia

- Describe the evolution of amphibians from fishes.
- Describe feeding and digestion in amphibians. Be able to label a diagram of the digestive system.
- Describe respiration in amphibians.
- Describe the structure of the nervous system of amphibians, including the brain and specialized sensory organs. Be able to label a diagram of the brain.
- Describe the circulatory system of amphibians.
- Describe the adaptations of amphibians that allow them to be less dependent on water than fishes.

Ph. Chordata: Subph. Vertebrata: Reptiles (including birds)

- Describe the evolutionary relationship between birds and non-avian reptiles.
- Describe feeding and digestion in birds and non-avian reptiles. Be able to label a diagram of the digestive system of each group.
- Describe respiration in birds and non-avian reptiles.
- Describe the nervous system of reptiles.
- Compare the circulatory systems of birds and non-avian reptiles to those of fishes and amphibians.
- Describe the adaptations of reptiles that allow them to be less dependent on water than amphibians.
- Describe the adaptations of birds for flight.

Ph. Chordata: Subph. Vertebrata: Cl. Mammalia

- Describe the following groups of mammals: monotremes, marsupials, and placental mammals.
- Explain how mammals maintain a constant internal body temperature.
- Compare dentition (teeth) of carnivorous and herbivorous mammals.
- Describe digestion in mammals. Be able to label a diagram of the digestive system.
- Describe respiration in mammals.
- Describe the nervous system of mammals and compare it to those of other vertebrates.
- Compare the circulatory system of mammals to those of fishes, amphibians and reptiles.
- Identify the major organs and organ systems on a dissected rat.

Name: _____

Cnidarian lab

In today's lab we will be looking at members of the phylum Cnidaria, which all exhibit _____ symmetry.

1. Live *Hydra*:

Hydra is a solitary cnidarian that belongs to Class _____. Which body plan (medusa or polyp) does it have? _____

Set up your dissecting microscope. Fill a watch glass (a small glass dish) about halfway with pond water and then capture one *Hydra* using a dropper and place it in the water in your watch glass. Observe the *Hydra* under the dissecting microscope.

a) Sketch the *Hydra*, and label with these parts: **tentacles, mouth, stalk, gastrovascular cavity**.

b) Wait until your specimen is relaxed, then try gently touching it with a probe. Describe its response.

c) What body part/tissue type was involved in detecting your touch? What group(s) of muscles was/were involved in the response you observed?

d) Try feeding *Hydra* while carefully observing it. Describe its feeding behaviour (if it doesn't work in your live specimen, watch a video to see it in action)

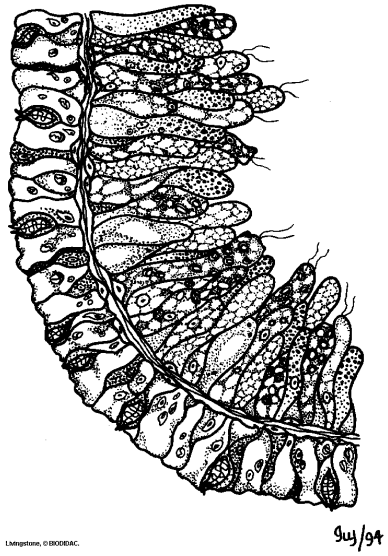
e) What cell type is involved in food capture in *Hydra*? _____
Describe what will happen to the food after ingestion.

2. Prepared slides:

Set up your compound microscope. Obtain a whole mount prepared slide of a *Hydra* and examine it under low power. You may be able to see the structures more clearly in this one; use it to add to your diagram above.

a) Look for a **bud**. What type of reproduction does this represent?

b) Obtain a cross section prepared slide of a *Hydra*. Label the **epidermis (ectoderm), gastrodermis (endoderm), mesoglea**, and **cnidocytes** on the diagram.



c) Describe how cnidocytes work.

3. Jellyfish

Watch the video of a jellyfish swimming and observe the preserved jellyfish.

a) To which class do jellyfish belong? _____ Which body plan (medusa or polyp) do jellyfish have? _____

b) Explain how the hydrostatic skeleton works to enable the jellyfish to swim.

c) How does the jellyfish “know” whether it is swimming up or down?

4. Anemones

Observe the live anemones in the tank.

a) To which class do anemones belong? _____ Which body plan (medusa or polyp) do anemones have? _____

b) How does the life cycle of anemones differ from the life cycle of jellyfish? Explain.

c) How do these anemones differ from corals?

Name: _____

Flatworm lab

Flatworms belong to the phylum _____.

In today's lab we will be looking at a live planarian called *Dugesia*, which is free-living (non-parasitic) and therefore belongs to the group _____.

1. Live planarian:

Set up your dissecting microscope. Fill a watch glass (a small glass dish) about halfway with pond water and then capture one planarian using a dropper and place it in the water in your watch glass. Observe the planarian under the dissecting microscope.

a) Draw a quick sketch of the planarian and label its **anterior** and **posterior** ends and its **dorsal** side. Then label the **eyespots.**

b) What type of symmetry do planarians have? How can you tell?

c) Observe and describe how the planarian moves.

d) Gently try to flip your planarian over using a blunt probe. How does it respond? What sense organs do you think it used to detect that it was upside-down?

e) Obtain a very small piece of food for your planarian, and place it in the water nearby. Observe it for a few minutes to see if you can see it feeding. What structure does it use to capture the food? Where is the structure located?

2. Prepared slides:

Set up your compound microscope. Obtain a whole mount prepared slide of a planarian. This slide has been stained so that you can more easily see the structures. Look at the slide under the lowest and medium-powered objectives but not high power (this could break the slide).

a) What structures can you see on the slide that you could not see on your live planarian?

Name: _____

Roundworm and earthworm lab

Roundworms belong to the phylum _____ and earthworms belong to the phylum _____.

In today's lab, we will dissect a parasitic roundworm (*Ascaris*) and an earthworm (*Lumbricus*) and compare them.

Before beginning, gather 2 dissecting pans, dissecting tools, and one of each type of worm. Finish both dissections before cleaning up, so that you can compare the two worms! Refer to the dissection guide (provided in lab) for more information.

1. Roundworm:

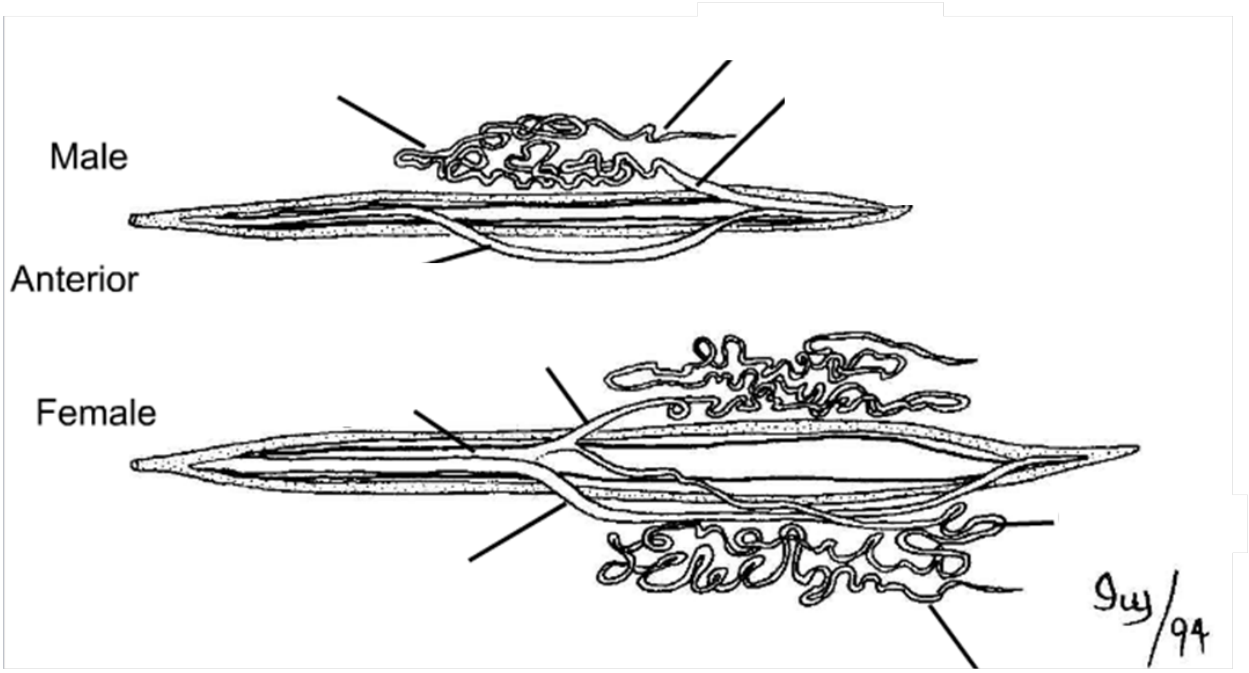
a) Examine your worm. Male worms are shorter than female worms and have a sharply curved **posterior** end. Is your worm a male or a female?

b) Look at the external features of your worm: the **mouth,** at the **anterior** end; and the tough **cuticle** that covers the outside of the worm. What is the function of the cuticle? (Think about where this worm lives...)

Using a pair of scissors, carefully slit the worm longitudinally, trying not to cut any internal structures. Pin the skin down to keep the worm open while you look at the internal structures.

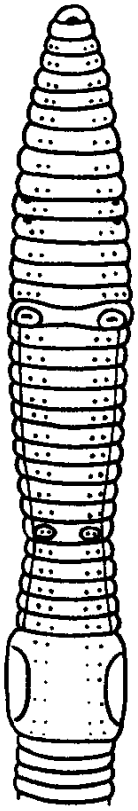
c) Look for the **digestive tract**. It is long and very flat - only one cell layer thick. What does this worm eat?

d) Identify the parts of the reproductive system, and label them on the diagram below. In a female, identify the single **vagina**, which divides into a pair of large, straight, **uterine tubes**. The uteri narrow down into the oviducts, which in turn continue into the long, thin, extremely coiled **ovaries**. The male reproductive tract consists of a single, long, very coiled tube. The largest part of this tube is the **seminal vesicle**, followed by the vas deferens and the long, slender **testes**. Make sure you see both a male and a female! (Also label the **digestive tract** on the diagrams below).



2. Earthworm:

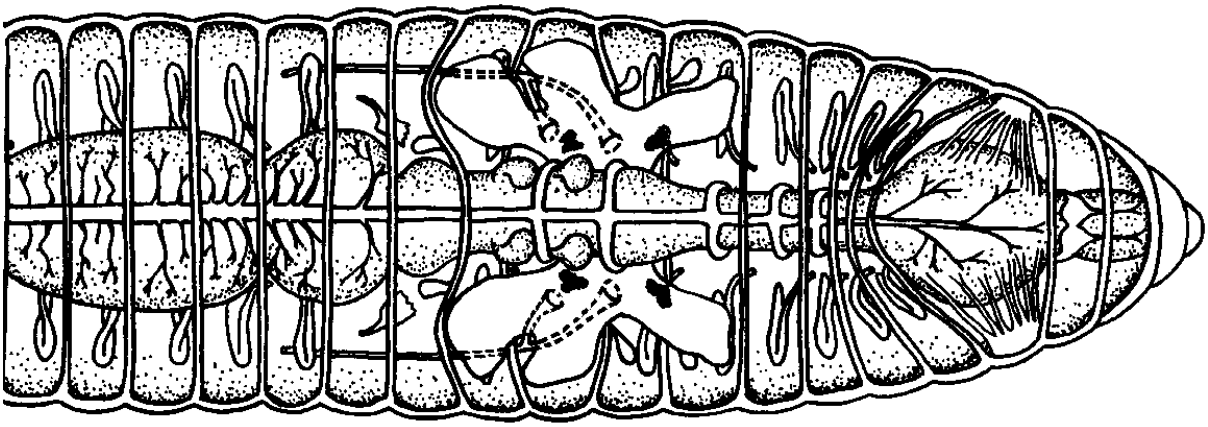
a) Identify the rounded **dorsal** surface of your worm, and the flattened **ventral** surface. Turn the worm ventral side up and identify the **mouth**, individual **segments**, and the **clitellum.** Label the structures on the diagram below.



b) What is the function of the clitellum?

c) Now turn the worm dorsal side up. Using the scissors, make a shallow cut starting at the clitellum. Cut forward (toward the anterior end). Spread the cut open as you go. Pin the skin to the dissecting tray so that you can easily observe the internal features.

Locate the **pharynx**, **esophagus**, **crop**, and **gizzard**, and label them on the diagram below. To which system do these belong? _____



J. Soucie © BIODIDAC

Locate the **dorsal blood vessel** and **hearts**. Add these to the diagram. To which system do these structures belong? _____

Locate the **seminal vesicles**. Add these to the diagram. To which system do these structures belong? _____

Since the earthworm has both male and female reproductive structures, it is considered a _____.

Name: _____

Mollusc lab

1. Clam dissection

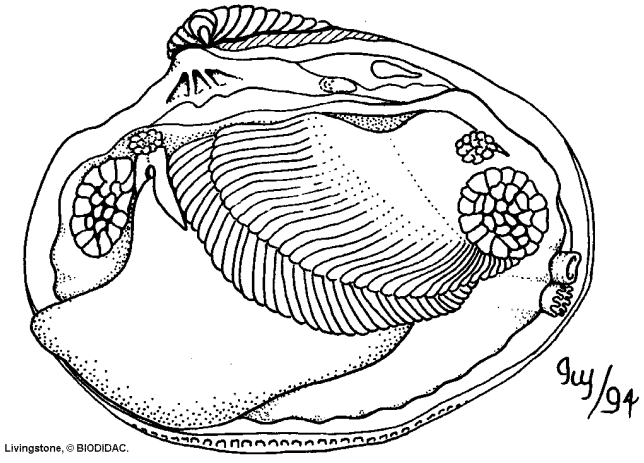
Clams (along with oysters, mussels, and scallops) are part of the Class _____.

You will need one clam, a dissecting tray, and dissecting tools.

Start by examining the external anatomy of the clam. Find the **anterior** and **posterior** ends of the clam by finding the **umbo** (the bump where the shell is most narrow) which is at the anterior end. Refer to the dissection guide (provided in lab) for more information.

If your clam has not been cut open already, you will need to use a scalpel to carefully cut the adductor muscles to separate the two **valves** (shell halves). Orient the clam so the anterior end is on your left. Insert a blunt end probe between the shells to help hold them apart. Slowly insert the scalpel blade, keeping it against the upper wall of the shell to avoid cutting into other structures. Once you have cut through both muscles, you should be able to lift back the top shell to identify the following structures.

On the diagram below, label the **mantle**, **foot**, **labial palps**, **anterior and posterior adductor muscles, gills**, and **siphons**.



What is the function of the foot?

Describe how the clam feeds (and what structures are involved).

2. Mussel feeding

View the demonstration of a mussel feeding under a dissecting microscope. Look for the movement of particles along the gill margin. Where are the particles going?
From:
To:

What structures and/or substances are involved in moving particles along the gill?

3. Diversity of molluscs

Displays of different types of mollusc shells have been set up in the lab. Find a snail shell and draw a quick sketch of it. Snails belong to Class _____.

Watch the video of a squid swimming. Squid belong to Class _____.
Describe the motion that it uses to swim.

Do squid have an open or closed circulatory system? Explain the advantage of their type of circulatory system (i.e. why it makes sense given their “lifestyle”).

Name: _____

Crayfish and grasshopper lab

Crayfish belong to the Phylum _____, Subphylum _____.

Get a crayfish, a dissecting pan, and dissecting tools. Examine the external anatomy before making any cuts. Refer to the dissection guide (provided in lab) for more information.

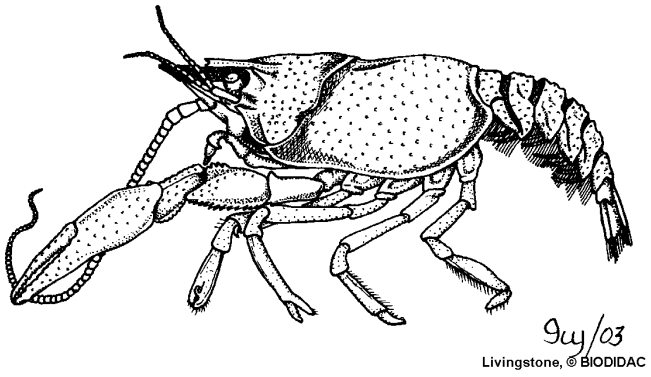
1. Crayfish external anatomy

With the dorsal side up, locate the **cephalothorax** and the **abdomen**. Locate the **carapace**, which covers the dorsal surface of the cephalothorax. Find the cervical groove which separates the head and thorax regions. Look at the head and find the two **compound eyes** on stalks under the rostrum. Locate the appendages on the head: the most anterior segment holds the **antennules**. Behind them are the longer **antennae**.

Turn the crayfish onto its side. Locate the **mouth** and then the following appendages for handling food, in order from anterior to posterior: **mandibles** (jaws) behind the antennae; two pairs of maxillae and 3 pairs of maxillipeds**.**

Turn the crayfish so that the ventral side is up. Locate the **chelipeds** (claws) followed by four pairs of **walking legs**. Count these - each is associated with a segment of the thorax. Next, locate the **swimmerets**. Count these - each is associated with an abdominal segment. On the last abdominal segment, instead of swimmerets, the appendages are modified into a pair of **uropods**. The triangular structure in between the uropods is called the **telson**.

a) Label the external features on the diagram below:



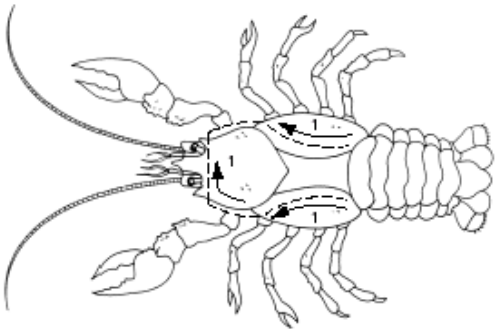
b) Which structures are used for capturing prey and securing and eating food?

c) Which structures are used for movement?

d) Is the crayfish most vulnerable to predators from the dorsal or ventral side? Why?

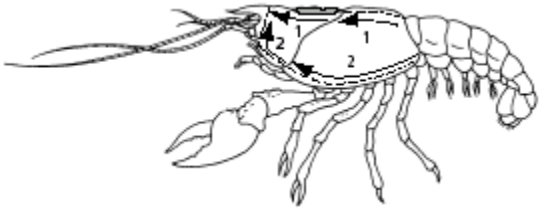
2. Crayfish dissection

Using one hand to hold the crayfish dorsal side up in the dissecting tray, use scissors to carefully cut through the back of the **carapace** along dissection cut line 1, as shown in the diagram below. Cut along the indentations that separate the thoracic portion of the carapace into three regions. Start the cut at the posterior edges of the carapace, and extend it along both sides in the cephalic region.



Use forceps to carefully lift away the carapace. Be careful not to pull the carapace away too quickly.

Place the specimen on its side, with the head facing left, as shown in the diagram below. Using scissors, start cutting at the base of cut line 1. Cut along the side of the crayfish, as illustrated by cut line 2. Extend the cut line forward toward the rostrum (at the top of the head).

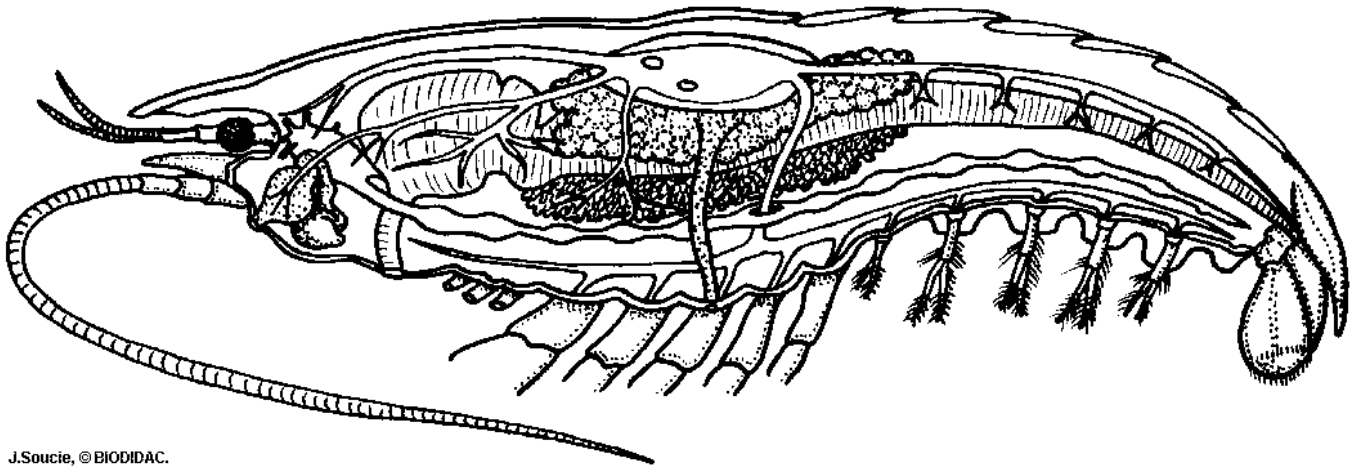


Use forceps to *carefully* lift away the remaining parts of the carapace, exposing the underlying **gills** and other organs.

Locate the **heart** and **arteries**. The crayfish has an **open circulatory system** in which the blood flows from arteries into **sinuses**, or spaces, in tissues. The blood flows over the gills before returning to the heart.
Nervous system: Find the **ventral nerve cord**. Locate a **ganglion**, one of the enlargements of the ventral nerve cord. Locate the **brain**, which is located just behind the compound **eyes**. Note the two large nerves that lead from the brain, around the esophagus, and join the ventral nerve cord.

Excretion: The blood carries cellular wastes to the disk-like **green glands**. Locate these organs just in front of the stomach. The green glands excrete waste through pores at the base of each antenna.

a) Label the internal structures of the crayfish discussed above. <u>Make sure you can find them in your dissected crayfish, not just on the diagram!</u> Note that some of the structures in the diagram are not drawn to scale (e.g. the brain is much smaller in real life).



b) Why is the large surface area of the gills important?

3. Comparison with grasshopper:

The grasshopper belongs to Phylum _____, Subphylum _____. Name another member of this subphylum: _____.

a) How many body sections can you see on the grasshopper?

b) Which section are the wings attached to?

c) How many pairs of antennae does the grasshopper have?

d) What adaptations does the grasshopper have for movement on land?

e) Find a **spiracle**. What is its function?

f) What structures does the grasshopper have for feeding? How do they compare to the crayfish?

Name: _____

Echinoderm lab

1. Live echinoderms:

Choose one of the live echinoderms to observe. The common name of your chosen organism is _____. It belongs to Class _____.

a) What kind of symmetry does your specimen have? How can you tell?

b) Are you looking at the **oral** or **aboral surface** of your echinoderm? How can you tell?

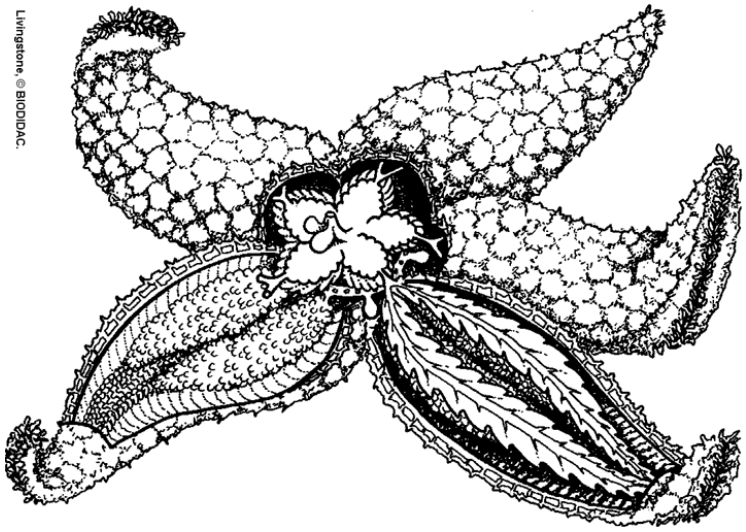
c) Look at the surface of your specimen under the dissecting microscope. Can you see any **tube feet**? Describe them, and explain their function.

d) Still looking closely at the surface of your specimen, see if you can see clear projections of the epidermis - the **dermal papulae (skin gills)**. (If your specimen does not have these, find one that does so you can see them!) What is their function?

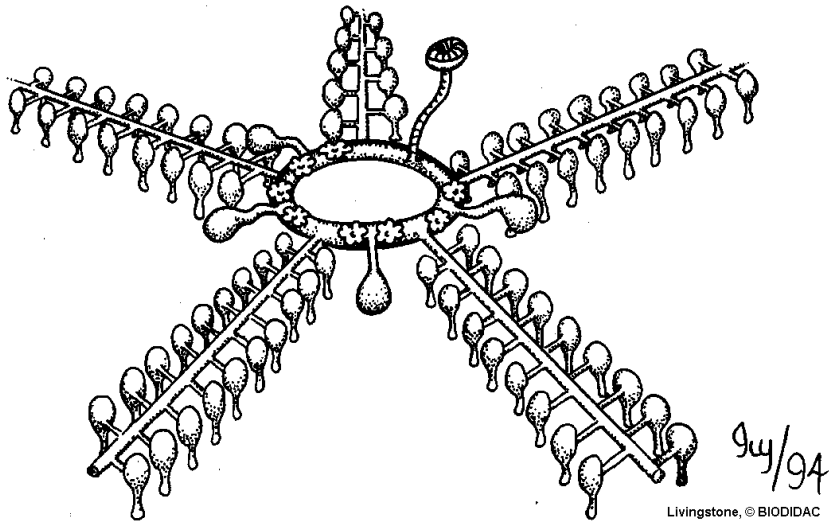
2. Sea star internal anatomy:

Examine one of the dissected starfish. It belongs to Class _____.

Inside the arm, locate the two long digestive glands called the **pyloric caeca**. Find the **gonads** underneath. Look in the central disc to find the **stomach**. Label the structures in bold on the diagram below (refer to the dissecting guide provided in lab for more information):



Find all the parts of the water-vascular system on your starfish, and label them below: the **madreporite**, the **ring canal** inside the central disc, the **radial canal** in each arm, the **ampullae** that are directly attached to the tube feet, and the **tube feet**.



a) What are the functions of the water-vascular system?

b) Describe how a sea star feeds.

3. Preserved echinoderms

Look at the preserved echinoderms on display. Find one that belongs to a different class than echinoderms you observed for parts 1 and 2.

Common name: _____

Class: _____

Compare it to the other echinoderms you observed:

a) What features can you observe in all 3 specimens?

b) What features indicate that the specimen you chose for part 3 belongs to a different class?

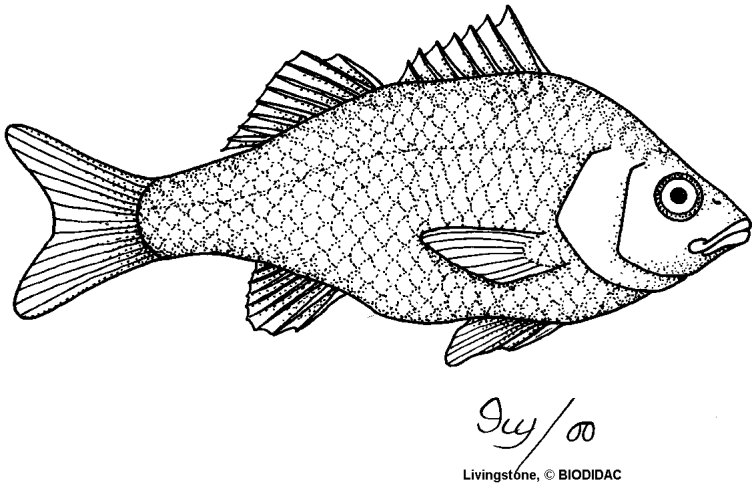
Name: _____

Perch dissection lab

In today's lab, we will be looking at a perch, which belongs to Phylum _____, Subphylum _____, Class _____.

1. External anatomy

Locate the following features and label them on the diagram below: **operculum, lateral line,** and the following **fins: dorsal (anterior and posterior), caudal, anal, pectoral,** and **pelvic.**



a) Lift up the edge of the **operculum** and raise it up as far as you can. What structures lie under it?

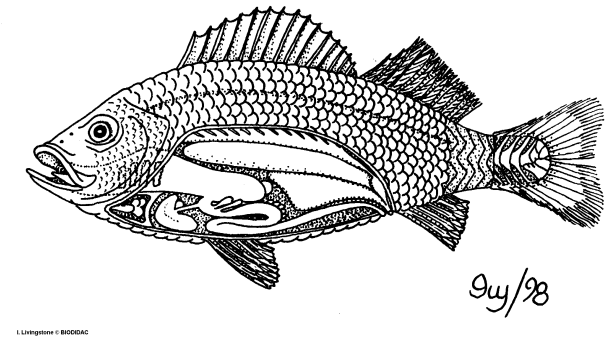
b) Based on what you can see, what do you think the function of the operculum is?

Use your scissors to cut the operculum off as close to the eye as possible to expose the **gills.** The gills are layered one on top of the other. Use the blunt probe to lift and separate these layers. Remove one gill arch by cutting its dorsal and ventral attachment points.

c) Describe how gas exchange occurs in the perch, and identify where water enters and exits.

2. Internal anatomy:

Make careful, shallow cuts using your scissors to cut a “window” into your perch to expose the internal organs, as shown below.



Very carefully lift away the cut section of the body wall. Use scissors to remove any membranes that stick to the body wall. The body organs may be covered with fat; if so, use forceps to carefully remove it. Refer to the dissection guide provided in lab to help you identify the organs.

Digestive system: Find the **liver**, then remove it to expose the **esophagus** and **stomach**.

a) What route would a piece of food travel through the perch’s digestive system?

Once you have finished looking at the digestive system, carefully cut it free at the mouth and anus and remove the entire digestive canal so that you can see the other systems.

Reproductive system: determine if your fish is male or female by locating either the **testes** (small, pale yellow masses on the ventral side) or the **ovary** (single, large, yellow and filled with eggs).

b) Is your fish male or female? _____

Find another group with a perch of the opposite sex so you can observe both male and female.

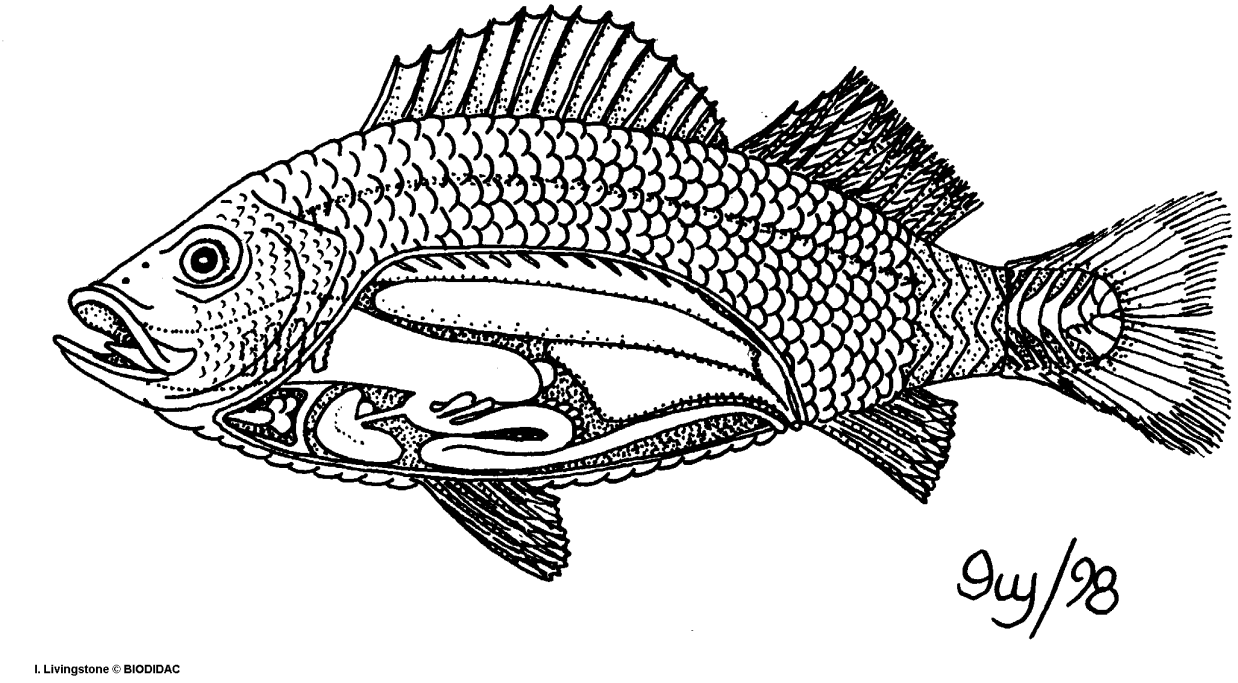
Respiratory and excretory systems: locate the **swim bladder** in the dorsal portion of the fish. On the dorsal wall of the body cavity, locate the **kidneys.** These are connected by urinary tracts to the urinary bladder (which may or may not be visible in your specimen).

c) What is the function of the swim bladder?

Circulatory system: cut through the fish's body wall anterior to where the liver was located to expose a cavity where the **heart** is suspended.

d) Describe how blood flows in the perch.

Label the structures you located on the diagram below. Make notes that will help you to identify these structures the next time you see them (i.e. on the test!).



Name: _____

Rat dissection lab

In today's lab, we will be dissecting a rat, which belongs to Phylum _____, Subphylum _____, Class _____.

Refer to the dissection guide provided in lab for labelled diagrams!

1. External anatomy

You can tell whether you have a male or a female rat by looking for the **testes**, which are external and found only on male rats.

a) Is your rat a male or a female? _____ Make sure you see a rat of the opposite sex too - you are responsible for knowing both.

2. Internal anatomy

Secure the specimen on your tray so that the ventral side is up. You will make a series of cuts to expose the abdominal and thoracic cavities; you will need to cut through the body wall (including muscles) but not through the internal organs. The best way to do this is to make one small cut with scissors, and then insert the blunt end of your scissors and cut along slowly and carefully.

Initial cuts:

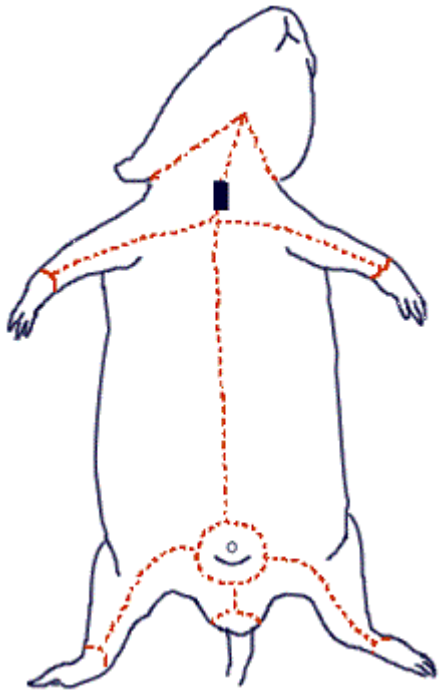


image: biologycorner.com

Make your first cut along the length of the rat, just off to one side from the midline, from just below the chin to just above the urogenital opening.

You may need to use bone cutters to cut through the ribcage.

Cut around the external genitalia.

Make additional cuts along the pectoral and pelvic regions in order to expose the entire abdominal and thoracic cavities and see the internal organs.

Label structures on the diagram on the next page as you find them, and make any additional notes that will help you to identify structures on the test.

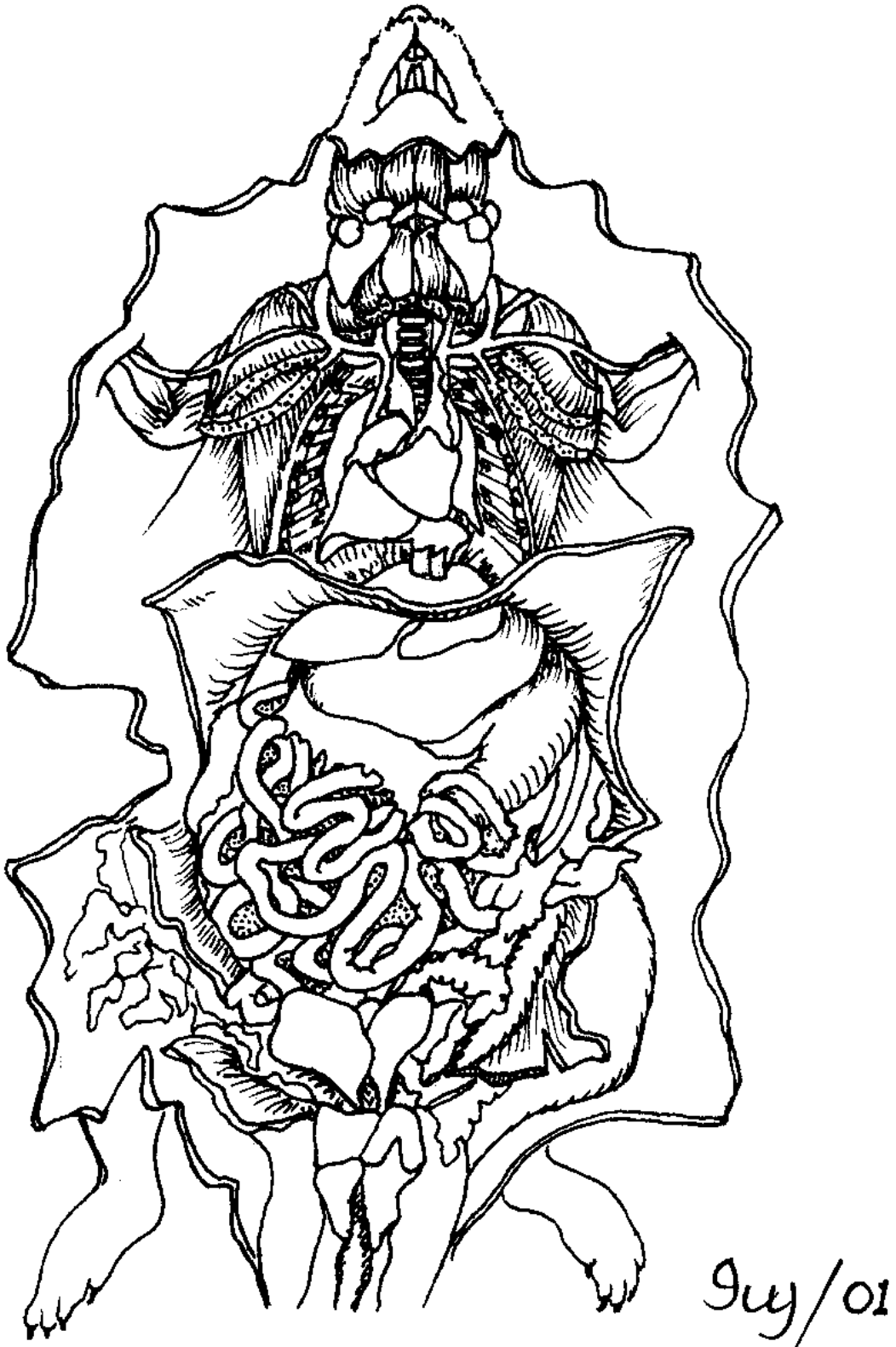
Digestive system: Open the mouth using a blunt probe and see the **tongue**, **teeth**, and **pharynx**. The pharynx is the chamber at the rear of the mouth cavity, and is part of both the digestive and respiratory systems.

If possible, gently insert your blunt probe from the mouth down into the **esophagus** (don't confuse the esophagus with the **trachea**, which has rings of cartilage and lies ventral to the esophagus, i.e. on top of it from your current view). Next, find the **stomach**, **liver** (large, reddish-brown organ with several lobes; sits just posterior to the diaphragm), **spleen** (similar colour to the liver, attached to the stomach), **small intestine** (named for its small diameter - it is actually very long), **large intestine**, **rectum**, and **anus**.

a) What are the functions of the liver and small intestine?

Respiratory and circulatory systems: The **trachea**, which you have probably already located, is part of the respiratory system. It branches into two **bronchi** and then the **lungs**, which are spongy and lie on either side of the **heart**. Find the major blood vessels attached to the heart. Find the **diaphragm** - a sheet of muscle just under the heart and above the liver.

b) What is the function of the diaphragm?



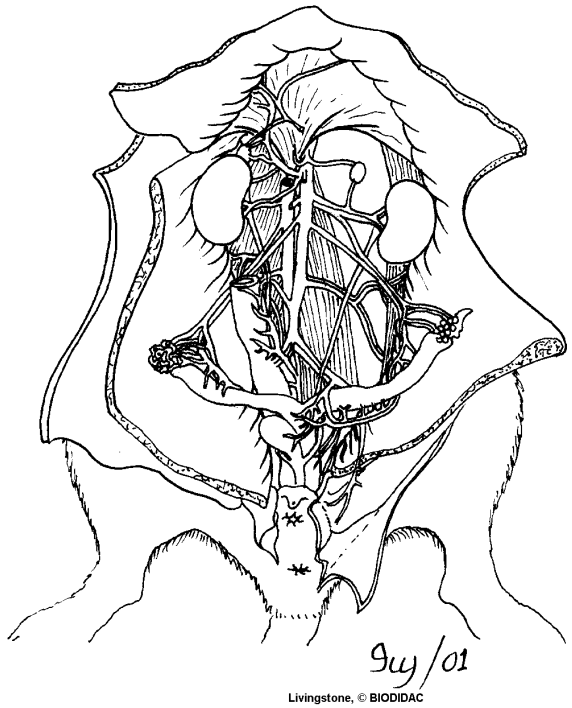
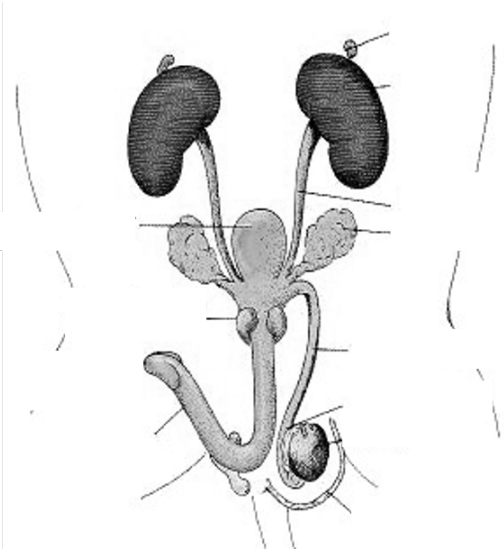
Livingstone, © BIODIDAC

Excretory system: Locate the **urinary bladder**, near the pelvic girdle and ventral to the rectum. Next, look for the bean-shaped **kidneys** located toward the back of the abdominal cavity on either side of the spine. The kidneys are connected to the bladder by the **ureters**. The urethra carries urine from the bladder to the outside of the body.

c) What is the function of the kidneys?

Reproductive system: In females, locate the **vagina** (a short tube dorsal to the urinary bladder). It divides into two **uterine horns**, at the tip of which you will see the **ovaries**. The ovaries are just posterior to the kidneys.

In males, cut open the **scrotal sac**, which contains the **testes** (singular: testis). Locate the epididymis, a coiled tube on the surface of the testis. The brown glands on either side of the urinary bladder are the seminal vesicles, and below the bladder you will see the prostate gland.

Female:	Male:
	

Make sure you have located all of the structures in **bold** and labelled them on your diagrams!

Name: _____

Skeleton comparison lab

Table 1. Comparison of vertebrate skeleton features

Feature	**Fish**	**Frog**	**Bird**	**Cat**	**Human**
Skull size (relative to body size)					
Eye socket direction					
General shape of vertebral column					
Number and type of forelimbs					
Number and type of hindlimbs					
Tail presence and relative length					
Other observations					

1. Look at the pelvic girdle of the frog, bird, and human skeletons.

a) Which ones appear to be proportionately larger/heavier?

b) Explain the adaptive significance (i.e. the benefits for survival) of the pelvic girdle structure in each group.

Frog:

Bird:

Human:

2. What features of the human skeletal system support our upright posture?

3. Which skeleton do you think is most primitive? What features of the skeleton support this idea?

4. Which skeleton do you think is most advanced? What features of the skeleton support this idea?

Field trips

Name:_____

Figurehead Point, Stanley Park

DUE DATE: _____ Your score (out of 20): _____

Part 1: Complete this section in class before the field trip. (2 marks) _____

Choose one organism from the marine tank, or from the preserved specimens available.

1. To which phylum does the organism belong? _____
2. What are some key features of this phylum?

3. Use a marine field guide to identify the organism.
   Common name:
   Scientific name:

4. Make a scientific drawing of your organism. Label it with **at least 3** distinguishing features that you used to identify it.

Part 2: Complete this section at Stanley Park, or later, using your field notes. (18 marks)

Fill out the tables below for 6 different species found in the intertidal zone at Figurehead Point. Remember to include at least 3 different phyla of animals, and at least one seaweed. **Include detailed scientific drawings of 2 of your specimens (attach a separate page for these).**

Common name: Phylum:	Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)	
Description or sketch, including distinguishing features:	

Common name: Phylum:	Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)	
Description or sketch, including distinguishing features:	
Common name: Phylum:	Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)	

Description or sketch, including distinguishing features:

Common name: Phylum:	Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)	
Description or sketch, including distinguishing features:	
Common name: Phylum:	Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)	
Description or sketch, including distinguishing features:	

Common name: Phylum: Scientific name:
Where you found it: (e.g. high intertidal zone, under a rock)
Description or sketch, including distinguishing features:

Name:_____

Vancouver Aquarium

DUE DATE: _____. **Your score (out of 35):_____**

Field trip date and time:_____
Meet at the Aquarium entrance at 10 am sharp! If you are late and we go in without you, you will have to pay full admission price.

What to bring: This handout, a clipboard, pencil and eraser, and class notes to help you identify animal groups.

Where to go: Meet at the entrance, then explore:
1) Treasures of BC
2) Exploration Gallery
3) Strait of Georgia tank
4) Marine Mammal exhibits
5) Frogs Forever exhibit
6) Another exhibit of your choice

Objective: To observe living examples of the animals we've discussed in class so far, and to appreciate the amazing marine diversity of BC - over 450 species of fishes and 4500 species of invertebrates inhabit the cold, nutrient-rich waters.

What to do: Answer as many questions as possible as you tour the aquarium – notice that the questions relate to specific tanks and those tanks are labeled on the walls above the glass. You may also have to research some questions at home. **DO NOT** ask Aquarium staff for answers - talk to your classmates, read the signs, ask your instructor!

**You are free to wander around the Aquarium and do the questions in any order you like. **

1) Treasures of BC Gallery
Note the signs and maps above each tank.
Long Beach Tank
The free-swimming, open-water fishes are in the Phylum _____ .

Name four of the fish species **you see**: *(Use the information stands for reference, but be careful: some stands are out of date, and you'll need to carefully check the pictures against the fish actually there.)* (2)

Guess the advantage (for survival or feeding) of the shape of the pacific sanddab, the starry flounder, or the sole. (1)

Find the sturgeon. Describe its mouth position. What does this suggest about where it lives in the water column (near the bottom, near the surface, mid-water)? (1)

Barkley Sound tanks - *The two tanks on either side of the doorway to the central hall display organisms that live near the low tide line or in deep tidepools on the West Coast of Vancouver Island. These shallow waters typically have a high-energy shoreline (crashing waves). Consider that type of habitat when you answer the questions below.*

Find the abalone or a red turban snail. They belong to the Phylum _____.

Identify 3 structures you can see on the abalone or snail, and state the function of each one. (3)

Structure	Function

Port Hardy Tank
Find two invertebrates from different phyla in this tank, and name one adaptation that each has for survival. (4)

Species	Phylum	Adaptation for survival

Look in the small tank between Port Hardy and Burnaby Narrows to find the hagfish. To what phylum do these belong? _____ Are they vertebrates or invertebrates? _____ (1)

Quadra Island Tank
Find and list **two** of the filter feeders from this area of high currents. (1)

Burnaby Narrows Tank
Many of these animals are **benthic** (bottom dwelling).

Find a chiton, which is a member of Phylum _____.

Check out the vacuum cleaner "mops" and the arrangement of tube feet on the California sea cucumbers. What type of food do these sea cucumbers eat? (1)

Jervis Inlet Tanks

Find the armoured sea cucumber (Ph. _____, Cl. _____). The feathery

structures leading from its body are _____, which are used for

_____. (1)

Sechelt Inlet tank

Sea pens are animals from the Phylum _____. Name two characteristics of animals from this phylum: (1)

1)

2)

Whytecliff Park tank
Find a sculpin (look closely - they're hard to spot). What adaptation does it have for survival? (1)

2) Exploration Gallery

Jellyfish tanks: *the blue-lit tanks at the end of the Exploration Gallery.*

Jellyfish, such as the Pacific sea nettle and moon jellies , are classified in Phylum._____**.**

What structures do they use to feed and protect themselves? (1)

Describe how jellyfish move. (1)

3) Central Hall: Strait of Georgia tank

Once in the central hall, you can see the open water at the top of this tank and might even see aquarium staff in scuba suits jumping in! Take the stairs down to the bottom of this massive tank.

Name and sketch the shape of a free-swimming, open water fish. Do the same for a fish that rests on the bottom. *The fish are named in the poster to the left of the tank.* (2)

Free-swimming fish:	Bottom-dwelling fish:

4) Marine mammal exhibits

Go back upstairs and proceed outside. Just to the right of the doors is the Finning Sea Otter Habitat.

Sea otters are in the Phylum _____ and the Class _____.

How do sea otters stay warm? (2) *Hint: there are informative signs in the underwater sea otter viewing area (follow the signs down the stairs).*

Name two ways that oil spills might hurt sea otters (watch their grooming behaviour). (2)

Wild Coast exhibit - *these are the large outdoor tanks; you can also view the Canadian Arctic tank and dolphin tank from downstairs, inside the Aquarium building.*

Find the dolphins. How do they breathe? (1)

Why might the coloration of dolphins (dark dorsal side, light ventral side) be an advantage? Explain. (2)

5) Frogs Forever?

Follow the signs to the amphibian exhibit on the lower level.

Many frog species are in danger of extinction. Name one frog species in the exhibit that is in danger of extinction (threatened or endangered) and list 2 specific factors that contribute to this danger. (2)

One of the amphibian species in the exhibit is an invasive species in BC. Name the species a explain why it is harmful to native amphibians. (2)

6) Another exhibit of your choice: _____

Explain 3 cool things that you learned from this exhibit! (3)

Name:_____

Bloedel Conservatory

DUE DATE: _____ Your score (out of 20):_____

Location: Bloedel Conservatory at Queen Elizabeth Park (4600 Cambie St)

Field trip date and time: _____
Meet at the entrance to the Bloedel Conservatory. Please have your admission fee ready in cash.

What to bring: This handout, a clipboard, pencil and eraser, and class notes to help you identify bird orders.

Objective: To observe plants and birds from 3 different climate zones: tropical, subtropical, and desert, and to compare their adaptations for survival.

What to do: Bloedel Conservatory is a very manageable size, so you can easily walk around it a few times to get your bearings and check out any birds and plants that you find interesting. You should also stop and watch a few different birds for a few minutes at a time - and look closely among the vegetation for more birds! The Conservatory has informational pamphlets that you can borrow to help you identify birds and plants.

Plants

1. Find a fruit tree (there are lots of them!). Species name: _____
   What is the advantage (to the plant) of bearing fruit? (1)

2. Find a bromeliad.
   What type of relationship does it have with the tree? Explain. (1)

3. Find an orchid. What is the advantage (to the plant) of its elaborate flower structure? (1)

4. Find a cactus. Species name: _____ (common name ok).
   List 2 adaptations it has for life in a dry climate. (1)

Birds

5. Find two birds that are classified in the Parrot order - macaws, budgies, parrots. Compare these two birds in terms of their size, colour, toe position, and any other features you observe. (4) Sketch the beak shape of both birds. (1)

Species		
Size		
Colour		
Toe position		
Other features:		
Beak shape		

6. Pick one bird in the Parrot order (can be one of the ones you described above) and observe its behaviour. Describe how it feeds and any other behaviour you observe. (2)

7. Find a pheasant. Species: _____ (common name ok)

a) Describe its movement. (1)

b) How does its body shape compare to that of the parrots? (1)

8. Find a passerine bird (a perching bird). Species: _____ (common name ok).

a) Sketch its beak shape. (1)

b) Describe its movement. (1)

9. Find a bird engaging in some kind of grooming behaviour (e.g. preening or bathing). Describe the behaviour you see, and what you think the function might be. (2)

10. Of the birds you see at the Conservatory, which do you think are the best at flying?

a) What adaptations do they have that tell you they might be strong flyers? (1)

b) Draw a sketch of the bird’s body shape and label features related to flight. (2)

Reifel Migratory Bird Sanctuary

Objectives:

1. Identify birds
2. Describe estuary habitat types and adaptations of birds to them
3. Describe avian structural and behavioural adapations for their food niches

Bring:

- Binoculars (KEC will provide a spotting scope)
- A field guide, previewed before trip. Recommended:
- National Geographic Society: *Field Guide to the Birds of North America*. Dunn *et al.*
- Focus Guides: *Birds of North America.* Kenn Kaufman (great for beginners)
- Peterson: *A Field Guide to Western Birds*. Roger Tory Peterson.
- Golden: *Birds of North America.* Robbins *et al.*
- Stokes Field Guides: *Stokes Field Guide to Birds: Western Region*. Donald and Lilian Stokes.
- American Bird Conservancy: *All the Birds of North America.* Jack Griggs.
- Audubon Handbook: *Western Birds*. John Farrand.
- National Audubon Society: *Sibley Guide to Western Birds.* David Sibley (the best).
- National Audubon Society: *Field Guide to North American Birds.* Miklos Vdvardy, revised by John Farrand.
- Field Notebook (page I-13; with a plastic bag) and pens (perhaps a clipboard)
- This guide to birding at the Reifel Sanctuary
- Protection from the elements: dress too warmly-- we spend a lot of time standing and sitting (a lot different than hiking). Wear a hat or toque and a windbreaker, and comfortable shoes. Wear boots if it's been wet. It is usually drier and windier here than in Vancouver.
- **Cash** for admission fee as part of our group

How to Get There(Note: The drive on the highway from campus to Ladner takes only half the time required to reach the sanctuary.)

From campus travel south on Clark, which turns into Knight, and cross the Knight Street Bridge. Take the Highway 91 interchange west (toward Richmond) and then Highway 99 heading south. Take the Ladner exit, the first right after you emerge from the Massey Tunnel. Follow River Road until it ends and turn left onto Elliott Street. Turn right at the stoplight onto 47A Avenue, then follow signs to the refuge, all along 47A Avenue (which becomes into River Road West). Look for the signs for Westham Island and Reifel Bird Sanctuary and make a right toward the narrow, wooden bridge onto Westham Island. Take care: this is a single lane bridge crossing. Now follow the road to the sanctuary for about 15-20 minutes. Caution: a very sharp left turn ends the straight stretch of road on Westham Is. When you reach the end of the road and see the large blue loons decorating the closed gates for the Canadian Wildlife Service, you are almost there. Turn left just before the gates onto the road that leads to the sanctuary parking lot.

About the Sanctuary:

The George C. Reifel Migratory Bird Sanctuary lies within the Alaksen National Wildlife Area. The B.C. Waterfowl Society, a non-government, non-profit organization, operates the sanctuary under a license agreement with the federal government. Membership, entrance fees, and donations support the sanctuary. The Canadian Wildlife Service and Ducks Unlimited cooperate with the Society in habitat management. A full time manager cares for the 346 hectare area.

The most important objective of the sanctuary is habitat preservation. It lies in the Fraser River Estuary, where more birds winter than in any other place in Canada. Over 280 species have been sighted at the sanctuary and at least 60 species breed here.

Find out more at http://www.reifelbirdsanctuary.com/

About Birding and Birders:

Reasons for birding include outdoor recreation and relaxation, photography, painting, sport (the challenge of identification and compiling lists), travel, nature study and science. Good observers can make valuable scientific contributions. Birdwatchers like to be called birders. Ornithologists are scientists who study birds (some aren't birders!); the vast majority of birders are not scientists.

At The Parking Lot:

1. Gather and sign-out school binoculars.
2. Bundle-up! You can always remove layers.
3. Visit the washrooms--these are all there are and we'll be on the trail 3 - 3.5 h.
4. Practice using your binoculars.
    a. leave the case in the vehicle
    b. put the strap around your neck
    c. look through the *left* eyepiece with your left eye and focus on something by turning the center focusing ring
    d. look through the *right* eyepiece with your right eye and focus on the same thing with the right eyepiece focusing ring
    e. adjust the width of the eyepieces so that you see one big circle rather than two small ones
    f. if the lenses are clean, you should now be set to focus on anything with the center focusing ring only
    g. it takes a bit of practice to use binoculars effectively--keep your eyes on your bird while you bring your binoculars to your eyes
5. Have your entrance fee ready.

(The fee is $5.00 without the group discount. Hours are 9 - 4 every day. *You can also buy bird seed here for $1 to feed the ducks.*)

In the Entrance Area:

First of all, ignore the horde of birds that are likely to descend upon you for handouts! We will gather on the porch over the water next to the Warming Hut on your left. Observe and identify as many birds as you can using your bird ID books. Match the bird to the picture. How many water birds can you identify here? Are there any birds flying overhead? Do you see raptors perched in the wildlife trees nearby? Record names in your bird trip assignment sheet of all birds you can identify with certainty. If you are not sure about the name of a bird, ask and point out your bird to the instructor or other trip leader.

Bird Identification tips:

Look for fine details on the bird itself. If you can find a similar bird in your ID book, pay attention to the book's description of those details. Look for:

size: compare to sparrow, robin, rock dove, crow, goose, heron
shape: bill, neck, legs, wings, tail, posture, body proportions
color and pattern: back and underparts
special markings on head and body
wings and tail
behaviour: walking, swimming, flying styles
voice: songs, call notes
habitat: marine, pond, marsh, field, shrubs, deciduous or coniferous forest
range: note seasonal distribution

Fuller's Slough Blind:

Proceed into or next to the blind, perhaps better referred to as a hide. Enter our location and the time in your Field Notebook. We spend a while here becoming familiar with some techniques of bird observation. The slough (pronounced *slew*) connected the Fraser River with the Strait of Georgia prior to 1920, but is now a pond.

Habitat Study:

Note (perhaps even map) these habitats:

open water
near-shore water
banks
field
air
and.....?

Examine these habitats more closely before identifying the birds.

open water: the pond is about 3 meters deep with a dredging hole about 6-7 m deep at the east end. Note floating logs. What other features do you see?

near-shore water: how is this similar to the open water? How is it different?

banks: the banks drop off steeply underwater. Are there little bays? What types of vegetation do you find on them? What growth patterns do they have?

field: is cultivated for winter grazing by waterfowl.

air: consider high air space, medium and low, over water, trees and field.

Some birds you may find here *(not all in all seasons):*

- AMERICAN COOT
- AMERICAN WIDGEON
- BALD EAGLE
- BARN SWALLOW
- BELTED KINGFISHER
- BLACK-CAPPED CHICKADEE
- BLACK-CROWNED NIGHT HERON
- BREWER'S BLACKBIRD
- BUFFLEHEAD
- BUSHTIT
- CANADA GOOSE
- CANVASBACK
- COMMON MERGANSER
- COOPER'S HAWK
- DARK-EYED JUNCO
- DOUBLE-CRESTED CORMORANT
- EUROPEAN STARLING
- FOX SPARROW
- GADWALL
- GLAUCOUS-WINGED GULL
- GOLDEN-CROWNED KINGLET
- GOLDEN-CROWNED SPARROW
- GREAT BLUE HERON
- GREEN-WINGED TEAL
- HOODED MERGANSER
- HOUSE FINCH
- HOUSE SPARROW
- LESSER SCAUP
- MALLARD
- MERLIN
- NORTHERN FLICKER
- NORTHERN PINTAIL
- NORTHERN SHOVELER
- NORTHWESTERN CROW
- PIED-BILLED GREBE
- RED-TAILED HAWK
- RED-WINGED BLACKBIRD
- ROBIN
- ROCK DOVE
- RUDDY DUCK
- SPOTTED TOWHEE
- SONG SPARROW
- SNOW GOOSE
- TREE SWALLOW
- TUNDRA SWAN
- VIOLET-GREEN SWALLOW
- WHITE-CROWNED SPARROW

Bird Abundance:

If you are ambitious you may count all the birds, but most of us will be content to estimate the abundance of each species this way:

abundant (a):	>100 seen in a day
common (c):	26-100 seen in a day
fairly common (fc):	5-25 seen in a day
uncommon (u):	<5 seen in a day
rare (ra):	seen <10 times in a year

Bird Dispersion Patterns:

Note how birds are dispersed by habitat. Note also the aggregation patterns. Which birds are:

- in large groups with the same species?
- in large groups with other species? (which other species?)
- in pairs or small groups?
- individuals?

Perhaps some overlap occurs (individuals may be in a large group of another species; small groups of one species may be among a large group of another).

What might determine the patterns you observe: space available, habitat type, food availability, mates, protection from predators?

Bird Feeding adaptations:

Birds often let you know what they eat by the shapes of their bills and feet, what they do with them and the habitat they use. Choose a few species to examine closely. If they do not show you their food, hypothesize as to what it might be.

Along the East Trail:

After reviewing the list of birds seen at Fuller's Slough, we proceed north along the East Trail. Border habitats (ecotones) such as the shrubs and trees edging the ditch and fields are favored by many species because they provide a combination of sheltered housing in and near good foraging. Walk quietly here--watch and listen--be prepared to become motionless. Observe the microhabitats where different species might occur: high in the trees, in branches just overhead, on or near the ground. Observe nest boxes and stump tops (the birds are fed here). Some species you might expect here:

- BLACK-CAPPED CHICKADEE
- BUSHTIT
- DARK-EYED JUNCO
- FOX SPARROW
- GOLDEN-CROWNED KINGLET
- GOLDEN-CROWNED SPARROW
- HOUSE FINCH
- NORTHERN FLICKER
- NORTHWESTERN CROW
- RED-BREASTED NUTHATCH
- AMERICAN ROBIN
- RUBY-CROWNED KINGLET
- SPOTTED TOWHEE
- SONG SPARROW
- WHITE-CROWNED SPARROW

Walk along until you come to a break in the shrubbery on your right, so that you have a clear view of the field. What resources are available for birds here? What dangers may be present? What species do you see? a, c, fc, u, ra? How are they dispersed? What are they doing? What would happen to these fields if they weren't tended? How would that affect the wildlife?

The building you see across the field is the Canadian Wildlife Service office (George C. Reifel's former mansion). Find the large cottonwood to the right of it. Are there bald eagles in the nest? Nests are used year after year and can weigh a tonne and measure three meters across.

Continue along the trail. If you're looking for owls (they do turn up here!) look near the trunk on horizontal tree branches with relatively thick vegetation overhanging them. If you find one be quiet and let it sleep. Small perching birds will mob a sitting owl during the daytime (what for?). The pshh-pshh sound birders use to attract small birds is actually a mobbing call which attracts many species of birds to the potential predator.

At the end of the trail go straight ahead to the Prinz Blind.

Ron L. Prinz Memorial Blind:

You now face west toward the Strait of Georgia and Vancouver Island. Note major habitat types. The **fresh-water marsh** immediately in front of you grades into a

somewhat dilute **salt-water marsh** and **estuary**. Many more animals than are obvious reside here. The rattling and buzzing you hear in spring and summer arise from the diminutive and polygamous marsh wrens, who hang bag-like nests on the cattails.

When you return from the blind turn right and walk along the north trail. At the end of this section find your way up the observation tower.

Observation Tower:

This often windy bird's eye vantage point affords an excellent opportunity to orient yourself and scan tree-tops, West Field, marsh and shores for more birds.

Orientation:

Find north, then, searching counter-clockwise, note the North Shore Mountains, Steveston across the Fraser River, Point Grey, Bowen Island at the mouth of Howe Sound, the mountains of the Sechelt Peninsula, the Strait of Georgia, Vancouver Island, the Gulf Islands, the Roberts Bank Coal Port and the Sanctuary behind you.

The Birds:

Birds that winter on the estuary are mostly large herbivores and most breed in the high Arctic. The eelgrass is as protein-rich as any crop plant, with the bonus of the protein of animals growing on them (epizoans). Most of the predatory water-birds in the estuary eat molluscs--the visibility in the water is too poor for fish-eaters. More fish-eating birds appear in winter and early spring, when river runoff and turbidity are relatively low. Other fish-eaters stalk their prey in shallow water. Shore birds migrate through here, but most winter further south. The migratory and wintering periods bring in a good variety and number of raptors--birds of prey--to forage for birds and mammals from the shoreline, marshes, and fields. Spring and summer hail some passerine insect-eaters which, along with a number of waterfowl and other waterbirds, breed in the marshes.

This is a good spot to observe flight patterns. Is the bird flying in a straight line, undulating, with a steady wing beat, soaring, teetering, hovering, near the ground, high in the air? Some species you may find beyond the dike are:

- AMERICAN BITTERN
- AMERICAN COOT
- AMERICAN WIDGEON
- BALD EAGLE
- BARN SWALLOW
- BELTED KINGFISHER
- BLACK-BELLIED PLOVER
- BLUE-WINGED TEAL
- BUFFLEHEAD
- CANADA GOOSE
- CANVASBACK
- CINNAMON TEAL
- COMMON GOLDEN-EYE
- COMMON SNIPE
- LONG-BILLED DOWITCHER
- MALLARD
- LESSER SCAUP
- MARSH WREN
- NORTHERN SHRIKE
- NORTHERN HARRIER
- NORTHERN PINTAIL
- NORTHERN SHOVELER
- NORTHWESTERN CROW
- PEREGRINE FALCON
- RED-BREASTED MERGANSER
- RED-TAILED HAWK
- RED-WINGED BLACKBIRD
- RING-NECKED PHEASANT

- DOUBLE-CRESTED CORMORANT
- DUNLIN
- GLAUCOUS-WINGED GULL
- GREAT BLUE HERON
- GREATER YELLOWLEGS
- GREEN-BACKED HERON
- GREEN-WINGED TEAL
- KILLDEER
- ROUGH-LEGGED HAWK
- RUDDY DUCK
- SNOW GOOSE
- SNOWY OWL
- SPOTTED SANDPIPER
- TUNDRA SWAN
- TRUMPETER SWAN

Raptors:

Birds of prey often excite us because we anticipate something dramatic: prey-catching. Because they are at the top of the food chain, most environments can support few raptors. The numbers we see here, especially in fall, winter and early spring, speak to the richness of the marshes and estuary. Different sizes, habitat preferences, hunting styles and prey minimize competition between the various species. Furthermore, females of a given species are larger than males and take larger prey, further dividing up food resources. The tower presents a good opportunity to see raptors over a number of habitats.

When you come down the tower circle to your left onto the trail on the outer dike.

The Outer Dike:

Note the habitats on either side of you. Although each of these areas may appear quite uniform, consider the patches that may appear to the birds. Some secretive birds such as the American bittern and the Virginia rail live in the marsh. Check posts and snags along the shore. What species are there? Why might they be there? As you walk, perhaps you notice that you recognize some of the call notes or songs you hear. Perhaps you use size, shape and flight pattern for visual identification.

Getting Back:

Make a left turn at the edge of the West Field and walk back along the ponds. At the next intersection veer right and follow the path back to the gatehouse. Be alert (sure you can!) for small perching birds in the row of trees. Glance also to your right as you approach clearings--perhaps a "new" duck or shorebird will appear in the Southwest Marsh.

The warming hut may be a good place to make concluding notes, summarize and list your birds. Return borrowed binoculars. The gatehouse includes a bird oriented gift shop.

The drive home differs from the drive here. Go straight at the stop lights in Ladner, turn left as you meet Highway 17 from the ferry, then pass over and circle right onto Highway 99 to Vancouver.

Extra Reading:

A Pacific Estuary, One Of The Richest Ecosystems In The World:

An **estuary** is a place where a stream or **river meets the ocean**. It is hard to overestimate the value of the Fraser River estuary and marshes to animals, terrestrial and aquatic. What you see is fresh-water marsh grading to salt-water marsh to eelgrass under the water. Bird migration routes from 20 countries and three continents converge here. We have around us the richest wintering area (with the highest mean wetland temperature) in Canada and the major Canadian stopover for waterfowl migrating along the Pacific Flyway, as well as the largest salmon producing river on the west coast.

"Cradle of the ocean" is a term often applied to an estuary because of its **high productivity**. What we have is an efficient **nutrient trap**, collecting a combination of rich nutrients from the land via the Fraser River and marine minerals from the Strait of Georgia. The nutrient concentration is fostered by the:

- weak wave action (low energy shoreline)
- water-slowing action of the tidal eelgrass, which promotes sedimentation
- wedge of sea water under the fresh water
- large adsorbing surface area of the silt particles.
- recycling of dead plants and animals

The nutrients enhance both bacterial and plant growth, leading to abundant zooplankton and a wonderful nursery for larval fishes and invertebrates. The marsh grasses, sedges and rushes contribute to the food chain mostly through detritus, as they decay and nourish bacteria. As the amount of organic material increases, the foreshore grows and the assemblage of aquatic creatures gets richer, dominated by:

- eelgrass and its extensive epiflora and epifauna
- a very complex microbrial community
- polychaete annelid worms
- bivalve molluscs
- crustacean arthropods

Because of the environmental fluctuations in the estuary, there are large numbers of relatively few species when compared to the more stable marine environment.

<u>The Threatened Estuary:</u>

The same mechanisms that trap nutrients in the estuary also trap pollutants, especially petroleum products and pesticides. The Fraser River is the biggest single contributor of pollution and sewage to the Strait of Georgia. In the area between Roberts Bank to the south, Steveston to the north, and New Westminster there are:

- 2 sewage plants
- 8 sites of industrial effluent discharge
- 1 municipal landfill
- 4 sites of industrial discharge to the ground next to the river
- 5 industrial refuse sites

Heavy metal and pulp mill effluents sink and may be carried back upstream by the denser marine water wedge beneath “fresh” river water.

While most estuarine organisms may be remarkably tolerant of pollution because of the naturally stressful conditions under which they evolved, the food webs may be more sensitive. Pollution is transferred to the food chain by detritus-eating invertebrates. The estuarine food webs are probably simpler than in totally marine webs because diversity seems to be less. Thus if a given population is severely reduced, it may greatly affect the whole system.

Consider the impact humans have had here. More than 70% of the Fraser River estuarine wetlands have been destroyed and fishing has been reduced by a similar figure. Consider the impact humans have here. Among groups which influence the use of the estuary are: the forestry industry, the marine transportation industry, the fisheries industry, unions, First Nations, agriculture, port developers, waste disposers, conservationists, hunters, recreationists and 60 government agencies. Consider the impact humans will have here. More than 200 industrial developments are proposed. Consider steps we must take to preserve these wetlands. Please consider all this.

Thanks to Gary Kaiser, Canadian Wildlife Service (ret.), Craig Runyan, Kwantlen College and past president of the BCWS, John Ireland, Sanctuary Manager, and Dr. Mary Taitt, Consulting Biologist and Sanctuary resident, for reviewing *Bird Ecology at the George C. Reifel Migratory Bird Sanctuary.*

Reifel Trip Assignment

_____
43

Last Name:

First Name:

Answer the following questions as you walk around the bird sanctuary.

1. **(1 mark)** The ecosystem at the bird sanctuary is called a(n) _____ .

2. **(1 mark)** Explain why this location is so rich in biodiversity.

Species survey:

3. **(5 marks)** List all bird species you can identify with certainty. If at all in doubt, confirm your identification with one of the trip leaders.

4. **(1 mark)** Define raptor:

5. **(2 marks)** List all the raptors that we see during the trip.

6. **(1 mark)** Define passerine:

7. **(2 marks)** List all the passerines that we see during the trip.

Reproduction:

8. **(2 marks)** Sketch 2 unique nests that we see during the trip and name for each the bird that creates/uses it.

9. **(1 mark)** Baby owls hatch much earlier in the winter/spring than other baby birds. *Do a little research at home to find one benefit to baby owls hatching before the others.*

10. **(2 marks)**
    a) What colours are the male mallards?
    _____

    b) What colours are the female mallards?
    _____

11. **(1 mark)** Answer question a) or b). *Your instructor will tell you which one to answer.*

a) Why do the male and female mallards both look the same right now?

Or

b) Describe one adaptive benefit of the males and females being different colours right now?

Feeding:

12. **(1 mark)** Define dabbling duck:

13. **(2 marks)** Name all the dabbling ducks we see

14. **(1 mark)** Define diving duck:

15. **(2 marks)** Name all the diving ducks we see

16. **(2 marks)** Describe the beak differences in a dabbling duck and a diving duck:

17. **(2 marks)** Name a raptor that we see on the trip and sketch its beak and do the same for a passerine we've seen.

18. **(2 marks)** For each beak, describe how its shape is adaptive for eating that bird's typical food.

Movement:

19. **(4 marks) a)** Describe the foot shape of both Mallards and Chickadees.

    b) Describe how each foot shape (described in part a) is adaptive to that bird's niche?

20. **(3 marks)** Now sketch the foot of a coot, a sandhill crane, and a mallard.

21. **(1 mark)** The family/order name of the coot is
    _____

22. **(1 mark)** The family/order name of the sandhill crane is
    _____

23. **(1 mark)** The family/order name of the mallard is
    _____

24. **(1 mark)** Which two birds are most closely related?

25. **(1 mark)** How does foot shape indicate which two birds are most closely related?

    Finally, gather in the warming hut with everyone else to make a common group list of the birds we've seen today.

Appendix

Lab safety

Labs are an important part of science coursework. These activities allow you to apply what you have learned in lecture to hands-on situations, to learn new skills and to develop good teamwork practices. Safe labs are effective labs. Everyone in the lab is responsible for working safely as part of a learning community. Instructors and lab demonstrators are here to support you and help you have a great lab experience and we always welcome your questions, comments and concerns.

General Laboratory Rules

Preparation

1. Come to the laboratory session prepared by pre-reading the lab material
2. Follow the instructions provided by your lab demonstrator and instructor
3. Before starting any lab activity take a few minutes to discuss procedures with your partner or team. This will ensure you all understand what you will be doing, and will help you to have a safe and effective lab.
4. Work calmly and patiently during a lab. Take your time, relax and enjoy yourself.

Lab Environment

5. Please do not perform unauthorized experiments.
6. Please do not enter the lab preparation room without consent from the instructor or laboratory demonstrator.
7. Eating or drinking is not permitted during lab activities to avoid the risk of ingesting toxic substances.
8. Avoid touching unknown drops of liquids on bench tops or tables with your hands.
9. Leave bench tops and floor passageways clear of books, bags, clothing, etc. Aisles should be clear to allow movement.

Eye & Skin Safety

10. Wear eye protection, such as safety glasses or goggles, whenever chemicals are used that could cause eye damage. If you wear contact lenses, eye protection is particularly important. Chemicals introduced into the eye will become concentrated under the lens, causing further damage.
11. Review the location and use of the eye-wash station and safety shower at the beginning of each lab period.
12. If you feel any irritation to your eyes wash the affected eye in the eyewash station quickly and without hesitation. Obtain assistance so that you wash the eye properly and for a sufficient time. Fifteen minutes of continuous eye rinsing is usually required. A first aid attendant will be called to assist.
13. If you have reagents splashed on your skin or clothing or suffer a burn, wash the affected parts under the tap at a nearby sink or use the safety shower. Obtain assistance so that you wash the affected parts properly and for a sufficient time.

Fire & Heat Safety

14. Review the location and use of the fire extinguishers and fire exits at the beginning of each lab period. Use them without hesitation when they are required.
15. Long hair should be tied back during labs using chemicals, flame or biohazards.
16. Turn off Bunsen burners when not in use. It is important to never leave a flame unattended.
17. Detect the heat from a hot object by placing the back of your hand close to the object. Use tongs or test tube holders to handle hot objects.
18. When heating a solution in a test tube, keep the tube slightly slanted with the open end pointed away from yourself and from other people. These precautions are especially important when boiling occurs.
19. When highly flammable organic solvents such as alcohol are being used, extinguish all open flames.

Hazardous Materials

20. Treat all reagents as though they were hazardous. If you are unsure of the specific hazards of a substance make sure to ask.
21. Carry and handle all reagents below eye level.
22. Never return unused chemicals or solutions to their original containers.
23. Where fumes are produced during a reaction, and you are required to smell them, waft the odours toward your nose with your hand. Do not breathe the fumes directly.

First Aid & Spills

24. If you cut yourself or puncture your skin, report immediately to your instructor or lab demonstrator who will call for First Aid. Do not touch anything in the lab until your wound has been cleansed and bandaged.
25. For spills and/or broken glass, inform your lab instructor or demonstrator so they can assist you to clean up in the correct way.

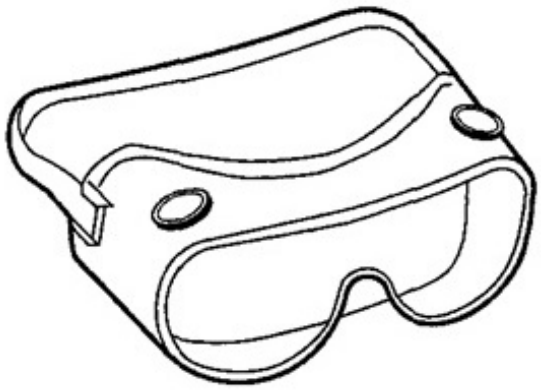
Clean-up

26. When your lab activity is completed, follow the cleanup procedures as described by the lab demonstrator. Ensure your workspace is clean in preparation for the next group of students. Wash your hands following the completion of every lab where chemicals, biohazards or preserved plants or animals were handled.

The following pages contain several sections with more detailed safety information relevant to ABE lab activities.

PPE (Personal Protective Equipment)

Eye protection

	
Safety Glasses (Impact Resistant) Provides protection against flying objects. Provides *partial protection* against chemical splashes.	**Safety Goggles (Indirectly Vented, Impact Resistant)** Provides good protection against chemical splashes and flying objects.

Description

Impact resistant **safety glasses** provide protection against flying objects, and partial protection against hazardous liquids or solids. In the event of a splash, there is a chance chemical could enter the eye area through the sides and bottom of the glasses. For labs involving small volumes of relatively low hazard chemicals, such as most of our biology labs, these glasses are considered adequate protection (http://riskmanagement.ubc.ca/). Properly fitted, impact resistant **safety goggles** will provide full protection against hazardous materials. If you are taking chemistry classes at VCC, you may be asked to use these. As these goggles provide a higher level of protection than safety glasses, they can also be used in the biology lab if preferred. These goggles have soft, pliable sides that provide a secure fit around the eye area. Goggles with indirect vents are best as they will reduce fogging.

Standards

Goggles or glasses should be CSA (Canadian Safety Association) or ANSI (American National Standards Institute) approved. Markings should be present on the frame of the goggles to indicate this.

Fit

Safety goggles have adjustable straps allowing adjustment to a comfortable fit. Prior to your first lab session, make sure to purchase your glasses or goggles and adjust so they fit comfortably. For goggles, the frame should be as close as possible to the face and should be supported by the nose. Ensure the side flanges fit snugly against your face.

Care
Clean your goggles or glasses after each lab session with hot soapy water or goggle cleaning wipes and store in a case to prevent scratching. Worn or scratched lenses lose strength and impair vision. Broken or overly scratched goggles should be replaced.

If you wear contact lenses or glasses
Contact lenses can present an additional risk during labs as they may trap chemicals close to the eye possibly resulting in more damage. It is important to be aware of these additional risks. Proper use of safety goggles should greatly reduce this risk. It is preferable to remove your contact lenses prior to class and wear glasses instead if possible. Safety goggles can be worn over top of glasses provided they still fit snugly. The other alternative is to purchase prescription safety glasses or goggles from your optometrist, however these may be expensive. If you do purchase these, ensure they are CSA or ANSI approved.

Purchasing eye protection
Safety glasses and goggles can be purchased at the VCC bookstore. For a wider selection of styles, you can also try the UBC or SFU bookstores, or online suppliers. Check with your instructor or laboratory demonstrator to ensure you have purchased the correct type of eyewear for your lab activities.

Reference Sources:
National Science Teachers Association - Eye Protection for Your Laboratory
http://www.nsta.org/safety/eyeprotection.aspx

Worksafe BC - Eye and Face Protection
http://www2.worksafebc.com/Topics/PPE/PPEBasics-Types.asp

Canadian Centre for Occupational Health and Safety (CCOHS) - Safety Glasses and Face Protectors http://www.ccohs.ca/oshanswers/prevention/ppe/glasses.html

UBC Risk Management Services
http://riskmanagement.ubc.ca/

Gloves
Gloves will protect your skin from irritating and harmful chemicals as well as those that may stain skin. It is good lab practice to wear gloves for any lab activity involving hazardous materials (including preserved dissection specimens).

Nitrile vs Latex
Nitrile gloves are considered excellent general purpose lab gloves with good chemical resistance to most chemicals. **Latex** gloves do not provide as much protection against some chemicals, such as organic solvents. Additionally, in some people, moderate to severe allergies to latex can develop. Both glove types will provide protection against the chemicals you will encounter in B0861/71 and 0983/0993, however, **nitrile gloves are the preferred option**. Prior to using gloves, check the box to see which type you have. Check the gloves for holes or puncture, and do not use them if they are compromised. If you leave

the lab to go into the hallway or common areas, remove and discard your gloves and put on a new pair when you return.

Reference Source: Princeton University Environmental Health and Safety webpage (http://web.princeton.edu/sites/ehs/labguide/sec_3.htm)

Chemical Safety

WHMIS (Workplace Hazardous Materials Information System)
WHMIS is an information system to ensure workers have adequate knowledge and training to work with hazardous materials. One or more of the hazard symbols listed below may appear on chemical containers you encounter in the lab. You can find out more about the WHMIS system on the Worksafe BC website:
http://worksafebc.com/publications/health_and_safety/whmis/default.asp

Material Safety Data Sheets (MSDS's)
Most chemicals used in laboratories have MSDS's that describe a number of details about the chemical, including hazards, physical properties, PPE, first aid and clean up measures. Ask your lab demonstrator or instructor if you would like to see a MSDS for a material that you are using in a lab session.

Symbol	WHMIS Classification
	**Class A: Compressed Gas** Compressed gases, dissolved gases and gases liquefied by compression or refrigeration.
	**Class B: Flammable or Combustible Substances** Solids, liquids and gases that can catch fire due to spark or open flame in normal conditions
	**Class C: Oxidizing Materials** Materials that allow or assist other substances to burn
	**Class D, Division 1: Poisonous and Infectious Materials that can Cause Immediate and Serious Toxic Effects** Acute poisons that can cause immediate injury or death on exposure to small amounts
	**Class D, Division 2: Poisonous and Infectious Materials causing other Toxic Effects** Can cause life threatening and serious long term health problems from repeat exposure. Also includes sensitizing materials.
	**Class D, Division 3: Poisonous and Infectious Material, Biohazardous Materials** Contains organisms that are known or suspected to cause disease
	**Class E: Corrosive Materials** Substances such as acids and bases that can burn through skin or metal
	**Class F: Dangerously Reactive** Products that may self–react, or react when exposed to forces such as physical shock, pressure or certain temperatures
Source: http://www2.worksafebc.com/Topics/WHMIS/SymbolsAndLabels.asp	

Dissection Safety

Dissections specimens may contain traces of formaldehyde, alcohol and other chemicals. While these chemicals are present in small amounts, they do have the potential to cause irritation or other toxic effects. To minimize risk to yourself and other students, it is important to follow the **Safe Dissection Guidelines** listed below. Some of our specimens are also injected with latex. For most people, latex is not harmful; however, some people have allergies to latex that can cause severe reactions. **Please let your instructor and lab demonstrator know if you have latex allergies, or notice reactions such as skin and throat irritation during a dissection.**

Safe Dissection Guidelines

- Safety glasses/goggles and chemical resistant gloves must be worn at all times during a dissection
- Food and drink must be put away prior to starting your dissection. If you require food or beverage, remove your gloves and goggles and leave the classroom prior to eating/drinking.
- Relax and take your time, ensure you understand the dissection steps and work with your team to proceed calmly through the dissection. If possible, alternate roles through the procedure to provide all team members a chance to dissect.
- Let your instructor or lab demonstrator know if you feel ill or uncomfortable during a dissection. Monitor yourself and take a break by stepping outside if you need to.
- Specimens should be mounted to the dissection tray with pins or flesh hooks prior to dissecting. This will make dissection easier and will reduce the chance for injury.
- Dissection tools are sharp and can cause injury, handle with care and take care not to point towards other students
- Cut away from your body and other students
- Use scissors instead of scalpels whenever possible
- All dissected parts should remain in dissection tray
- Dissection parts should be properly disposed of – please follow instructions provided by your lab demonstrator or instructor
- Carefully clean your work space when finished to ensure area is clean for the next group of students.

Reference Source: Flinn Scientific Dissection Safety Tips (http://www.flinnsci.com/media/396301/dissectionsafety.pdf)

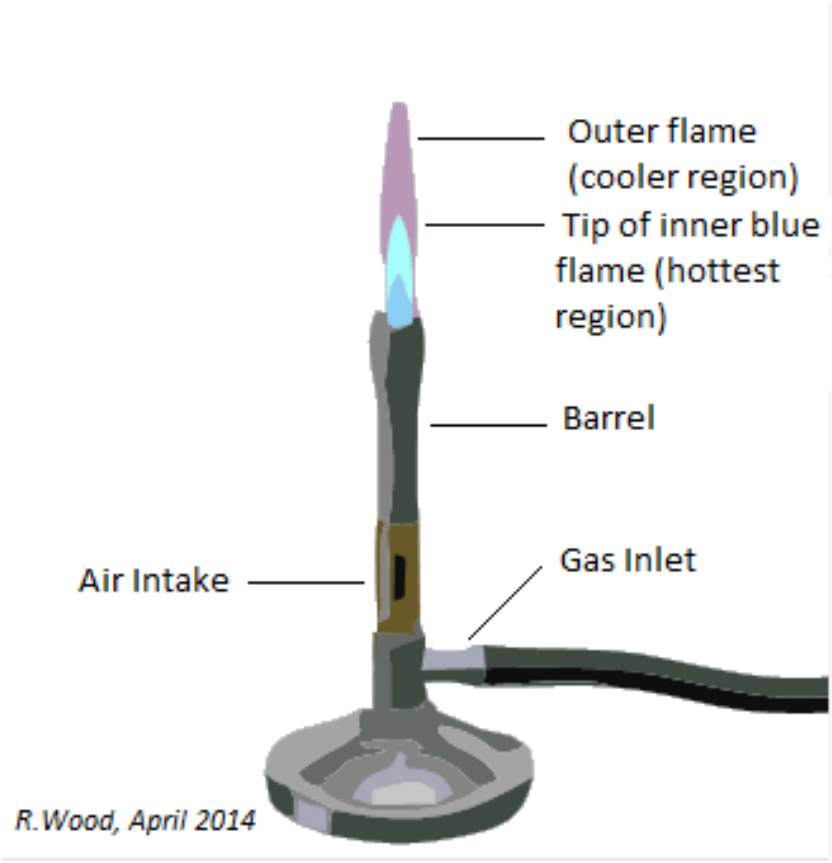
Biohazards

Biohazards are living organisms or parts of organisms that have the potential to cause or spread disease or other harm. Examples include bacteria, viruses and human blood. We will use bacteria species in the gram stain lab that are non-pathogenic, meaning to the best of our knowledge, they are not known to cause disease or illness. However, when using any bacterial culture, care should always be taken to limit exposure and maintain a clean working environment, both for yourself and students who come after you.

Safety tips to keep in mind when working with potential biohazards:

- Pay close attention to instructions provided in the lab on aseptic technique.
- Wear safety glasses or goggles and gloves. When you are actively using the Bunsen burner or another source of flame, remove your gloves.
- Make sure to wash your hands well with soap and warm water before and after handling cultures.
- Work surfaces should be wiped down with disinfectant wipes, 70% alcohol or 10% bleach solution before and after the lab.
- Biohazardous waste materials (i.e. slides) should be placed in appropriate biohazard containers. Usually sharp objects, such as slides or lancets, are placed in the hard sided yellow biohazard containers. Soft objects, such as tissues or swabs, should be placed in red or clear biohazard autoclave bags.
- Keep culture containers (usually petri dishes) closed at all times unless otherwise directed. As some culture components may be airborne, opening the culture dish increases risk of contact.
- Do not eat or drink in the lab while using biohazardous material.

Bunsen Burner/Flames



Bunsen burners are used in biology labs when aseptic technique is required, such as in the bacteria lab. They may also be used in chemistry labs to heat samples. These devices use natural gas to produce a very hot flame when lit by a spark.

Safety tips to keep in mind when using the Bunsen burner:

- Hair and loose clothing should be tied back or secured.
- Ensure you are familiar with procedures for lighting the Bunsen burner prior to turning on the gas.
- Flames should never be left unattended, as they are difficult to see and could harm another student.
- Do not wear gloves while working directly with flame, as the flame can melt the glove material causing burns.
- Ensure the workspace around the flame is free of paper and other flammable material.
- Natural gas has a very small amount of mercaptan added to provide a “rotten egg” odour, allowing for detection of gas leaks. Sometimes when the burners are in use, the smell is detectable in the classroom. If the smell becomes very strong, it may indicate a gas leak or that an outlet has been left on. Please let your instructor or lab demonstrator know immediately if you notice this.

Microscopy

Using the dissecting microscope

Use the dissecting microscope:

1. Get a dissecting microscope and a power cord from the cupboard.
2. Carry the microscope with two hands.
3. Plug in the scope without obstructing a walkway.
4. Clean lenses and stage with *lens paper*.
5. Place an object on the stage. Live or wet specimens should always be in a dish, not directly on the stage.
6. Switch the light "on" by pressing the M (mode) button.
7. Press the M button repeatedly to explore the 4 different light modes:
    - Reflected light: light comes from above the stage
    - Transmitted light: light comes from under the stage
    - Both transmitted and reflected: all lights are on
    - Standby mode: all lights are off
8. Select the light mode that works best for the object you are viewing.
9. Look through the ocular lenses and adjust them until you see only one circle of light (#1).
10. Use key + and – to adjust the light intensity (#6)
11. Locate the magnification knob (#2) and the focusing knob (#3).
12. Find object at the lowest magnification, 8X on the magnification knob.
13. Focus with the focusing knob.
14. Raise magnification to the maximum, 32X, and focus.

If the dissecting microscope is set up this way, the image sharpness (focus) will be retained over the entire zoom range.

Putting the microscope away:

1. Make sure the microscope is clean and dry.
2. Disconnect the cord from the scope and roll the cord loosely.
3. Return both dissecting scope and cord to the cupboard.
4. Make sure to put the dustcover back on.
5. Return your scope to the same cupboard where you found it, without overcrowding.

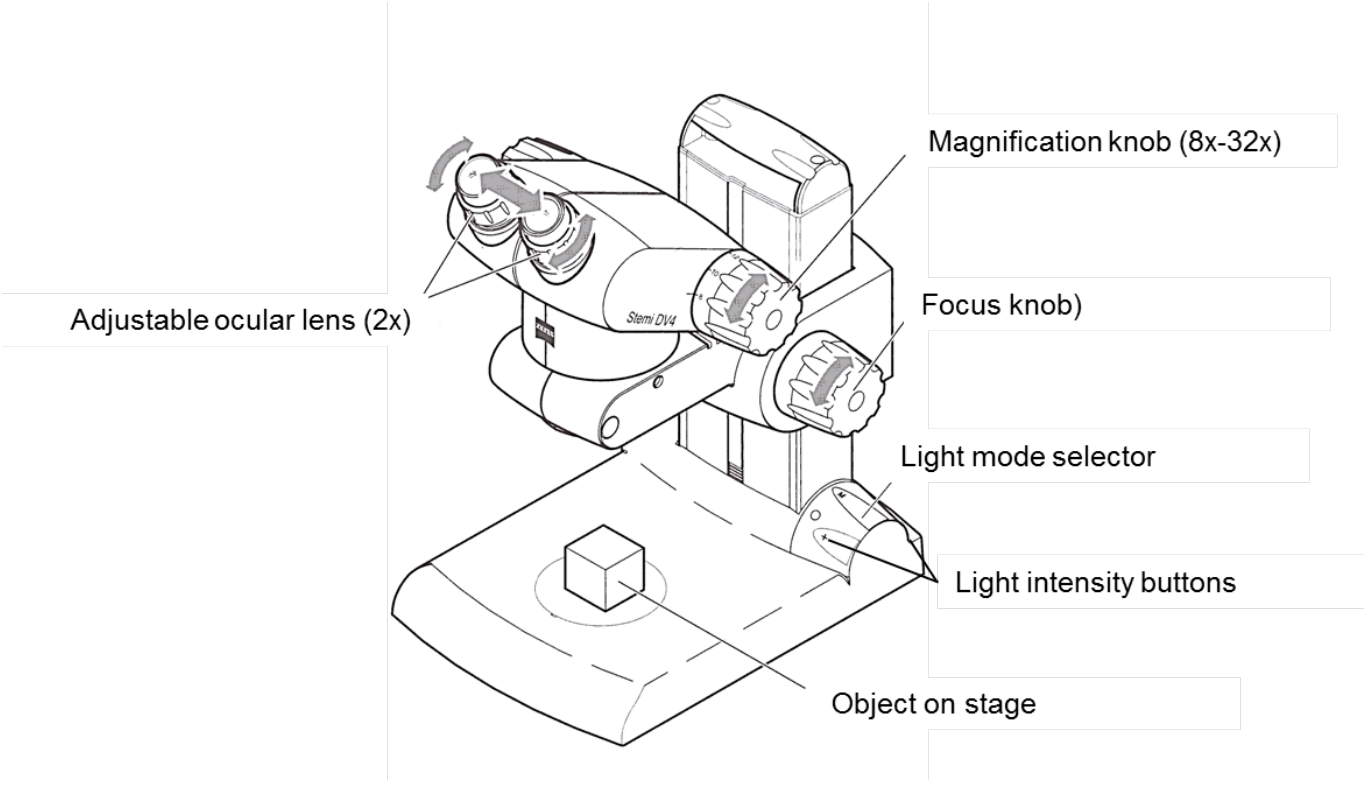


Figure 1. The dissecting microscope.

Modified from D. Pellerin, Biology 061/071 Manual

Using the compound microscope

Cautions:

- Always carry the scope with two hands!!!
- Microscopes are heavy. Protect yourself by bending your knees while taking the microscope from the low shelves
- A prolonged session in poor posture may hurt your back. Assume a proper ergonomic posture during this session – ask for help.
- Never put a wet slide on the microscope stage. Dry a wet stage immediately.
- Do not use the 100x objective (longest of 4 lenses, with black ring around bottom of lens) unless instructed to do so.
- Make sure you identify the condenser and do not move its specific alignments – this could make your observations more difficult – if you suspect that it has been misaligned notify an instructor for help.
- This is a precise and fragile instrument – take good care of it and it will show you some amazing things!

Use the compound microscope:

1. Remove the protective cover from microscope and leave it in the cupboard.
2. Lift, hold and carry the microscope with 2 hands. One hand supports the base, the other holds the arm.
3. Place the microscope carefully on your desk or a counter near a power source.
4. Check that the light is switched off and the light level is set to very low before plugging it in. Plug in the scope without obstructing a walkway.
5. Check all the lens surfaces for cleanliness and clean as needed with *lens paper*. Use the nosepiece to turn the **low power** (shortest, 5X) **objective lens** into place above the stage.
6. Find the large **coarse focus** knob and turn it so that the stage moves down. Move the stage as far down as it will go.
7. On low power, place a slide on the stage and clip it into place. If it clipped in properly, you should be able to move it around smoothly by rotating the knobs under the stage (#9 and 10 on Figure 2).
8. Look at the microscope from the side (not through the lenses) while you turn the coarse focus knob until the stage is as far up as it can go without hitting the lens.
9. Double-check that the light is dimmed, then find the light switch and turn it on.
10. Look through the **ocular lenses** with both eyes. Adjust the ocular lenses until you see only one circle of light. Adjust the light level so that it is comfortable for your eyes.
11. Focus on the specimen by adjusting the coarse focus knob to move the stage down. Further adjust the focus using the **fine focus knob**.

12. Find the **lever for the iris diaphragm**. Slide left and right to change the amount of light. Adjust the light level further with the rheostat.
13. Rotate the objective lenses until the next (middle length, 10X) lens clicks in place.
14. Center the object of interest, then adjust the light level again if needed. Adjust the fine focus only to see the cells better - you should not need to adjust the coarse focus at this point!
15. Watching from the side, rotate the objective lenses until the 40X lens clicks in place. ***Careful****:* at this power you could crush the slide and the lens while adjusting the fine focus - so move very slowly and don't go to the 40X lens if it's going to touch the slide. Use the fine focus to adjust the image, but do not adjust the coarse focus.Carefully find the iris diaphragm again and move it while looking at the object – move it to the position that gives you the best detail resolution of the viewed object. Adjusting the light level may help you achieve a better resolution

Putting the microscope away:

1. Dim the light and turn the power off.
2. Turn the turret to engage the low power objective.
3. Move the stage to its lowest position.
4. Remove the slide from the stage and return it to its proper tray.
5. Clean all lenses and surfaces with lens paper.
6. Unplug and roll the cord loosely and secure it with the Velcro.
7. Lift, hold and carry the microscope with 2 hands.
8. Cover it with its protective dustcover.
9. Carefully place the microscope back in the cupboard. Do not overcrowd!

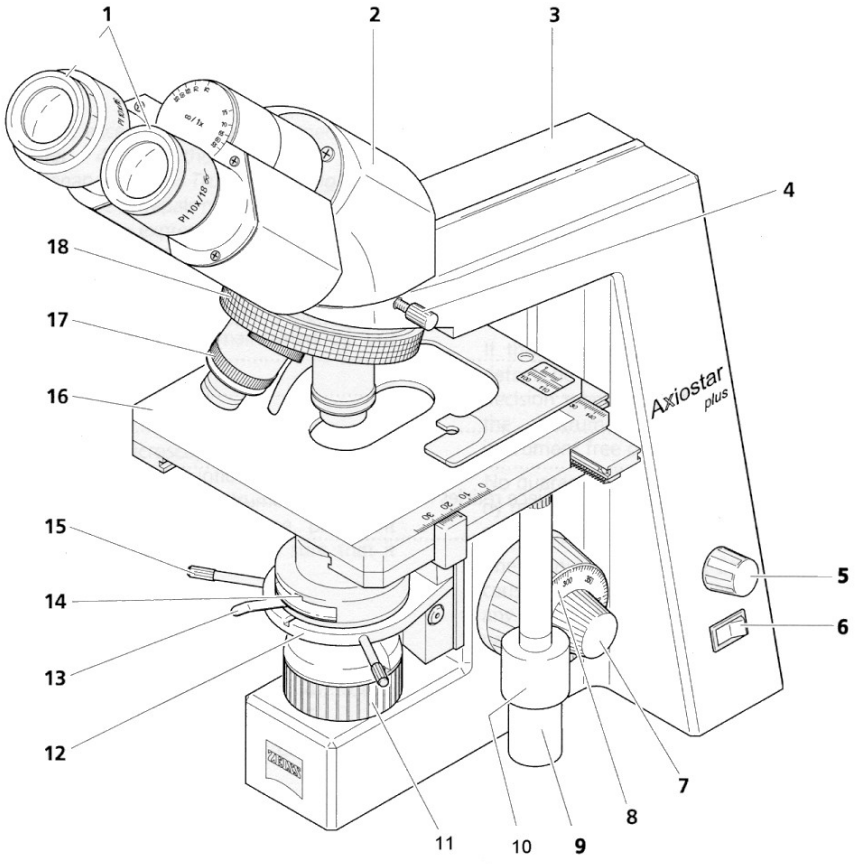


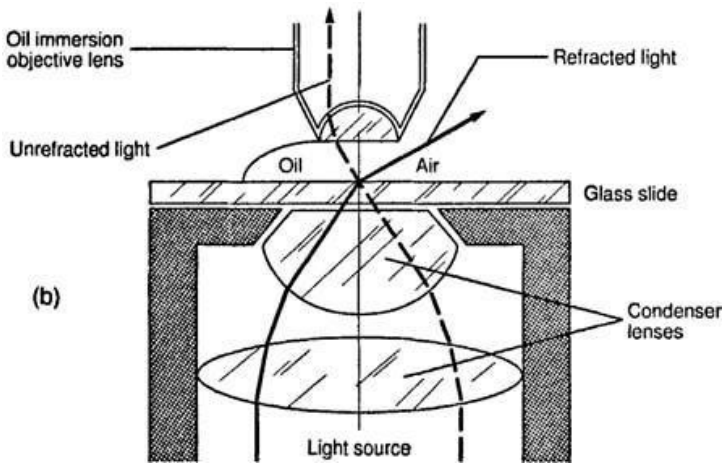
Figure 2. The compound microscope.

1. Eyepieces
2. Binocular tube
3. Microscope stand or arm
4. Screw for tube locking
5. Brightness control (rheostat)
6. On/off switch
7. Fine focus knob
8. Coarse focus knob
9. Knob for adjusting slide clip in x direction
10. Knob for adjusting slide clip in y direction
11. Field diaphragm (don't adjust)
12. Condenser carrier
13. Lever for adjusting iris diaphragm
14. Condenser
15. Centering screw for condenser (don't adjust)
16. Stage with specimen holder (slide clip)
17. Objective
18. Nosepiece

Modified from D. Pellerin, Biology 061/071 Manual

Using the oil immersion lens

The oil immersion procedure allows viewing of specimens at 1000X magnification. A drop of oil is placed on the slide, and the oil immersion lens is rotated into place. Oil reduces refraction of light, improving ability to focus on a specimen at high power.



Procedure:

1. Bring your specimen into focus at high power (400X) by first focusing at lower powers (50 then 100X) then moving up to 400X.
2. It is important at this point that you move the area of slide into view that you would like to observe using oil immersion. Once you have placed oil on the slide, it can only be moved minimally.
3. Swing the 400X lens out of the way so that the area over the slide is clear, between the 400X and 1000X oil immersion lens.
4. Find the circle of light where your light hits the slide.
5. Without touching the slide, drop 1 drop of immersion oil onto this circle of light.
6. Watching from the side, carefully swing the oil immersion lens into place.
7. Avoid moving the slide (very slight movements are OK, but moving it too much will change the thickness of the oil layer, decreasing resolution of the specimen)
8. Adjust the light level as required.
9. Use only slight adjustments with the fine focus wheel to adjust focus.
10. When you are finished, clean the 1000X oil immersion lens and the slide well with ethanol and lens paper.

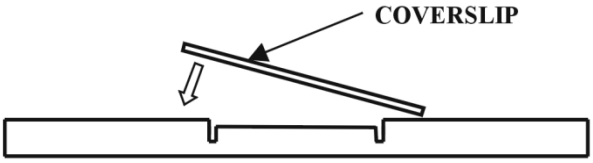
Caution: Please ensure oil does not contact the three “non-oil immersion” objective lenses. If it does, wipe them well with ethanol and lens paper to remove oil.

Modified from D. Pellerin, Biology 061/071 Manual

Making a wet mount

You will need to make a wet mount (a slide of a living specimen) in some of your labs. You may use a regular slide for very small organisms, or a **depression slide** (it has a recessed circle in the middle of the slide) for larger microscopic organisms such as *Paramecium*.

1. Take a slide (making sure you have the right type) and wipe it clean using **lens** paper.
2. Use the dropper to place a single drop of liquid in the depression and carefully put the dropper back in the container from which it came (or else you'll cross-contaminate the droppers!)
3. Gently lower a coverslip at an angle over your drop like this:



4. Use a grease pencil to label a dry corner of the slide with the name or initials of the organism.

Microscope measurements and diagrams

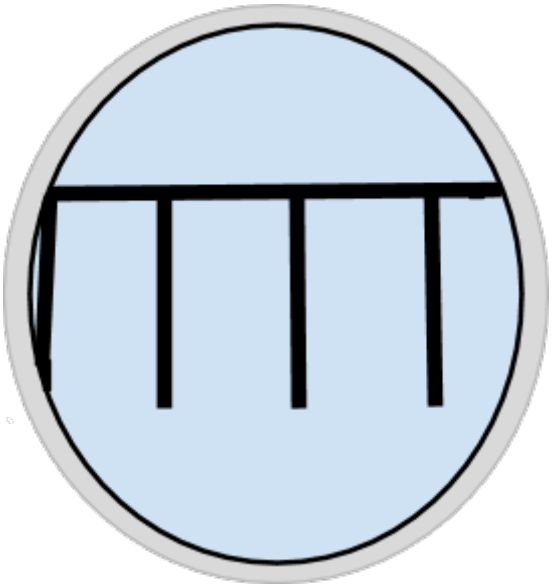
The objectives of this activity are to learn how to:

1. **Determine the size of the field of view**
2. **Determine the size of a microscopic specimen**
3. **Sketch a specimen and calculate the drawing magnification**

Methods

Determining the size of the field of view

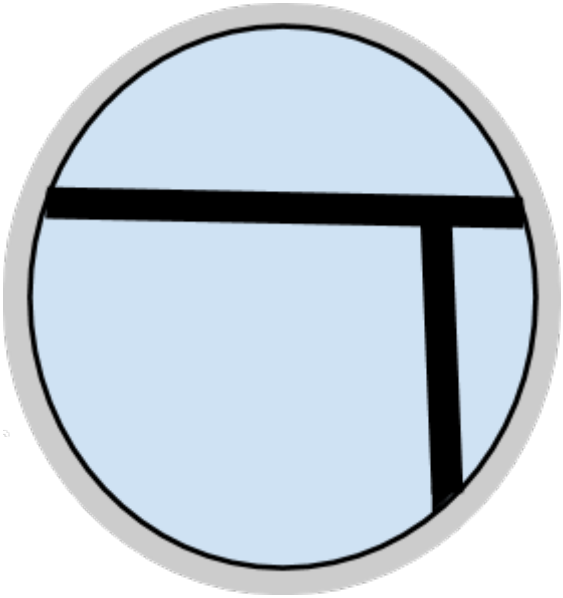
What is a field of view?



This is the circle you see when looking through the eyepieces of a microscope. The size of the field of view is equal to the diameter of the circle.

How do you determine the field of view size using a microscope?

The simplest way is to use a ruler slide (just a slide with a small ruler taped to it).
Place the ruler slide onto the microscope stage and focus on the millimeter lines. At the lowest power on our compound microscopes (50X mag) you should be able to count ~ 3.5mm.



How do you find the field of view size at higher magnifications?

At higher magnifications you can only see at most one line on the ruler which is not very useful. Instead, field of view size at higher powers can be calculated based on our estimate of field of view at 50X magnification.

As magnification increases, the field of view should decrease proportionally. Therefore, if the magnification doubles (from 50X to 100X), the field of view diameter is halved. To calculate the field of view at 100X, multiply the field of view diameter at 50X by 50/100 or 1/2
i.e. 3.5 mm * 50/100 = 1.75mm

Given this, how would you calculate the field of view at 400X? 1000X? Calculate these values:

The final step is to convert your values into micrometers (μm):

Record your values for future use:

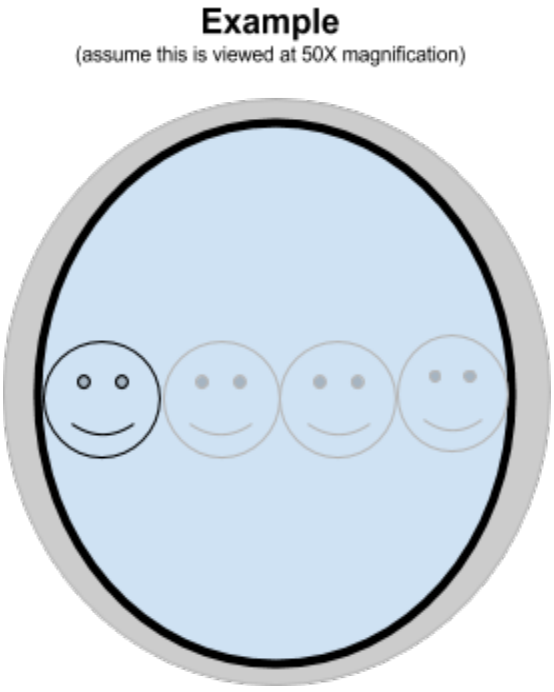
Microscope Brand & Model:

Magnification	**field of view diameter in millimeters**	**field of view diameter in micrometers (μm)**
50X		
100X		
400X		
1000X		

B) Determining the Size of a Microscopic Specimen

First determine the diameter of the field of view (as described in section A) for the magnification at which you would like to estimate your specimen size. In the example to the right, the magnification is 50X therefore the field of view diameter is 3.5 mm (or 3500 micrometers)

Estimate how many specimens might fit across the field of view (along the diameter of the circle).
In the example, we would estimate 4 specimens.
Finally, divide the field of view size by the number of objects that fit across the field of view. Remember to include units.
For the example, our calculation would be: 3.5 mm/4 = 0.88mm. *The actual size of our specimen is 0.88mm (880 micrometers)*



C) Sketching your specimen and calculating the drawing magnification

It is good practice to measure and sketch specimens you observe during microscope labs. Sketches should be simple line drawings, clearly representing only observed features. Avoid including any extra features that you do not see.

Include a **title, simple labels, your name, date and the actual size** along with the **drawing magnification**. Use the highest magnification possible for your sketch, as that will provide the most detail. If you are viewing a complex sample with many specimens, you do not have to draw all of them; just choose one or several representative specimens to draw.

When you sketch a specimen, calculating the **drawing magnification** is an important step.

The drawing magnification tells a viewer how much larger your drawing is than the actual specimen.

To determine the drawing magnification, measure your actual drawing with a ruler.

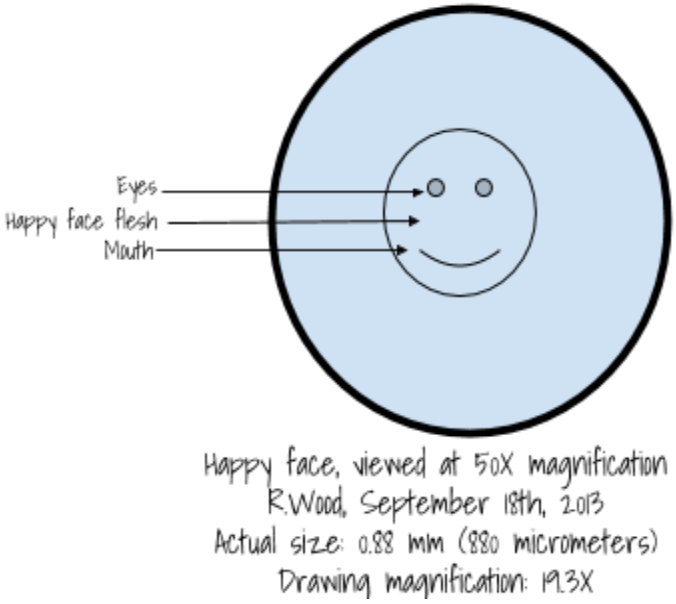
For example, the drawing of the happy face in example 2 is 17mm in diameter

Divide the **drawing size** by the **actual specimen size**. Remember to convert both into the same units before dividing.

Drawing magnification for example 2: 17mm/0.88 mm = **19.3 X**

This specimen has been drawn 19.3X larger than it actually is.

Example 2



Making a bar graph

Bar graphs are used to compare the amounts or frequency of occurrence of different categories of data. For example, you could make a bar graph to compare the amount of sugar in different beverages:

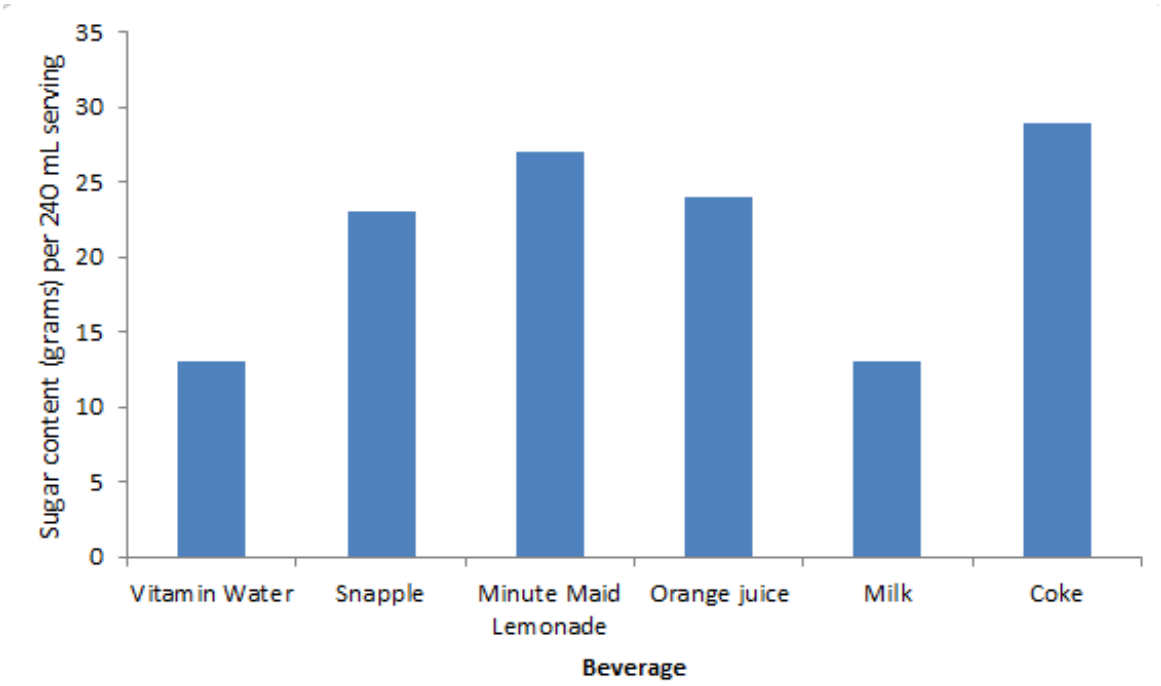


Figure 1. The sugar content of a 240-mL serving of commercially available beverages.

Note the following requirements of bar graphs:

- No title above the graph - instead, detailed information is given below the graph as a **figure legend**. This information begins with the figure number and should tell readers everything they need to know to understand the graph.
- **Axes** with labels, and units (grams, for example) where appropriate
- Categories on the x (horizontal) axis and amounts or frequencies on the y (vertical) axis
- **Bars** that are clear, crisp and distinct from each other

You can also make a bar graph to show the frequency of a certain size range (e.g. sizes of mussel shells, or leaf length). In this case, each category on the x-axis would be a numerical range, and the y-axis would still be the frequency.

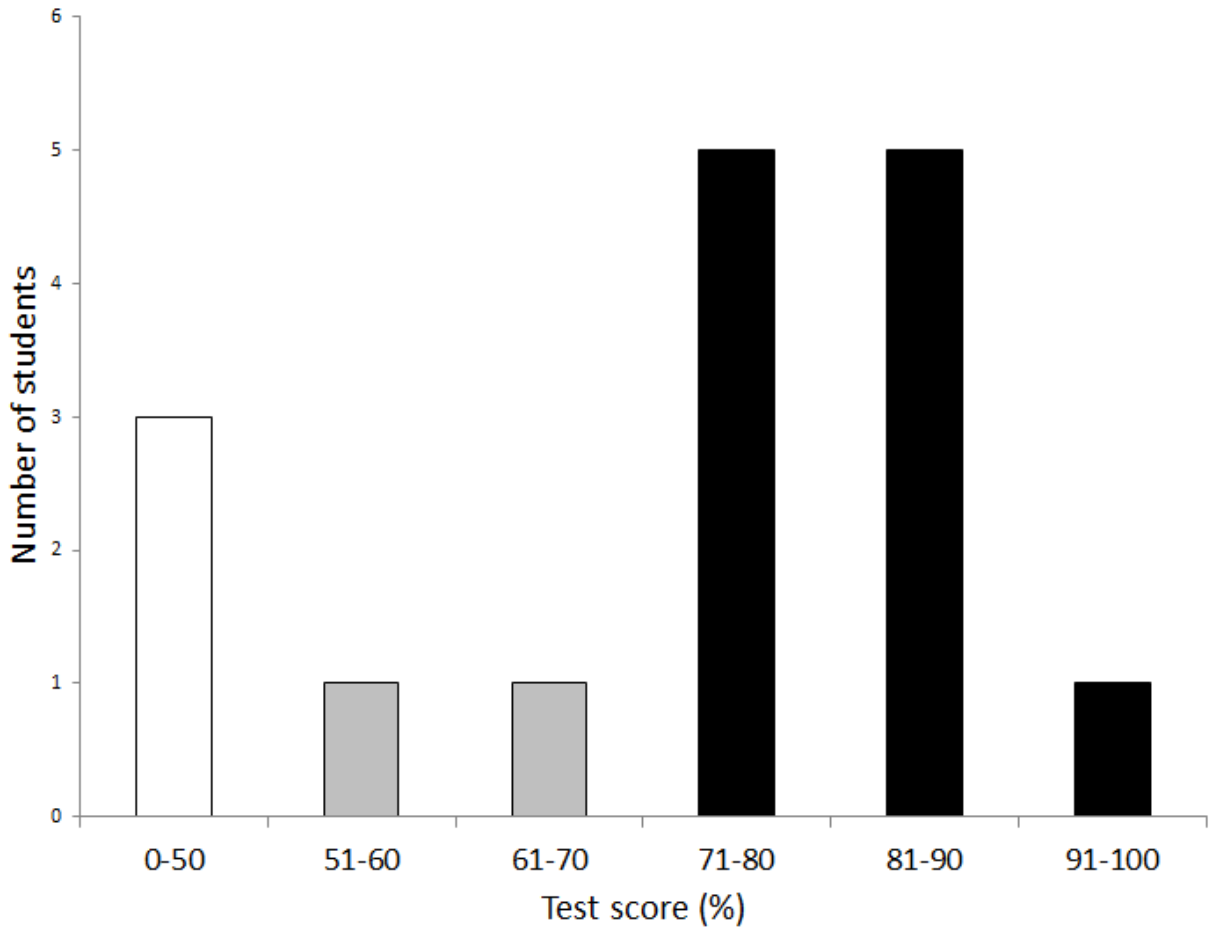


Figure 2. Test scores of students in Biology 12 at Vancouver Community College in July 2013. Black bars represent “A” and “B” letter grades; gray bars represent “C” and “D” letter grades; white bars represent failing grades.

This bar graph also illustrates an additional option, which is to colour-code bars of the graph to provide additional information.

Formatting references

How to cite and format references using the Harvard System

While studying life sciences at VCC, you will be asked to hand in a variety of assignments that will require proper referencing. This can be a relatively easy task once you know how to go about it.

If you have taken other college courses, you may already have experience with one or more reference formats. The format you will be using in this course is known as **Harvard Referencing System**. This system is commonly used for referencing life science papers and lab write-ups.

There are two main components involved with referencing. The first involves **citing references** within your report. The second involves **creating a reference list (also known as works cited)** at the end of your report.

Why Cite References?

Citing references allows the reader of your work to know exactly what sources you used in your research. In all written reports, you need to cite references anytime you write material that is not your own original work or idea. Most assignments, papers and lab reports will require proper reference citation.

Within a formal lab write-up, there are several places that reference citations will be required. For labs that require you to research and write background theory, you will need to properly cite the sources that you used.

For example, if you research blood as part of a lab report, you will need to find a reliable source to get your information. Reliable sources include textbooks, journal articles, some websites and many other possibilities. It is up to you to find the most reliable source available. Whatever source you decide to use will appear as a reference citation within your write-up. Even though your write-up is written in your own words, you need to cite the reference for the source that you acquired the information from.

In science writing, you usually do not quote directly. You are required to **paraphrase** the information found in the sources you cited. Be careful with this as most biology instructors will not accept direct quotes in lab write-ups, even if the source is cited.

Below are several examples of reference citations within a report.

A book with one author - (last name of author and date published)

Humans evolved along with parasites, bacteria, viruses and mutualists. Some modern immunological problems have resulted from becoming disconnected from this evolutionary relationship (Dunn, 2011).

You can also include the author directly within the sentence.

Dunn (2011) reminds us that humans evolved along with parasites, bacteria, viruses and mutualists.

A book with two authors - (last names of both authors and date published)

If the work has two authors, list both, citing the senior author first. The senior author is the author whose name appears first on the book.

The cell membrane consists of a phospholipid bilayer with various proteins projecting through, known as intrinsic proteins (Raven & Johnson, 2002)

A book with more than two authors - (last name of senior author followed by *et al*. and date published)

For works with more than two authors, just list the senior author, followed by *et al.* This is a Latin term, short for et alia, which literally means "and all the others". Note that "*et al"* is italicized or underlined.

When body tissues are not getting adequate oxygen, the kidneys release a hormone called erythropoietin. This hormone acts on stem cells in the bone marrow, resulting in production of new red blood cells (Reece, Taylor, Simon, & Dickey, 2009).

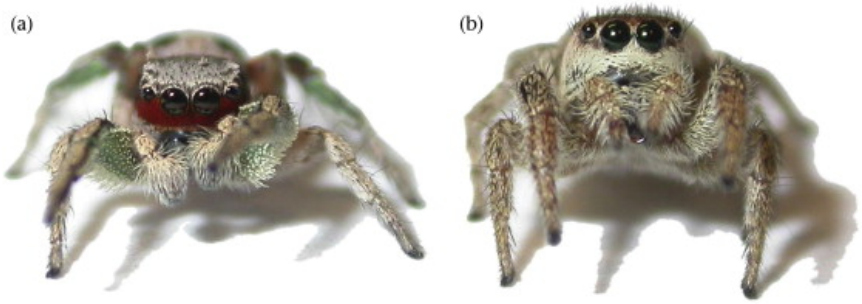
Article from website – (if an author is known include the last name of author and date of article) (If there the author is not known, include a corporate author followed by date of article as shown below)

As atmospheric CO_2 levels increase, ocean acidification is creating problems for the Vancouver Island Scallop industry and global marine life in general (CBC News, 2014).

Journal Article - (If there is only one author, include the last name of the senior author followed by date of publication. If there are several authors include last name of senior author followed by *et al.* and the date of publication)

When jumping spiders Habronattus pyrrithrix were presented with artificially coloured juvenile crickets, an apparent colour bias was revealed when the spiders avoided red and yellow crickets while attacking blue crickets. These biases appeared across age and sex categories (Taylor, Maier, Burn, Amin, & Morehouse, 2014).

Citing an image – If you need to include a graphic, chart or table that you acquired from a source, you must cite the source. Do not include graphics, charts or tables without a citation unless you created them!



(Taylor *et al.*, 2014)

Works Cited (also called a Reference List)

These are complete detailed references for the works cited above. This list must appear at the end of your report. Take a moment and find each of the following works cited and match them to the corresponding cited references above. Note that you no longer use *et al.* in works cited. You need to list all of the authors here. When your instructors read your reports, they will check to see that all of the references cited within a report appear on the Works Cited page at the end of your report.

CBC News, 2014. Acidic ocean deadly for Vancouver Island scallop industry. [Online] Available at: http://www.cbc.ca/news/canada/british-columbia/acidic-ocean-deadly-for-vancouver-island-scallop-industry-1.2551662 [Accessed 6th March 2014].

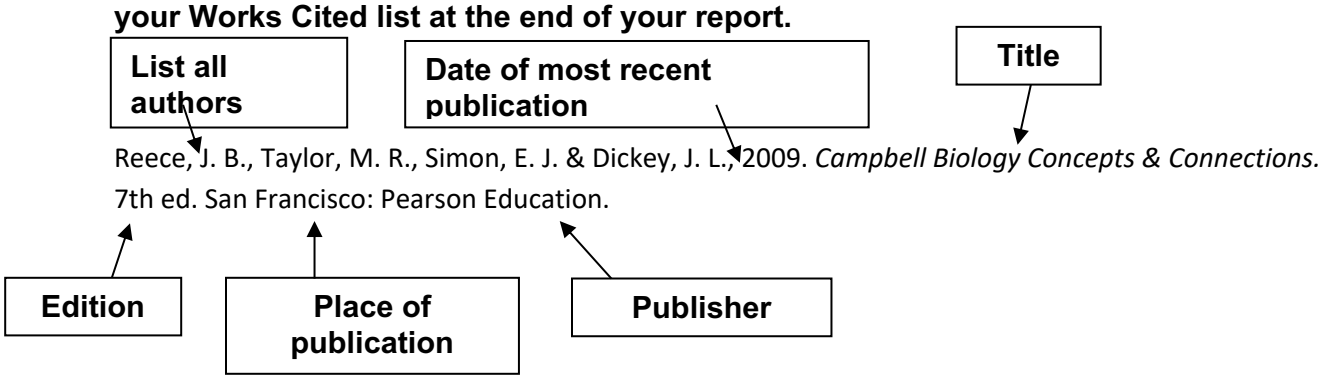
Dunn, R., 2011. *The Wildlife of Our Bodies*. New York: Harper Collins.

Raven, P. H. & Johnson, G. B., 2002. *Biology*. 6th ed. Boston: McGraw-Hill.

Reece, J. B., Taylor, M. R., Simon, E. J. & Dickey, J. L., 2009. *Campbell Biology Concepts & Connections*. 7th ed. San Fransisco: Pearson Education.

Taylor, Lisa A; Maier, Emily B; Burn, Kevin J; Amin, Zarreen; Morehouse, Nathan I. 2014. Colour use by tiny predators: jumping spiders show colour biases during foraging. *Animal Behaviour*, 90, pp. 149-157.

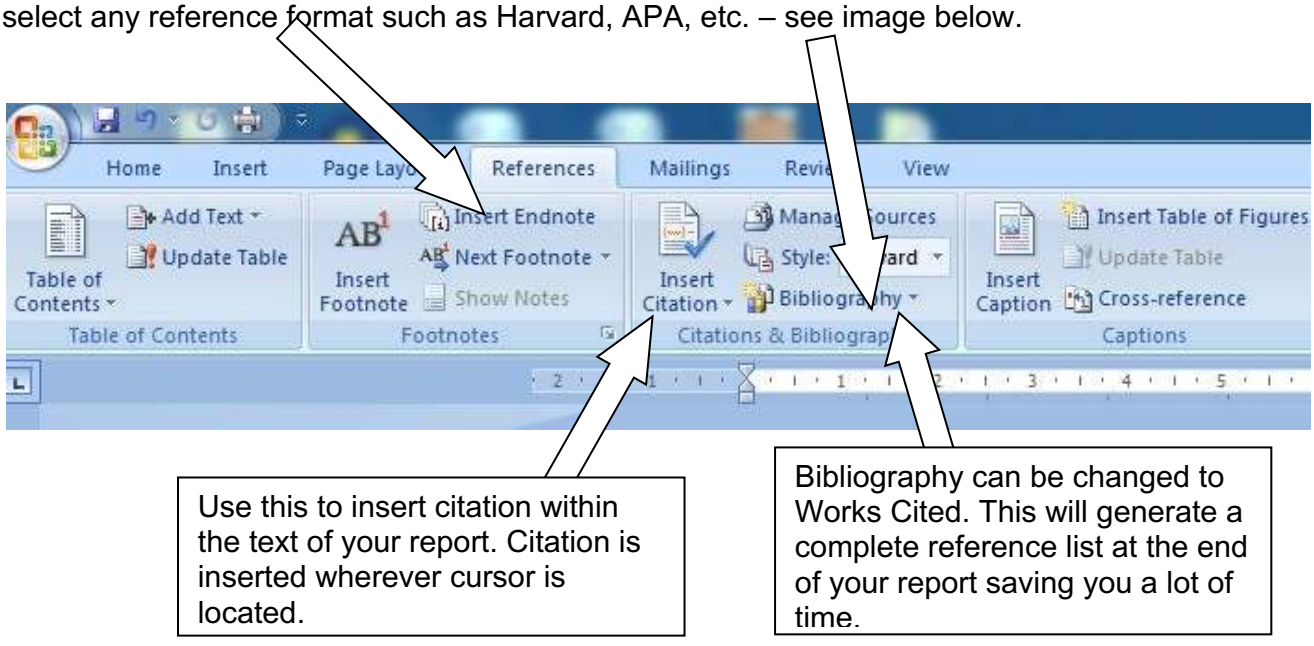
Below is one example showing exactly how a book with multiple authors appears in your Works Cited list at the end of your report.



For more detailed examples showing how to reference all possible sources, visit the VCC library website at www.vcc.ca . From the library home page locate Referencing – Harvard style. Librarians will also assist you with referencing. Be sure to tell them you are using Harvard Style.

Microsoft Word –Referencing tool

If you use Microsoft Office – Word to write your report you will find an easy to use REFERENCE tool. It allows you to cite references, keeps track of them, and automatically enters your Works Cited list, properly formatted at the end of your report. It allows you to select any reference format such as Harvard, APA, etc. – see image below.



Use this to insert citation within the text of your report. Citation is inserted wherever cursor is located.

Bibliography can be changed to Works Cited. This will generate a complete reference list at the end of your report saving you a lot of time.