BIOLOGY DEPARTMENT

BIOLOGY 103

NON-MAJORS GENERAL BIOLOGY

Laboratory Manual

2021-2022

Student Name: _____

Section: _____

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General Department Policies

1. Attendance in lab periods is a **requirement** of this course. Marks will be lost for missed labs as will opportunities to complete related lab work.

2. Greater than **3 unexcused absences** from lab will result in a failing mark in the course.

3. Students must **pass** the laboratory component of this course in order to receive a passing mark in the whole course.

4. All labs begin **promptly** at their start time and will take the **entire lab period**. Late arrivals or early departures will result in loss of marks or loss of opportunity for lab work.

5. Lab manual must be read **in advance** of the lab period and **pre-lab** work must be completed **prior to arrival**. Failure to do so will result in loss of marks.

6. All lab manual work must be checked by the instructor **before** leaving the lab.

7. Lab assignments are typically due at the **beginning of the following lab** (one week later). Late lab assignments **may** be accepted but at a penalty of **10% per day** up to a certain number of days. Please see the course outline for more details.

8. Lab exams **must** be written when they have been scheduled. There are **NO** make-up lab exams. In case of extreme illness or emergency, contact the instructor PRIOR to the exam.

9. The use of electronic devices is **prohibited** during exams (e.g., smart watches, phones).

10. Cheating and plagiarism are not acceptable and will be dealt with as described in the **Student Conduct Policy**, available on the Camosun website. It is the **student's responsibility** to understand what constitutes cheating and plagiarism by reviewing the policy.

11. Respect for the laboratory space, equipment, specimens, and others is crucial for a positive and safe lab experience as outlined in the **Student Conduct Policy**.

12. Individual courses may have additional policies which may be included on handouts, announced in class, or described on a course website. It is the **student's responsibility** to be aware of this information.

Laboratory Rules and Procedures

Laboratory safety is the responsibility of **everyone** working in the lab. Your work in the biology lab will involve the use of equipment, specimens, and chemical reagents that may be harmful if handled improperly. It is essential that regulations are followed to ensure a safe environment for everyone. Failure to adhere to safety regulations will result in removal from the lab.

Familiarize yourself with the location and use of the follow laboratory safety equipment, as well as the procedures and precautions listed below:

- FIRE EXTINGUISHERS
- FIRE BLANKET
- EYE WASH STATION
- EMERGENCY SHOWER

General Lab Procedures and Precautions

1. **Closed-toe shoes** are to be worn in the lab at all times (no sandals or flats).

2. **Long hair** must be **tied back.**

3. Lab benches must be **cleaned** at the **beginning** and the **end** of each lab session.

4. Bags and other items must be placed **under** the lab bench. Chairs must be **pushed in** at the end of the lab.

5. Food/drink items must be kept inside bags or in the hallway at all times.
   a. Eating, drinking, and chewing gum are **prohibited** in the lab space.

6. Cuts, wounds, and/or abrasions must be **covered**.

7. Lab coats are **not** required for this lab; however, gloves and safety goggles will be provided for your use, if advised.

8. Accidents, spills or unsafe conditions must be **reported** to the instructor immediately.

9. Any medical conditions that might necessitate special precautions must be **reported** to the instructor.

Laboratory Safety Contract

Please read and initial the following policies. Sign and date at the bottom.

____ I have read, understand, and agree to follow the **General Department Policies** and **Laboratory Rules and Procedures** as well as any other written or verbal instructions regarding department and college policies.

____ I understand that failure to adhere to these regulations will result in my removal from the laboratory and/or loss of marks for missed work and assignments.

____ I understand that I must pass the laboratory component of this course in order to receive a passing mark in the whole course.

____ I understand that greater than **3 unexcused absences** from lab will result in a failing mark in the lab portion of this course.

____ I understand that an unexcused lab absence can result in a 1% loss of total lab marks per missed lab and that **I cannot receive marks for lab assignments from missed labs.**

____ I understand that I am to contact the instructor as soon as possible **AND BEFORE THE EXAM** when I am going to miss an exam.

____ I understand that I am to contact the instructor before I return to class after missing an exam to arrange writing a make-up exam.

____ I understand that all instances of cheating, plagiarism and use of electronic devices in exams will be documented and sent to the Dean.

_____

Signature

_____

Name (please print)

_____

Date

_____

Course and Section

Hand in this safety contract to the instructor on your first laboratory session, when prompted.

General Lab Manual Layout

Before attending the first lab, review how the lab manuals are laid out to ensure you understand how to best prepare and complete each lab:

"Following this lab, students should be able to"

- In this section, all of the concepts that you will be tested on for a future lab exam are listed
- Use this as a **study guide** when preparing for the lab and lab exams

"Required prior knowledge from lecture material"

- This section suggests **lecture material** to review and bring with you to aid in your understanding and the completion of each lab

"Introduction"

This section briefly outlines the lab procedures for the lab session

"Pre-Lab"

- This section lists required work that must be completed **before arriving** to the lab session
- Typically, there are one or two questions to answer
- The pre-lab work will be checked at the very beginning of the lab (late arrivals result in lost marks for pre-lab work)

"Parts 1-N"

Procedural steps are listed here and must be followed exactly during the lab session. The instructor will typically give an overview of expectations and demonstrations as needed. Lab manuals are required to be on hand during the lab (online versions do not count).

Your lab work will always be checked by the instructor before you leave the session.

"Written Assignment"

Post-lab assignments are listed with specific requirements and marks in this section. All assignments should be **stapled** (if more than one page), and must have students' **full names, course code**, **section,** and **date** in top right corner. The **title** of the lab should be at the top of the page.

Depending on the lab and the instructor, students may be able to submit electronically and may be able to complete some labs in pairs (your instructor will clarify their expectations in their first lab with you).

Lab 1: Science & Data

Following this lab, students should be able to:

- Estimate the length, volume, and mass of various objects using the metric system
- Convert measurements from one metric to another (e.g. km to m, mL to µL)
- Recognize the independent, dependent, and controlled variables of an experiment
- Create a high quality graph when given data
- Interpret graphs and infer results

Required prior knowledge from lecture material:

- Scientific method, experimental variables

Introduction

To complement the theoretical understanding of science and scientific method from lecture, students will explore laboratory measurements, conversions, create hypotheses, collect data, and create graphs. This lab is to be done in pairs, though each student is required to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts
  - Answer the following questions to the best of your ability:
    - What do scientists endeavor to do? What is their goal?
    - How do scientists support or refute claims?
    - What would make other scientists more willing to accept another's results or claims?
    - Can scientific understanding change over time? Explain.

Part 1: Data Collection

Science only concerns itself with **measurable data**. There are different types of data that can be collected.

Qualitative data consider the qualities of observation (e.g. colours, smells, sounds, etc.).
Quantitative data consider the quantities of observation (e.g. numbers and calculations).

1. Consider the following data and indicate whether they are **qualitative** or **quantitative**:
    a. Yuriko counted 42 bacterial colonies on his agar dish _____
    b. The bacterial colonies were fuzzy and white _____
    c. The colonies had a slight banana smell to them _____
    d. The colonies of bacteria did not grow in a 2cm area around a fungal colony on the plate _____

2. Collect two points of qualitative data and two points of quantitative data about yourself or your lab partner:
    a. Qualitative data: _____
    b. Quantitative data: _____

Part 2: Estimating, Measuring, and Converting

In scientific inquiry, information is collected during preliminary observations, then more specifically counted/measured during an actual experiment. Students should be able to roughly estimate lengths, masses, and volumes, and convert these amounts into different metrics.

Length

We measure length in **metres (m).** 1m is equal to 1000mm (millimetres), which is equal to 1,000,000µm (micrometres) (see **Table 1**).

Table 1. Four of the most comment length units, their symbols, and their values.

Unit	**Symbol**	**Value**	
Kilometre	km	1000m	(1km= 1000m)
Metre	m	1m	
Millimetre	mm	0.001m	(1m = 1000mm)
Micrometre	µm	0.000001m	(1mm = 1000µm)

1. Discuss with your partner which units of measurement (km, m, mm, or µm) the following objects should be measured in:
   a. An airplane _____
   b. A desk _____
   c. A bacterial cell _____
   d. A country _____
2. Discuss with your partner what other objects you would measure using the following metrics:
   a. km _____
   b. m _____
   c. mm _____
   d. µm _____
3. Observe the different objects and estimate the length of each (do not use a ruler):
   a. Unknown #1: _____
   b. Unknown #2: _____
   c. Unknown #3: _____
4. Measure the length of each unknown using the rulers provided.
   a. Actual length of unknown #1: _____
   b. Actual length of unknown #2: _____
   c. Actual length of unknown #3: _____
5. Convert the following lengths by <u>dividing</u> the number by 1000:
   a. 1550mm = _____ m
   b. 600µm = _____ mm
   c. 50,300m = _____ km
6. Convert the following lengths by <u>multiplying</u> the number by 1000:
   a. 0.180mm = _____ µm
   b. 0.017km = _____ m
   c. 2.9m = _____ mm

7. Convert the various lengths using the correct calculation:
   a. 0.008m = _____mm
   b. 350µm = _____mm
   c. 0.72mm = _____µm

Mass

Mass is how much matter is in a particular object. We measure mass in **grams (g).** 1g is equal to 1000mg (milligrams), which is equal to 1,000,000 µm (micrograms) (see **Table 2**).

Table 2. Four of the most comment length units, their symbols, and their values.

Unit	**Symbol**	**Value**	
Kilogram	kg	1000g	(1kg= 1000g)
Gram	g	1g	
Milligram	mg	0.001g	(1g = 1000mg)
Microgram	µg	0.000001g	(1mg = 1000µg)

1. Discuss with your partner which units of measurement the following objects should be measured in:
   a. An elephant _____
   b. A bag of chips _____
   c. A bacterial cell _____
   a. 1/8 tsp of sugar _____
2. Discuss with your partner what other objects you would measure using the following metrics:
   a. kg _____
   b. g _____
   c. mg _____
   d. µg _____
3. Observe the different objects and estimate the mass of each:
   a. Unknown #1: _____
   b. Unknown #2: _____
   c. Unknown #3: _____

4. Measure the mass of each unknown using the electronic scale. Turn it on and tare the scale (this resets it to 0g). Always tare the scale before use (or before putting something into a container to be measured).
    a. Actual mass of unknown #1: _____
    b. Actual mass of unknown #2: _____
    c. Actual mass of unknown #3: _____
5. Convert the following masses by <u>dividing</u> the number by 1000:
    a. 2650µg = _____ mg
    b. 450mg = _____ g
    c. 86,300g = _____ kg
6. Convert the following masses by <u>multiplying</u> the number by 1000:
    a. 0.077mg= _____ µg
    b. 0.808 kg = _____ g
    c. 4.0 g = _____ mg
7. Convert the various masses using the correct calculation:
    a. 8900 mg = _____ g
    b. 880 µg = _____ mg
    c. 0.99 mg = _____ µg

Volume

Volume is the amount of space taken up by matter. We measure volume in **litres (L).** 1L is equal to 1000mL (millilitres), which is equal to 1,000,000 µL (microliters). If you are a baker or cook, there are four cups (250mL) in a litre (see **Table 3**).

Table 3. Three of the most comment volume units, their symbols, and their values.

Unit	**Symbol**	**Value**	
Litre	L	1L	
millilitre	mL	0.001L	(1L = 1000mL)
microlitres	µL	0.000001L	(1mL = 1000µL)

1. Discuss with your partner which units of measurement the following objects should be measured in:

   d. A swimming pool _____

   e. A tea cup _____

   f. Cytoplasm of a cell _____

2. Discuss with your partner what other objects you would measure using the following metrics:

   a. L _____

   b. mL _____

   c. µL _____

1. Observe the different tools you will use to measure volume in this lab:

Erlenmeyer flask	used to informally contain an approximate volume
Beaker	used to informally measure an approximate volume
Graduated cylinder	used to measure smaller volumes with more accuracy
Pipette	used to precisely measure smaller volumes- best accuracy

3. Observe the various volumes of water and then estimate how much water is in each of the unknown containers.

   a. Unknown #1: _____

   b. Unknown #2: _____

   c. Unknown #3 _____

4. Measure the volume of each unknown using the appropriate tool. Note that water in glass cylinders and pipettes seems to rise up the glass container. This curved ridge is called a **meniscus** and we should always measure at its lowest point.

   a. Actual volume of unknown #1: _____

   b. Actual volume of unknown #2: _____

   c. Actual volume of unknown #3: _____

5. Convert the following volumes by dividing the number by 1000:
    a. 1400mL = _____ L
    b. 80 mL = _____ L
    c. 20,500µL = _____ mL
6. Convert the following volumes by multiplying the number by 1000:
    a. 0.140mL = _____ µL
    b. 0.005L = _____ mL
    c. 1.2mL = _____ µL
7. Convert the various volumes using the correct calculation:
    a. 0.001L = _____ mL
    b. 400µL = _____ mL
    c. 0.1mL = _____ µL

Part 3: Creating an Experiment

Once scientists have made their observations and measurements, this may bring up curiosity-based or application-based questions. Next, comes some research. Is there an answer to your question in scientific articles? Is there an explanation for what you have observed?

Hypotheses

If you conduct some preliminary research and do not find a suitable answer, the next step is to design an experiment to test a tentative hypothesis.

A **hypothesis** is a theoretical explanation that can be tested for its validity. It will be tested by manipulating one variable and seeing if there is an effect on another variable.

For example, “adding fertilizer to my plants will make them grow larger” or “eating protein after my workouts will increase my physical strength”.

1. Consider the following observation: when gardening, you notice that if you put too many plants close together in the soil, you end up with shorter plants compared to when you spread the plants farther apart.
    a. What is a possible **testable hypothesis** for this observation?

b. How would you test this hypothesis?

Variables

In order to test your hypothesis, you need to set up an experiment. Experiments are not simply collecting survey information; they involve active manipulation of what are called **variables**.

Scientists will manipulate one variable (called the **independent variable**) in order to determine its effect on another variable (called the **dependent variable**).

For example, if you were testing the hypothesis that increasing fertilizer will increase the size of your plants, your experiment would involve you manipulating how much fertilizer you give (independent variable) and measuring the size of your plant (dependent variable).

1. Consider the hypothesis that placing plants farther apart in the soil results in taller plants.

   a. What is the **independent variable** in this experiment?
   (Think: what are we actively manipulating?)

   b. What is the **dependent variable**?
   (Think: what do we expect to change?)

2. Consider another hypothesis: the amount of caffeine I consume will affect my heart rate.

   a. What is the independent variable? _____

   b. What is the dependent variable? _____

In order to ensure that the only variable impacting our dependent variable is the independent variable, we have to control for all other possible variables that may have an effect. Any variable that needs to remain constant during an experiment is called a **controlled variable**.

3. Consider the hypothesis that placing plants farther apart in soil will result in taller plants. What are some **controlled variables** that would need to be kept constant to ensure it is only the distance of the plants that will affect their growth? (*Think: what else might affect a plant's size?)*

4. Consider the other experiment mentioned previously: the amount of caffeine I consume will affect my heart rate. What are some controlled variables to consider for this experiment? (*Think: what other variables could affect my heart rate?)*

Part 4: Demonstrating and Analysing Data

Once your experiment is complete, you will need to demonstrate your data to you to see if your hypothesis was supported. Typically, the more data collected, the better.

A **graph** is a visual display of data that allows you to summarize your numerical observations. A graph is created using perpendicular lines called **axes** that make a coordinated system.

The two axes are the **x-axis** (horizontal) and the **y-axis** (vertical). Each axis represents a particular variable (x-axis is usually the **independent variable**, while y-axis is usually the **dependent variable**) (see **Figure 1** below).

Bar Graphs

Bar graphs are used when data will be compared across experimental groups that do not show a linear trend. In this case, the x-axis is not numerical and instead is based on the experimental conditions (e.g. **Figure 1**).

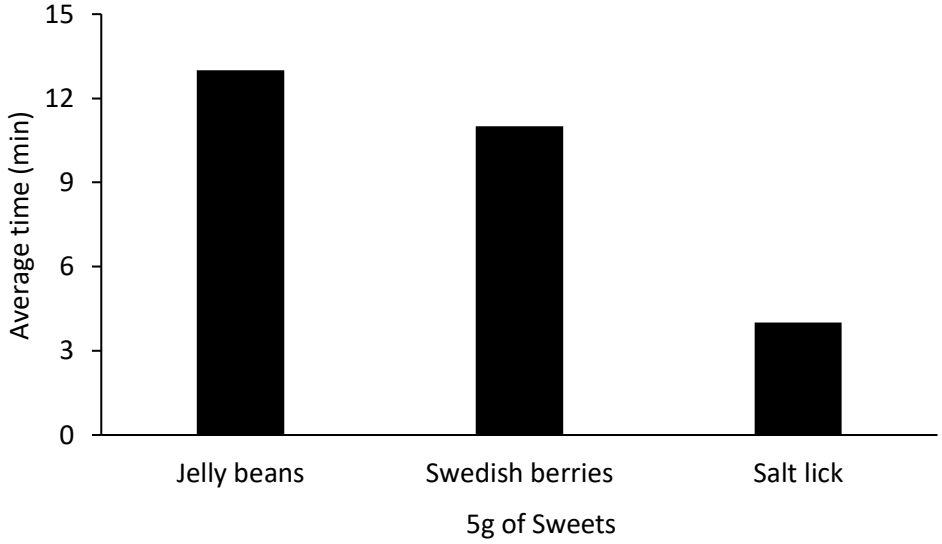


Figure 1. The average (n=20) amount of time (min) rats spent on a running wheel after eating 5g of various sweets.

Observe **Figure 1**. Notice that each axis is **labeled** and includes measurement **units**. Notice that the **title** sits **below** the graph and re-iterates the independent and dependent variables (as well as their units) and adds any **specific details** as needed.

1. Determine the **independent** and **dependent variables** for **Figure 1**.

   Independent variable: _____

   Dependent variable: _____

2. What are some conclusions that you can draw from **Figure 1**?

Line Graphs

Line graphs are used when there are **linear trends** that can be observed. For example, when variables are being measured over time. Often times the data points that are collected are connected with a line, presuming a linear relationship between them (see **Figure 2**).

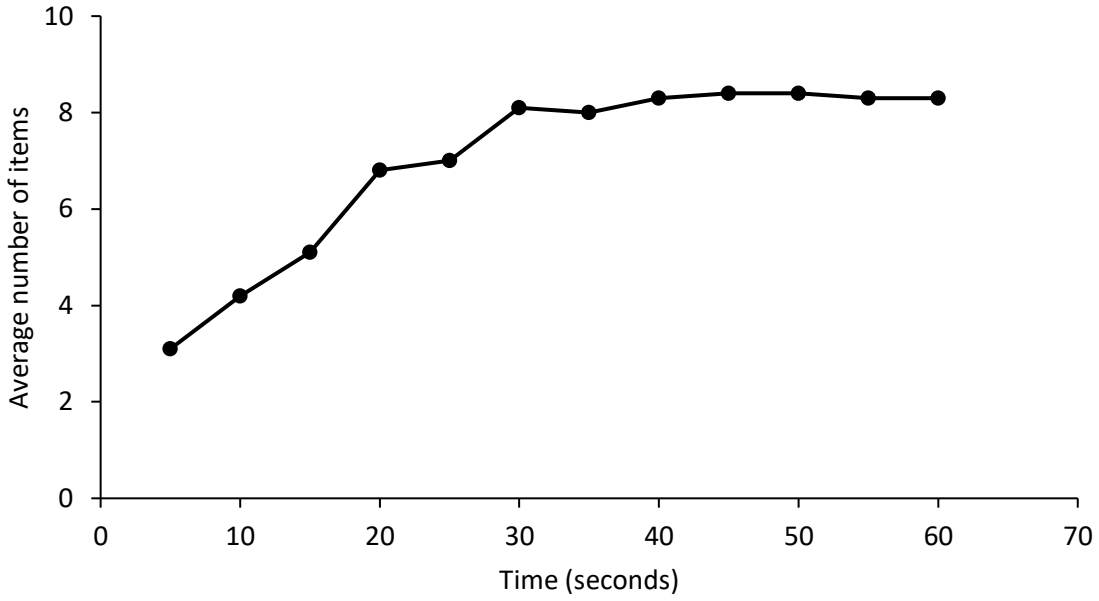


Figure 2. Average (n=20) number of items remembered by subjects after given a list of 10 items after being given a specific amount of time (seconds) to read and memorize the list.

Remember, the horizontal **x-axis** is the **independent variable** (amount of time given (s)) and the vertical **y-axis** is the **dependent variable** (how many items were remembered).

Again, notice that each axis is **labeled**, and includes the measurement **units**. The **title** sits **below** the graph and re-iterates the independent and dependent variables (as well as their units) and adds any specific details as needed.

3. What are some conclusions that you can draw from **Figure 2**, based on the visual trends observed?

Your instructor will spend some time to teach best practices on how to build a graph and how to create appropriate titles, either using Excel or graphing paper.

Part 4: Running an Experiment

If there is time and availability of materials, your instructor will introduce you to a 2-4 week-long experiment that you and your lab bench may complete to demonstrate your understanding of this lab's material.

Lab 1: Science & Data Full names: _____

BIOL 103 _____

Date: _____

Written Assignment (Due at the Beginning of Next Lab) 10 marks

1. Come up with a **scientific question** for an experiment that you can test over the next 2-4 weeks. **(1 mark)**

2. Come up with a **testable hypothesis** for your experiment. What do you expect the relationship is between the variable you will manipulate and the variable you will observe? **(1 mark)**

3. Briefly explain your simple experiment. What is your **independent variable**? Your **dependent variable**? What are at least two **controlled variables**? **(2 marks)**

4. Create a graph that will demonstrate what you predict you will observe based on your hypothesis (choose either a bar graph or a linear graph, depending on your data) and attach it to this document using staples. Ensure that your graph has the following qualities:

    a. Axes are labelled with appropriate titles and units **(1 mark)**
    b. Graph is neat and clean (no shadowing, shading, bar lines, etc.) **(1 mark)**
    c. Data is correctly shown (data points connected with line, NOT line of best fit) **(1 mark)**
    d. Figure title underneath that has clear descriptive title, that indicates what took place in the experiment and includes units and all required details **(2 marks)**

5. Write a statement below the graph indicating what you predict will occur. **(1 mark)**

Lab 2: Water and pH

Following this lab, students should be able to:

- Explain how the chemical properties of water (polar covalent bonds and hydrogen bonds) relate to the physical properties of water (high surface tension, cohesion, adhesion, high heat capacity, lower density when solid, and water as a solvent)
- Make predictions and explain results for experiments that relate to the physical and chemical properties of water
- Explain the concept of pH in terms of H^+ concentration and the pH scale

Required prior knowledge from lecture material:

- Properties of water (chemical and physical)
- pH

Introduction

To complement the theoretical understanding of the properties of water and pH from lecture, students will explore how water and acids/bases interact with changing environmental factors through a series of experiments and demonstrations. Experiments are to be done in pairs, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
    - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
    - Describe water's **chemical properties** by answering the following prompts:
        - What atoms make up a water molecule? _____
        - What bonds are found in a water molecule? _____
        - How do water molecules interact with each other? _____
        - Use a drawing to support your descriptions.

Part 1: Specific Heat Capacity

This experiment will be in the form of a demonstration. Two balloons will be held over an open flame for 15 seconds. One balloon will be filled with air and the other balloon will be filled with air and a small amount of water.

1. Before the demonstration, discuss the following questions with your partner and record your answers:

   a. What do you predict will happen when **the air-filled balloon** is placed over the open flame?

   b. What do you predict happen when **the balloon with a small amount of water in it** is placed over the open flame?

2. Following the demonstration, discuss and answer the following questions:

   a. What actually occurred? Were your predictions accurate?

   b. What is the main take away from this experiment?

   c. Why can water receive **large amounts of heat** but not increase in **temperature**? Consider the relationships between **hydrogen bonds** and **energy** in your answer.

   d. How is water's **resistance to temperature changes** useful for life on Earth? Name two examples of its importance.

Part 2: Water's Volume and Density

In this experiment, you will explore what happens to **volume, density,** and **mass** of water when it goes from **liquid** to **solid**.

1. Collect a plastic water bottle and fill it with cold water from the tap until it has approximately 2 inches of space left at the top and close the cap. Mark the water line with a permanent marker.

2. Measure the **mass** of the bottle of water in grams (g) and record it. _____

3. Fill up a water basin at your lab bench. With your partner, discuss what you predict will happen when the bottle of water is placed into the tub of water (will it sink, float, remain somewhere in the water column?). Write your prediction below.

4. Place the bottle of water into the tub of water. Record your observations below.

5. Place the bottle of water in a -87°C freezer for an hour (set a timer). Use this time to answer questions 6-8 and complete other experiments.

6. Predict what you expect to happen to the **volume** of the water after it freezes. Will water expand? Shrink? Stay the same?

7. Predict what will happen to the **density** of the water after it freezes. Consider how volume and density relate. Will the bottle float, sink, or something in between?

8. Predict what will happen to the **mass** of the water when it freezes. How does mass relate to density and volume? Will it change?

9. After the hour is up, observe what occurred to the **volume** of the water. Record your observations (**qualitative** and **quantitative** data) and explain WHY you saw what you did.

Qualitative data:

Quantitative data:

Explanation:

10. Place the bottle of frozen water into the tub of water. Observe what occurred to the **density** of water. Record your observations below and explain WHY you saw what you did.

Observations:

Explanation:

11. Take the bottle out and dry it off. Weigh the bottle of frozen water and record its **mass** below. Did it change dramatically compared to when the water was liquid? Explain WHY.

12. Did the results match your predictions? Explain.

13. What are the main take aways from this experiment?

14. List one way that the **change in volume** and **density** of water as it freezes supports life on Earth.

15. When finished, place the frozen water bottle in the bin provided and empty the water basin into the sink.

Part 3: Surface Tension

In this experiment, you will explore the **surface tension** of water and how it changes in the presence of an **amphipathic substance** (soap).

1. Before beginning, discuss with your partner why water has high **surface tension**. Write your thoughts below.

2. Soap molecules are **amphipathic**, meaning they have both **polar** and **non-polar** properties. When you add soap to water, what do you predict will happen to water's surface tension?

3. Fill two small bowls with approximately 250 mL of water. Collect a small handful of paperclips.

4. Add 5 drops of soap to the second bowl.

5. Before beginning, predict which liquid will support more paper clips on its surface (**Table 1**).

Table 1. Predicted and final number of paperclips on surface of water and soapy water.

	Water		**Soapy Water**	
	Prediction	**Result**	**Prediction**	**Result**
Number of paperclips on surface				

6. Gently place a paper clip onto the surface of the bowl containing just water (you may need to practice for the first few).

7. Continue to add paper clips to the surface until they sink. Record the maximum number of paper clips that sat without breaking the surface in the results column of **Table 1**.

8. Empty and rinse the bowl and dry the paper clips fully with paper towel.

9. Repeat steps 7-9 with the soapy water.

10. Following the experiment (and its clean up) answer the following questions:

    a. Did your results match your predictions? Explain.

    b. What is the main take away from this experiment?

    c. Would it hurt more or less to perform a belly flop in a lake or soapy water? Why?

Part 4: Cohesion and Adhesion

In this experiment, you will observe as water climbs a **polar** substance (paper towel) due to its **adhesive** and **cohesive** properties.

1. Before beginning this experiment, discuss the **adhesive properties** of water with your partner. Consider why water sticks to some objects but not others. Write down your notes below using terms like **polar** and **non-polar.**

2. Cut two pieces of paper towel that are 2cm x 10cm.

3. Draw a thick line 2cm from the end of one of the paper towel strips using a **water-soluble** marker (e.g. a highlighter). On the other, draw a line 2cm from the end with **permanent** marker.

4. Fill a 200mL beaker with approximately 25mL of water.

5. Before placing the paper towels into the beaker, answer the following questions:

   a. Paper towel is made up of **polymers of cellulose**, which have **polar** properties. What do you predict will happen when the water comes into contact with the paper towel?

   b. What do you predict to happen with the washable marker line compared to the permanent marker line? Why do you think that is?

6. Place the paper towel strips into the beaker so that the bottoms of the paper strips are in the water, but the marker lines are <u>above the water line</u>. Tape the strips to the top of the beaker. Observe what occurs over the next few minutes.

7. What you are observing is called **capillary action**. Explain how the **adhesive** and **cohesive** properties of water play into this phenomenon.

8. When water has reached the top of the paper towel strips, remove them from the beaker. Most likely, some drops of water will remain stuck to the side of the beaker. Why is that? What does that mean about the chemical properties of glass (is it **polar** or **non-polar**)?

9. Rinse out the beaker and discard the paper towels. Observe the other examples of capillary action at the instructor's bench. What are some examples of this phenomenon on Earth?

Part 5: pH

In this experiment, you will explore how a universal pH indicator reacts to household **acids** and **bases.**

1. Before beginning, discuss with your partner how the **pH of a solution** relates its the ratio of **H^+** and **OH^- ions**. Write your understanding below using words like **acids** and **bases**.

2. Collect and fill various test tubes with ~4mL red cabbage juice using the pipettes provided. Red cabbage juice acts as a natural pH indicator and changes colour depending on the acidity of a solution.

3. Label the test tubes 1-6.

4. Decide which six solutions you want to test the pH of and record them in **Table 2**.

5. Before adding the solutions and substances to the test tubes, predict the pH of each based on your understanding of these products (no Googling!) and record your predictions in **Table 2**.

Table 2. Predicted, observed, and actual pH levels of various household substances.

Test Tube #	Substance	Predicted pH (0-14)	Results (Colour)	Modified pH Predictions	Actual pH
1					
2					
3					
4					
5					
6					

6. Pipette ~3mL of each liquid substance into their respective test tubes (or add 1 tsp if substance is solid). Take a picture for your records and record the colour results in **Table 2**.

7. After making your observations, modify your pH predictions for any substances that may have changed based on the results of the pH test and record these in **Table 2**.

8. Once predictions are modified, consult the pH list at the instructor's bench to learn the actual pH of each substance and record these in **Table 2**. How accurate was the indicator? Explain.

9. Using coloured pencils, colour the pH scale below based on your red cabbage juice observations (what colours are low pH? Neutral? High?)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

10. Discuss with your partner what you think is happening to the red cabbage juice when in the presence of acids. What do you think is chemically occurring? Consider the concepts of **donation** and **acceptance** of **protons (H^+)** in your answer.

11. Empty the test tubes into the sink, wash/scrub and rinse them, then place them upside down on their racks to dry over some paper towel.

Once you have completed all the experiments, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 2: Water and pH Full name: _____

BIOL 103 _____

Date: _____

Written Assignment (Due at the Beginning of Next Lab) 10 marks

1. Draw three water molecules and label an **oxygen atom, hydrogen atom, covalent bond,** and **hydrogen bond** (**2 marks**).

2. Explain why adding **heat** to water molecules won't immediately increase their **temperature** (**2 marks**).

3. Explain why, if we **lowered the temperature** of water, it would **increase in volume, decrease in density,** and **maintain its mass** (**1 mark**).

4. Explain why small insects can stand on water, despite their **higher density**, using your understanding of **surface tension** (**1 marks**).

5. In paper chromatography, a **non-polar solvent** travels up a **polar paper surface** to separate chemicals based on their **polarity.** As the solvent moves up the paper, the chemicals that are more polar stick to the paper sooner, while those that are non-polar follow the alcohol front up the paper (see **Figure 3**).

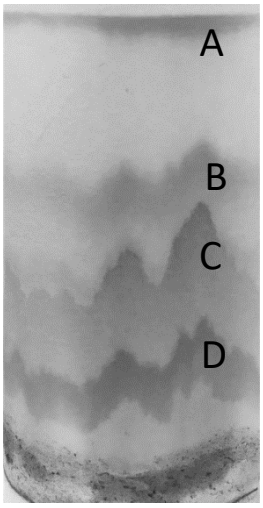


Figure 3. Various pigments (A-D) are separated from a spinach leaf rubbed along the base of chromatography paper (bottom of image) after the paper is placed into a small amount of non-polar solvent.

   a. State which chemicals are **least polar**, and which are **most polar** in **Figure 3** (A-D). **(1 mark)**

   b. Explain what is occurring using your understanding of **adhesion** and **cohesion**. (**2 marks**)

6. Explain what happens when an acid is added to a solution: what does it disassociate into? What do those particles then do to the molecules that make up our cells, if exposed? (**2 marks**)

Lab 3: Macromolecules

Following this lab, students should be able to:

- Outline the polymers and their subunits of the four major organic macromolecules
- Distinguish between negative and positive controls and explain their use in an experiment
- Name the colourimetric reagents used for identifying specific organic compounds
- Predict and interpret the results of a colourimetric test to determine the presence or absence of an organic compound

Required prior knowledge from lecture material:

- Organic macromolecules and their subunits
- Experimental design and variables

Introduction

To complement the theoretical understanding of organic macromolecules from lecture, students will explore how to test for organic polymers and their subunits using colourimetric reagents and use these tests to predict and interpret experimental results. Experiments are to be done in pairs, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
    - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
    - List the **four major organic macromolecules** covered in lecture and state their **monomers/sub-units**. Consider a drawing to support your understanding.

In this lab, students will conduct a series of tests to assess the presence or absence of organic macromolecules in unknown mythical milks (see **Table 1**).

Table 1. List of macromolecule contents (g) in four mythical beast milks in 250mL.

Mythical Beast Milks	Lipids (g)	Proteins (g)	Simple Sugars (g)	Total Sugars (g)
Griffin milk	0	8	10	10
Manticore milk	10	0	7	7
Yggdrasil milk	5	0	0	13
Mandrake milk	1	8	8	14

Colourimetric reagents will be used to test for the presence of organic compounds. These reagents react with specific organic compounds to produce dramatic colour changes. If the reagents do not change colour, this indicates the absence of that compound.

Controls

In order to ensure that our results are not due to other factors, we will be using negative and positive control groups in our experimental design:

Negative control groups are used in an experiment as a basis for comparison. Typically, there will be no change or response expected in that group, as no independent variable will be present. For example, if one test group receives a treatment and another does not, the group that does not receive the treatment is the negative control group.

Positive control groups are also used as a basis for comparison. Typically, there is an expected positive response, as they usually have a high amount of the independent variable, or another variable known to cause a change. For example, if one test group will receive a new treatment, and another group receives a treatment that produces the known response, the group that receives the treatment that produces the known response is the positive control group.

1. Answer the following questions to confirm your understanding of control groups:

   a. Experimenters want to test if exposure to a waste product from a new factory causes death in fish. Indicate which group is the **negative control (N), positive control (P),** and **experimental group (E).**

      i. One group of fish is not exposed to the waste product ____
      ii. One group of fish is exposed to the waste product ____
      iii. One group of fish is exposed to a different toxin (known to cause death in fish) ____

b. Experimenters want to test if a new drug reduces headache pain. Give an example of a negative control group, experimental group, and positive control group.

i. Negative control group: _____

ii. Experimental group: _____

iii. Positive control group: _____

Part 1: Testing for Lipids

A simple and easy test for the presence of **lipids** is the **grease spot test**. A sample is placed on paper towel and the observer waits until it fully dries. If lipids were present, the paper will remain stained (darker) and translucent (like an oil stain on clothing).

1. Before beginning, answer the following questions:

   a. What are some **examples of lipids** in the human body?

   b. Are lipids **polar** or **non-polar**? How do they react to water?

   c. Of the available options, what solution would act as a **good negative control**? This substance should be negative for the grease spot test as there should be no lipids present.

   d. What liquid would act as a **good positive control**? This substance should be positive for the grease spot test as there should be lipids present.

2. Once you have confirmed appropriate negative and positive controls, test each of the controls as well as the two unknown milk samples for the presence of lipids by dropping a few drops onto paper towel pieces and waiting for them to dry (begin another experiment while you wait).

   Hint: consider a way of recording which piece of paper towel is which.

3. Fill in your observations in **Table 2**. Consider a scale from most lipids present (+++) to least (-).

Table 2. Results of the grease spot test for various samples.

Sample	Grease Spot Result (+/-)	Lipids Results (Present/Absent)	Qualitative Observations
Negative control ( )			
Positive control ( )			
Unknown #1			
Unknown #2			

4. After collecting your results, answer the following questions.

   a. Were your **negative and positive control groups** well chosen? How could you tell?

   b. Which of your unknowns had lipids present? What possible milks could they be (refer to **Table 1**)?

5. When observations are complete, take a picture for your records and discard the paper towels in the provided receptacle.

Part 2: Testing for Proteins

A simple and easy test for the presence of **proteins** (specifically, **peptide bonds**) is the **Biuret reagent** test.

Typically, Biuret reagent is blue in colour. If it changes colour dramatically to pink, purple, or even brown or yellow, this is considered a positive result. If it remains a blue shade, it is considered a negative result.

NOTE: BIURET REAGANT CONTAINS A STRONG BASE AND COPPER SULFATE. IT IS CAUSTIC AND CAN BURN SKIN. HANDLE WITH CARE, REPORT ANY SPILLS, AND DISPOSE PROPERLY.

1. Answer the following questions before beginning:

    a. What are some **examples of proteins** in the human body?

    b. What is the difference between a solution of **amino acids** and one with **proteins**?

    c. Of the available options, what solution would act as a **good negative control**? This substance should be negative for the Biuret test as there should be no proteins present.

    d. What liquid would act as a **good positive control**? This substance should be positive for the Biuret test as there should be proteins present.

2. Once you have confirmed appropriate controls, test each of the controls as well as the unknown milk samples for the presence of proteins by pipetting 1mL of the sample into a test tube and adding 10 drops of Biuret.

    Hint: consider a way of recording which test tube contains which sample.

    a. After gentle mixing (lightly flick the bottom of the test tube several times), observe the results. Record your observations in **Table 3** on the next page. Consider a scale from most proteins (+++) to least (-).

Table 3. Results of the Biuret test for various samples.

Sample	Biuret Result (+/-)	Proteins Results (Present/Absent)	Qualitative Observations
Negative control ( )			
Positive control ( )			
Unknown #1			
Unknown #2			

3. When observations are complete, take a picture for your records and empty the tubes into the labelled waste bins (**DO NOT POUR THEM DOWN THE SINK**).

4. Wash/scrub and rinse the tubes and place them upside down in the racks to dry on some paper towel.

5. Answer the following questions:

   a. Were your **negative and positive control groups** well chosen? How could you tell?

   b. Which of your unknowns had proteins present? What possible milks could they be (refer to **Table 1** and remember any other results collected so far)

Part 3: Testing for Simple Carbohydrates

An easy test for the presence of **simple carbohydrates** is the **Benedict reagent** test.

Typically, Benedict's reagent is blue in colour. If it changes colour dramatically to green, yellow, orange or red, this is considered a positive result. If it remains a blue shade, it is considered a negative result.

NOTE: BENEDICT'S REAGANT CONTAINS A STRONG BASE AND A COPPER COMPOUND. IT IS CAUSTIC AND CAN BURN SKIN. HANDLE WITH CARE AND REPORT ANY SPILLS.

1. Answer the following questions:

   a. What are some **examples of simple sugars** in the human body?

   b. Of the available options, what solution would act as a **good negative control**? This substance should be negative for Benedict's test as there should be no simple sugars present.

   c. What liquid would act as a **good positive control**? This substance should be positive for Benedict's test as there should be simple sugars present.

2. Once you have confirmed appropriate controls, test each of the controls as well as the two unknown milk samples for the presence of simple sugars by pipetting 1mL of the sample into a test tube and adding 10 drops of Benedict's reagent.

   Hint: consider a way of recording which test tube contains which sample.

3. Gently mix the test tubes (lightly flick the bottom of the tube), then heat all the test tubes in a hot water bath (~87°C) for 5 minutes (this activates the reagent).

4. After 5 minutes, use tongs to remove the tubes from the water bath.

5. Gently mix the tubes again and observe the results. Record your observations in **Table 4**. Consider a scale from most simple sugars (+++) to least (-).

Table 4. Results of the Benedict's test for various samples.

Sample	Benedict's Result (+/-)	Simple Sugars Results (Present/Absent)	Qualitative Observations
Negative control ( )			
Positive control: ( )			
Unknown #1			
Unknown #2			

6. When observations are complete, take a picture for your records and empty the tubes into the labelled waste bins (**DO NOT POUR THEM DOWN THE SINK**).

7. Wash/scrub and rinse the tubes and place them upside down in the racks to dry on paper towel.

   a. Were your **negative and positive control groups** well chosen? How could you tell?

   b. Which of your unknowns had simple sugars present? What possible milks could they be (refer to **Table 1** and remember any other results collected so far)?

Part 4: Testing for Complex Carbohydrates

A simple and easy test for the presence of **starch**, a complex carbohydrate, is the **iodine solution** test.

Typically, iodine (I_2KI) is yellow/orange in colour. If it changes colour to dark blue/brown/black, this is a positive result. If it remains a yellowish orange, it is a negative result.

NOTE: IODINE WILL STAIN SKIN CLOTHING. HANDLE WITH CARE.

1. Answer the following questions:

   a. What are some examples of **other complex carbohydrates** (in animals and plants)?

   b. Of the available options, what solution would act as a **good negative control**? This substance should be negative for the iodine test as there should be no starch present.

   c. What liquid would act as a **good positive control**? This substance should be positive for the iodine test as there should be starch present.

2. Once you have confirmed appropriate controls, test each of the controls as well as the unknown samples for the presence of complex sugars by pipetting 1mL of the sample into a test tube and then adding 4 drops of iodine.

   Hint: consider a way of recording which test tube contains which sample.

3. After gentle mixing, record your observations in **Table 5** on the next page. Consider a scale from most starches (+++) to least (-).

Table 5. Results of the iodine test for various samples.

Sample	Iodine's Result (+/-)	Complex Sugars Results (Present/Absent)	Qualitative Observations
Negative control ( )			
Positive control: ( )			
Unknown #1			
Unknown #2			

4. When observations are complete, take a picture for your records and empty the tubes into the labelled waste bins (**DO NOT POUR THEM DOWN THE SINK**).

5. Wash and rinse the tubes and place them upside down in the racks to dry on paper towel.

6. Answer the following questions regarding carbohydrates:

   a. Were your **negative and positive control groups** well chosen? How could you tell?

   b. Which of your unknowns had starch present? What possible milks could they be ((refer to **Table 1** and remember any other results collected so far)?)
   Note: calculate complex sugar content by subtracting simple sugars from total sugars.

Optional: If there is time, test a known milk (see those available) for each test, predicting results based on their ingredients list.

Once you have completed all the experiments, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 3: Macromolecules

Full name: _____

BIOL 103 _____

Date: _____

Written Assignment (Due at the Beginning of Next Lab) 10 marks

1. Briefly state the purpose of the use of **negative and positive controls** in today's lab (**1 mark**)

2. Complete the table below that summarizes the results for your two unknown milks for the four organic molecules tested. (**1 mark**)

Table 6. Presence or absence of various macromolecules in two unknown milks based on the results of various colourimetric tests.

Unknown Milk	Lipids (+/-)	Proteins (+/-)	Simple sugars (+/-)	Complex sugars (+/-)
#1				
#2				

3. Observe the list of various mythical beast milks in **Table 1** (shown below again) and answer the questions on the next page.

Table 1. List of macromolecule contents (g) in four mythical beast milks in 250mL.

Mythical Beast Milks	Lipids (g)	Proteins (g)	Simple Sugars (g)	Total Sugars (g)
Griffin milk	0	8	10	10
Manticore milk	10	0	7	7
Yggdrasil milk	5	0	0	13
Mandrake milk	1	8	8	14

a. Which milk do you believe unknown #1 is, based on its lipid, protein, simple carbohydrate, and complex carbohydrate content? Explain your reasoning (**2 marks**)

b. Which milk do you believe unknown #2 is, based on its lipid, protein, simple carbohydrates, and complex carbohydrates content? Explain your reasoning. (**2 marks**)

c. What do you predict the experimental results would be for Griffin milk for each of the macromolecule tests, based on its contents? (What colour do you predict the reagents would turn and will the results be positive or negative?) (**4 marks**)

Lab 4: Microscopes and Cells

Following this lab, students should be able to:

- Name and identify the parts of a microscope and their functions
- Recognize and display best practices on how to use and store a microscope
- Calculate total magnification, field size, and estimate the size of a cell or structure
- Identify parts of plant and animal cells from both models and microscopic slides and state general functions of each organelle
- Recognize the differences between single and multicellular life, as well as prokaryotic and eukaryotic cells, and plant and animal cells
- Identify the important cells and structures shown in this lab

Required prior knowledge from lecture material:

- Cell biology (organelles, eukaryotes and prokaryotes, plant cells and animal cells)

Introduction

To complement the theoretical understanding of cell biology from lecture, students will explore how to use a microscope to observe cellular life. Observations are to be done in pairs, and each student is to write their own notes in the lab manual for studying purposes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
  - Watch the videos posted on D2L
  - Draw an **animal cell** below and label the following organs: **plasma membrane, nucleus, nucleolus, rough ER, smooth ER, Golgi apparatus, ribosomes, mitochondrion, vesicle,** and **cytoplasm.** Your drawing will be checked by your instructor (not for its beauty, but for its accuracy and completion).

Part 1: Identifying Microscope Components

Microscopes are used to observe structures that are too small to see with the human eye. In our labs, we will primarily use the **compound microscope** (also called objective microscope) to magnify cells and structures anywhere from 40 to 1000 times their actual size.

The following steps may be completed as a class or in partners; your instructor will clarify.

1. Collect a microscope from where they are stored.

   *Note: always hold a microscope with **one hand on the arm** and another **hand on the base***

2. Unwrap the power cord and plug in the microscope.
3. Using **Figure 1** below, identify each of the components of the microscope and attempt to determine their functions by adjusting and moving the parts.

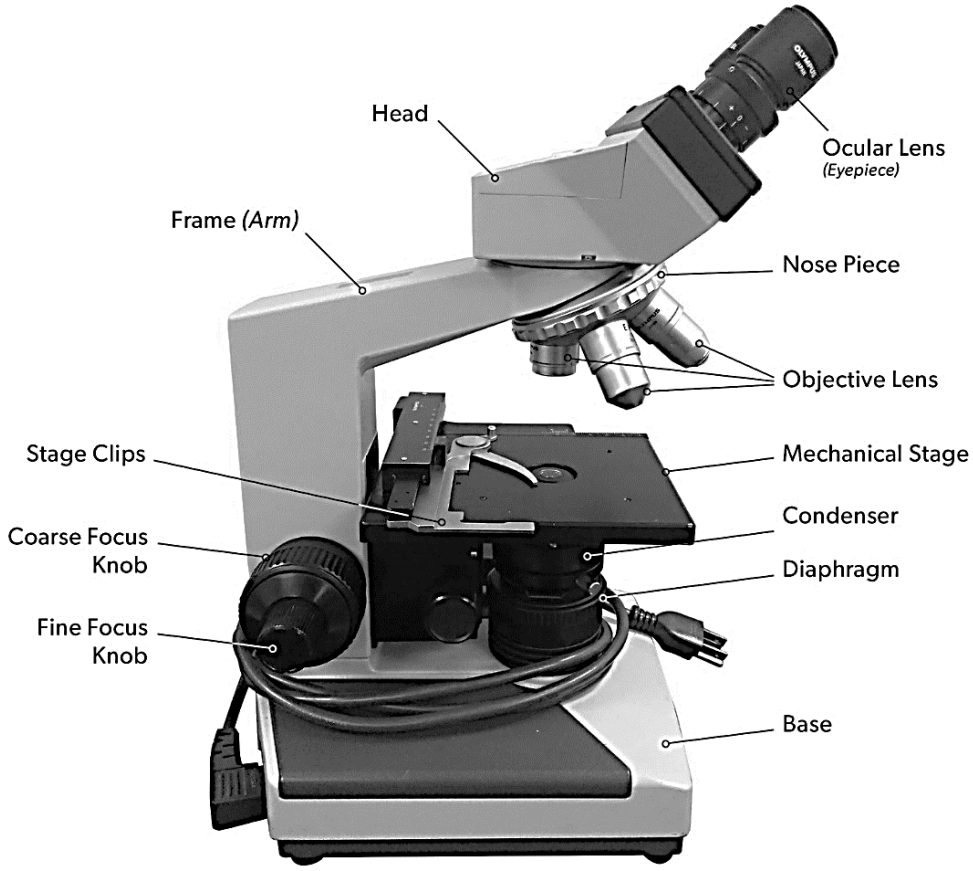


Figure 1. Compound microscope with its various components labelled. Not visible: **stage control knobs** (found on the right side of the stage), **light intensity dial** (on the right side of the base) and **power switch** (found on the back of the base).

4. Once you and your lab partner feel confident with the various components, test each other on three parts each (the name and function). Confirm any unknown or challenging concepts with the instructor before continuing.

Part 2: Observing A Microscopic Slide with the Compound Microscope

1. Collect a glass microscope slide from those available and bring it back to your bench.

   Note: always hold microscope slides at the edges to reduce smudging from fingers.

2. Ensure the following on the microscope is in place before adding the slide:
   a. **Stage** is as low as it can be (use **coarse focus knob** to do this)
   b. **Lowest objective lens** (red colour, X4) is pointing down (use **nosepiece** to do this)
   c. **Light** is on (use switch at back of base)
3. Pull back the stage clip and place the slide at the back of the stage and clip it into place.

   ****Show instructor that this step was done properly before continuing****
4. Using the **stage control knobs**, move the slide left/right and front/back so that the contents of the slide are directly under the objective lens.

   Note: you should be able to see the stained cells/structures directly above the light source without looking through the lenses if this is done correctly.

5. Looking through the **ocular lenses**, move the stage up towards the objective lens by adjusting the **coarse focus knob** until you see the cells come into view (may be blurry).

6. When cells/structures are visible, use the **fine focus knob** to make the structures crisp. You are now looking at the structures X40 magnified (X10 from ocular lens and X4 from low objective lens).

7. Adjust the **ocular lens** magnifications by twisting one until both lenses are in focus.

8. Adjust the lighting by modifying the intensity of the light (**light intensity dial** on the base), the focus of the light (**condenser unit**), and the amount of light (**diaphragm**).

9. Depending on the size and thickness of the cells/structures you are observing, you may move the slide around to view its contents (using **stage control knobs**) and use the **fine focus knob** to view different depths.

10. To increase magnification, rotate the **nosepiece** to place the **medium objective lens** (yellow, X10) in the lowest position.

11. The image will be slightly blurry now, but still visible. Use only the **fine focus knob** to bring the image into crisp focus (**never the coarse focus knob at this magnification**- it could break the lens or slide). You are now looking at the image X100 magnified.

12. Adjust the lighting again as needed.

13. You may continue to use the **fine focus knob** and **stage adjustment knobs** to examine various regions of the slide (remember- **do NOT adjust coarse focus**).

14. To further increase the magnification, rotate the **nosepiece** to place the **high objective lens** (blue, X40) in the lowest position.

15. You will again need to adjust the **fine focus knob** to bring the image into crisp view. You are now viewing the cells and structures at X400 their actual size.

16. Adjust the lighting as needed.

17. You may continue to use the **fine focus knob** and **stage adjustment knobs** to examine various regions of the slide.

18. When finished, rotate the **nosepiece** back to **medium objective**, then to the **lowest objective**.

19. Once the lowest objective lens is in place, use the **coarse focus knob** to lower the stage.

20. With the lowest objective lens is down and the stage lowered, remove the slide and return it to its correct tray.

    Note: this is ALWAYS how the slide must be removed- with the lowest objective facing down and the stage fully lowered.

21. Repeat these procedures to ensure both students feel comfortable with each step before moving on. Your ability to use a microscope will be crucial for lab procedures and lab exams, so take your time. Make any notes for your studying purposes below:

Part 3: Size Calculations

To determine the **actual size** of the structures seen with a microscope, we need to know the **field size** of the area being observed.

Field size is the diameter of the circle that you see when you look through the ocular lenses (see **Figure 2**).

On the microscopes that we use in this lab, the field size at the lowest objective is 4.5mm (your instructor may get you to test this using a ruler).

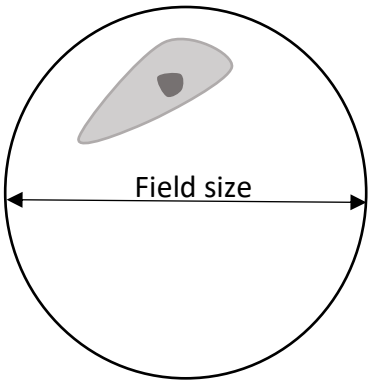


Figure 2. Example of what is seen through the ocular lens of a compound microscope.

To calculate **field size** at any other magnification, use the following formula:

Magnification A (known) x field size A (known) = field size B (unknown)
Magnification B (unknown)

For example, if you wanted to calculate the field size at total magnification 1000X and you know the field size at total magnification 40X is 45mm:

40X (Mag A) x 4.5mm (field size A) = 0.18mm (field size B)
1000X (Mag B)

Once you know the field size, you may estimate the **actual size** of a structure or cell use the following formula:

Field size = actual size of structure
 # times the structure fits across the field

See **Figure 3** as an example.

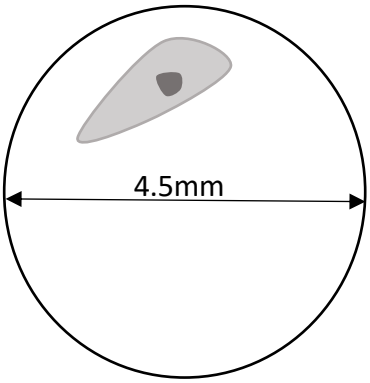


Figure 3. Unknown microscopic structure fits across the field size of 45mm roughly 2.5x lengthwise, thus its actual length is 4.5mm/2.5 = 1.8mm.

With your partner, complete the following:

1. On your own microscope, determine the **ocular lens magnification** and **objective lens magnifications** for **low, medium,** and **high objectives**. Fill this information into **Table 1** on the next page.

2. Calculate **total magnification** for **low, medium,** and **high objective lenses** (ocular lens multiplied by objective lens). Fill this information into **Table 1.**

3. Calculate the **field size** in mm for medium and high objective lenses using the first formula on this page. Fill this information into **Table 1.**

4. As these structures are so small, we use micrometers (**µm**) to measure them. Convert the field sizes from mm to µm (recall that 1mm equals 1000µm). Complete **Table 1.**

Table 1. Field sizes at various magnifications in a typical compound microscope.

Objective Lens	Ocular Lens Magnification	Objective Lens Magnification	Total Magnification	Field size (mm)	Field size (µm)
Low	X	X	X	4.5	4500
Medium	X	X	X		
High	X	X	X		

5. Check your calculations with the instructor before continuing.

Now that you know the **field sizes** for each magnification, you can easily calculate the **actual sizes** of structures being viewed. (field size divided by the number of times the structure fits across).

Part 4. Observing Single-Celled Eukaryotic Life

In this section, you will be observing a **single-celled eukaryotic organism** called *Paramecium caudatum*.

1. Before beginning, fill in **Table 2** below with your understanding of the similarities and differences between **eukaryotic** and **prokaryotic** cells:

Table 2. Similarities and differences in sizes and organelles present in eukaryotic and prokaryotic life.

Eukaryotes	Both	Prokaryotes

While we may have live organisms to observe, you will begin with a **preserved specimen** of *Paramecium caudatum* which has been stained for easy viewing. These larger microscopic organisms will be distinguishable due to their **double nuclei** and thin lining of **cilia** along their **plasma membrane**. They are approximately 300µm in length.

2. Collect a microscope slide containing *Paramecia* (remember, hold the glass at the edges) and bring it back to your lab bench.

3. Before placing the slide on the stage, hold it up to the light to see stained specks on the glass; these are the organisms you will be observing.

4. Following the steps covered in **Part 2**, find a *Paramecium* and bring it into focus at the lowest, medium, and high objective lenses, adjusting the light as you go. Take a picture for your records by placing your phone's camera up to the ocular lens.

5. Determine the **actual length** of a *Paramecium* in µm by using the calculations outlined in **Part 3**.

   Total magnification: X _____ Field size: _____ µm

   Approximate number of times *Paramecium* fits across field: _____

   Estimated actual size of *Paramecium*: _____ µm

6. Draw a *Paramecium* below and label its **nuclei, plasma membrane,** and **cilia.**

7. List at least two features about this organism that clearly identify a *Paramecium* as a **eukaryotic cell**.

8. When observations are complete, lower the objective lenses and the stage and remove and return the slide.

9. If there is time and availability, observe the live specimens of *Paramecia* available. Look for their **ciliated movement, water vacuole,** and **oral groove.**

Part 5. Observing Multicellular Plant Life

In this section, you will view **multicellular plant cells** approximately 50µm in length that are living, rather than preserved.

Biologists use **wet mounts** to study fresh material. A wet mount is made by placing a thin specimen onto a clean slide, adding droplets of water/dye (optional), and placing a small plastic **cover slip** over top. Excess fluids are blotted off the edges using tissue.

1. Use tweezers to collect a thin leaf from an *Elodea* plant and place it on a slide.

2. Add a small drop of water to the center of the slide.

3. Gently lower a cover slip onto the slide (one edge down first, then the other) to avoid catching air bubbles. Excess water can be blotted from the edges using a tissue.

4. Place the slide onto the stage and find the cells at the lowest objective lens, then medium, and finally high, adjusting lighting as you go.

5. At the high objective lens (X40), you should be able to see a green brick-like wall full of plant cells. Draw one of these cells below, and label its **cell wall** and **chloroplasts**.

6. Determine the **actual length** of a typical *Elodea* leaf cell using calculations from **Part 3**.

   Total magnification: X _____ Field size: _____ µm

   Approximate number of times *Elodea leaf* cell fits across field: _____

   Estimated actual size of *Elodea* leaf cell: _____ µm

7. Consider why the chloroplasts are all around the edges- what invisible structure is taking up all of that space?
   Hint: it's not the nucleus!

8. If there is availability and time, your instructor may add an unknown liquid to your slide and ask you to observe changes in the cells' shape and response. Note any observations below.

9. Take a picture for studying purposes. When finished, lower the objective lens and the stage then discard the slide in the appropriate receptacle.

Part 6. Observing Multicellular Animal Life

In this section, you will observe **multicellular animal cells** by making a wet mount of your own cheek cells (approximate size of these cells is 60µm).

1. Using the flat end of a sterile toothpick, gently scrape the inside of your cheek to exfoliate the epithelial lining and collect dead cells.

2. Smear the scraping onto a slide using the toothpick.

3. Add a small drop of methylene blue dye to the slide (this will stain the DNA and make the nucleus obvious).

   NOTE: While not dangerous, methylene blue dye will stain skin/clothing! Take care in its use.

4. Gently lower a cover slip onto the liquid (remember, one edge first to reduce air bubbles).

5. Place the slide onto the stage and find some cells at the lowest objective lens, then medium, and finally high, adjusting lighting as you go. The cells will look like fried eggs, with large blue dots inside of them (their nuclei).

   Note: if you can't find any, repeat another wet mount and try again.

6. At the high objective lens (X40), you should be able to see the **squamous epithelial cells** (thin and flat cells on the lining of many of our organs). Draw **one** of these cells below, and label its **plasma membrane** and the **nucleus**.

7. Determine the **actual size** a typical cheek cell. Show your calculations below.

8. What are **two obvious visual differences** between these epithelial cells and the *Elodea* plant cells that make them clearly **animal cells**?

9. See if you can find a cell that has small blue dots/bean-shaped structures. What do you think they are? Why?

10. Take a picture for study purposes. Lower the objective lens and stage and discard the slide in the appropriate receptacle.

11. Depending on time and availability, observe other microscopic slides and live specimens and practice finding the structures, determining if they are prokaryotic or eukaryotic, single celled or multicellular, and plant or animal. Draw some of the structures and practice your size calculations below.

12. When finished with the microscope slides, prepare your microscope for storage (S.L.O.W.C.O.):
    a. **S**tage clips flush to the slide of the stage
    b. **L**ower stage fully
    c. **O**bjective lens down (X4)
    d. **W**ipe lenses
    e. **C**ord should be loosely wrapped around the base
    f. **O**cular lenses will face the back of the cabinet

13. Before returning the scope, have your instructor confirm it has been successfully prepared for storage.

Part 7: Animal and Plant Cell Models

1. Examine the animal and plant cell models and identify the organelles listed in **Table 3** (remember, some organelles are only found in ONE type of cell, not the other).

Table 3. List of various organelles found in animal and plant cells.

Organelle	Observed in Animal Cell (√)	Observed in Plant Cell (√)
Cell wall		
Plasma membrane		
Cytoplasm		
Ribosomes		
Rough endoplasmic reticulum		
Smooth endoplasmic reticulum		
Golgi apparatus		
Vesicles		
Central water vacuole		
Nucleus		
Nuclear membrane (and pores)		
Nucleolus		
Mitochondrion		
Chloroplast		

2. After looking at the models, list **two cytoskeletal structures** that might be found on the outside of a cell to aid in **movement**, and distinguish between them:

3. List **one internal organelle** that an **animal** cell has that a plant cell does not:

Once you have completed all the observations, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

<u>Written Assignment (due at the beginning of next lab)</u>

- See D2L for a virtual tutorial/quiz (to be completed individually)

Lab 5: Osmosis

Following this lab, students should be able to:

- Recognize the difference between qualitative and quantitative data
- Apply the terms osmosis, hypertonic, hypotonic & isotonic to experimental results
- Determine the independent, dependent, and controlled variables within an experiment
- Create a high quality graph based on data and interpret the graph to come to a conclusion
- Explain the biology and chemistry behind hydrating and dehydrating cells and organisms

Required prior knowledge from lecture and lab material:

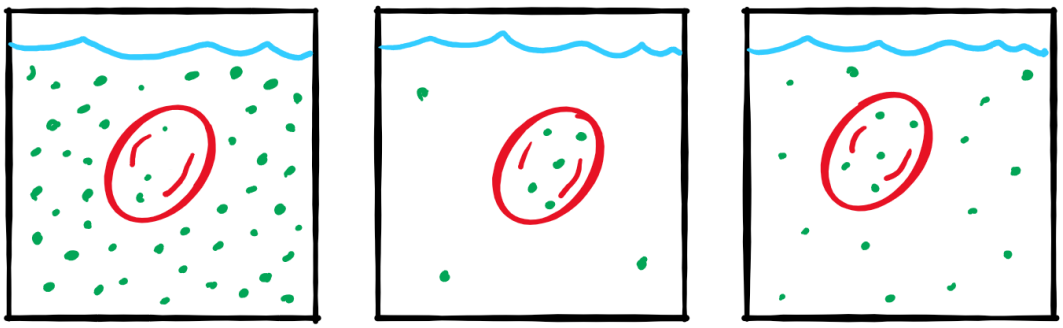
- Cell membranes and passive transport
- Osmosis and tonicity
- Microscope use and calculations

Introduction

To complement the theoretical understanding of cell transport, students will experiment with osmosis in potatoes and *Elodea* leaves. Experiments and observations are to be done in pairs and each student is to write their own notes for studying purposes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
  - Observe the drawings below of red blood cells placed in three different solutions. The specks represent **solutes** in the water.
    - Indicate which solutions are **isotonic, hypertonic**, and **hypotonic** to the cells
    - **Draw the direction** water will move in each situation using arrows (remember, water moves from **high water concentration** to **low water concentration**)



_____ _____ _____

Part 1: Osmosis in Potatoes

In this experiment, you will be placing 6 cored pieces of potato into different concentrations of NaCl solutions (salt water) and examining their difference in texture and mass over time.

1. Before beginning, discuss with your lab partner what you predict will occur to cores of potato in terms of **mass** (will it go up? Go down?) and **texture** (will it become soft or rigid?) after being placed in 0% and 20% NaCl water solutions for 45 minutes.

Table 1. Mass and texture predictions for cored potato pieces placed in 0% and 20% NaCl water solutions.

Solution	Mass change prediction (+/-)	Texture change prediction
0% NaCl water solution		
20% NaCl water solution		

2. Using the core borer, prepare 6 cylindrical pieces of potato.

3. Cut each potato cylinder to 4 cm in length and blot them dry with a paper towel.

4. Measure the mass of each potato core using the electric scale (don't forget to tare it!) and record their mass (g) as the "**initial mass before incubation**" in **Table 2** on the next page.

5. Record general initial texture observations below:

6. Label 6 test tubes as indicated in **Table 2**.

7. Add the potato cores to the test tubes.

8. Fill each test tube with the appropriate solution (enough to cover the potato cores).

Table 2. Effect of NaCl concentration solutions on mass of potato cores after 45 minutes

Test Tube #	NaCl concentration (%)	Potato cores				
		Initial mass before incubation (g)	Final mass after incubation (g)	Mass change (g)	Mass change (%)	Texture change
1	0					
2	0.5					
3	1					
4	5					
5	10					
6	20					

9. Incubate the test tubes at room temperature for 45 minutes. Use this time to complete **Part 2** and answer the following questions:

    a. What is the **independent variable** in this experiment (the variable we are modifying)?

    b. What is the **dependent variable** in this experiment (the variable we expect to change)?

    c. What are some **controlled variables** in this experiment (variables we want to stay constant or the same across all groups)?

9. After 45 minutes, pour off and dispose the solutions into the sink.

10. Gently dry the potato cores using a paper towel.

11. Weigh each core and record their mass under "**final mass after incubation**" in **Table 2**.

12. Include any major texture changes compared to the original textures recorded and include these in **Table 2.**

13. Once all potatoes have been measured, they may be discarded in the compost and the test tubes can be emptied, washed/scrubbed, rinsed, and placed upside down to dry.

14. Calculate the **change in mass** (g) of each core by subtracting the **initial mass** (g) from the **final mass** (g) (Note: the change in mass may be a negative number!). Record the mass change (g) under the **"mass change (g)"** column in **Table 2**.

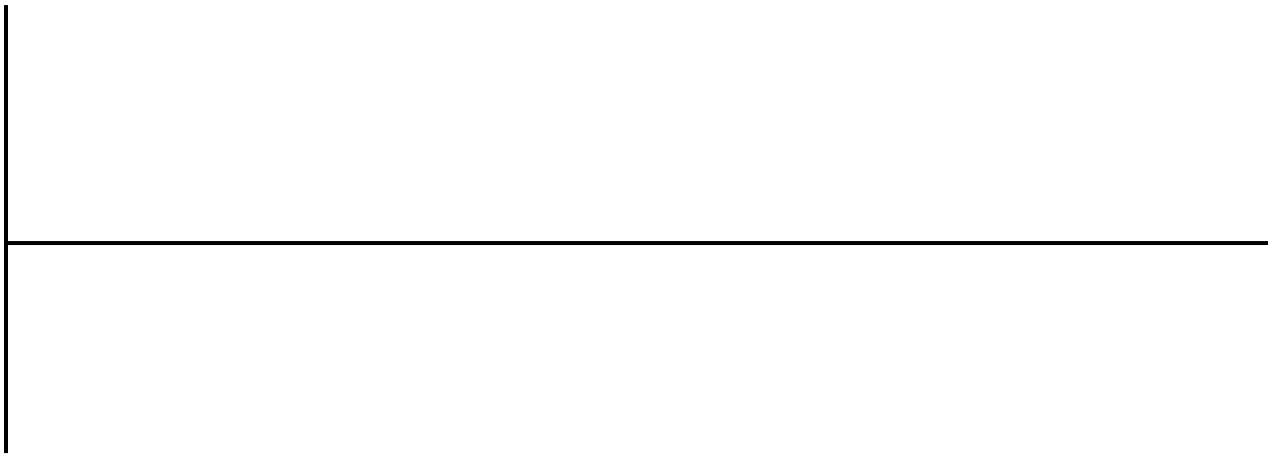
15. To control for initial differences in mass between the potato cores, calculate **change in mass as a percentage** (%). To do this, divide the **change in mass** (g) by the **initial mass** (g). Multiply the new value by 100% (remember to keep negative numbers negative!). Record the **mass change (%)** in **Table 2**.

16. Your instructor will collect the class data for the average % mass change for the six different potato cores. Copy this information into **Table 3** below.

Table 3. Average % mass change (n= _____) for potato cores placed in various NaCl solutions after 45 minutes.

NaCl concentration (%)	Average mass change (%)
0	
0.5	
1	
5	
10	
20	

17. Using the space below, sketch a preliminary graph that demonstrates average % mass change (y-axis) as a function of NaCl concentration (x-axis).



18. Answer the following questions with your lab partner:

    a. Which NaCl concentrations (%) were **hypotonic** to the potato cells?

    b. How did your data demonstrate this? Explain what water was doing in these circumstances.

    c. Why did the potato cores in the 0 % NaCl solutions gain more mass than those in the 0.5% or 1% solutions?

    d. Which NaCl concentrations (%) were **hypertonic** to the potato cells?

    e. How did your data demonstrate this? Explain what water was doing in these circumstances.

f. Which NaCl concentration (%) was closest to being **isotonic** to the potato cells?

g. Explain what water was doing in this circumstance.

19. Wipe down and dry off the lab bench.

Part 2: Osmosis in *Elodea* Leaves

In this experiment, you will be observing *Elodea* leaves in **hypotonic** and **hypertonic** solutions at a microscopic level to see how the cells themselves respond to these conditions.

1. Before beginning, predict what you expect plant cells will look like in two different solutions and record your predictions in **Table 3**.

Table 3. Predicted cell shape and structure in *Elodea* cells in distilled water and 20% NaCl.

	***Elodea* leave cells**	
	Distilled water	**20% NaCl**
Predicted changes to cell shape and organization		

2. Use tweezers to collect a thin leaf from an *Elodea* plant and place it on a slide.

3. Add a small drop of distilled water (dH_2O) to the center of the slide.

4. Gently lower a cover slip onto the drop of water (one edge down first, then the other) to avoid catching air bubbles. Excess water can be blotted from the edges using a tissue. Let it incubate for 5 minutes.

5. Prepare a second wet mount of another *Elodea* leaf with one drop of 20% NaCl. Let it incubate for 5 minutes. Be sure to keep track of which slide is which.

6. Set up a microscope following instructions outlined in **Lab 4**.

7. When the leaves have finished incubating, place the slide containing the distilled water onto the stage. View it first at low, then medium, then finally high magnification, adjusting the light as you go.

8. Take a picture of the cells and see if you can observe **cytoplasmic streaming** (the chloroplasts moving in a cycle within the cell). Do the cells' shape and organelle organization match your predictions? Explain.

9. Draw a single *Elodea* leaf cell in distilled water below, with focus on the **cell wall, water vacuole,** and **chloroplasts** (label each). Estimate the **actual width** of a typical cell in distilled water using calculations from **Lab 4**.

10. Return to the lowest magnification, lower the stage, then remove the slide.

11. Place the second slide containing the NaCl solution onto the stage and view it first at low, then medium, then high magnification, adjusting light as you go.

12. Take a picture of the cells in saltwater. Do the cells' shape and organelle organization match your predictions? Explain.

13. Draw an *Elodea* leaf cell in the saltwater below, with focus on the **cell wall, water vacuole**, and **chloroplasts** (label each). Estimate the **actual width** of a typical cell in saltwater using calculations from **Lab 4**.

14. Once finished, discard both wet mounts in their appropriate containers and return the microscope to its storage set-up. Have the instructor confirm the microscope is in the proper position before returning it.

15. Answer the following questions regarding this experiment:

    a. Was the data you collected in this experiment **qualitative** or **quantitative**, or both? Explain.

    b. Why did you observe what you did in the distilled water wet mount? Use **osmosis, hypotonic,** and **concentration gradient** in your answer.

    c. Why did you observe what you did in the NaCl solution wet mount? Use **osmosis, hypertonic,** and **concentration gradient** in your answer.

Once you have completed all the experiments, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 5: Osmosis

Written Assignment (See instructor for due date) 10 marks

This assignment may be typed or handwritten, and must to have your full name, the full course code and section, and the date at the top right. Please title the lab assignment "Lab 5: Osmosis".

Students may complete this individually or in pairs, as outlined by your instructor.

1. Create a high quality graph that demonstrates average % mass change (y-axis) as a function of NaCl % concentration (x-axis) from **Part 1**. Follow previously outlined graphing rules, and ensure that your graph has the following qualities:

    a. Axes are labelled with appropriate titles and units **(1 mark)**

    b. Graph is neat and clean (no shadowing, shading, bar lines, etc.) **(1 mark)**

    c. Data is correctly shown (data points connected with line, NOT line of best fit) **(1 mark)**

    d. Figure title underneath that has clear descriptive title, that indicates what took place in the experiment and includes units and all required details **(2 marks)**

2. Write a statement below the graph indicating what the graph data is showing (what is the trend being observed in this graph)? **(1 mark)**

3. Write a statement indicating what this trend means in terms of **solute concentration gradient** and **osmosis** (how does concentration gradient affect the movement of water across a plasma membrane?) **(1 mark)**

4. Suggest another factor that you could modify that may change the rate of osmosis, and explain your choice based on your understanding of experimental factors that can affect diffusion rate. **(1 mark)**

5. Consider the following: if ever stranded on an island, would it be safe to drink ocean water to hydrate the body? Based on **Part 1** and **Part 2** of this lab, use terms like **hypertonic** and **hypotonic** (as well as **diffusion**, and **high** and **low concentration**) to explain your answer. **(1 mark)**

Lab Exam #1

Instructors typically mark the half way point in the course with a lab exam, scheduled during regular lab time.

These lab exams will assess your understanding of the concepts, methods, and calculations from Labs 1-5 and will typically take 1-2 hours to complete.

Each instructor offers their own version of the lab exam, but typically there are ~20 stations with questions and challenges that relate to previous lab material.

Use the "**Following this lab, students should be able to**" sections of the labs to prepare, as well as reviewing the lab manual and any previously completed assignments.

Reminder: lab exams CANNOT be rescheduled due to the complicated set-up of the exams.

Your instructor may provide more information on the weeks leading up to your first lab exam.

Good luck!

Lab 6: Enzymes

Following this lab, students should be able to:

- Explain the structure and function of an enzyme using the terms substrate, active site, activation energy, and products
- State the equation for the specific reaction that is being investigated in this lab (name the substrate, enzyme and products, and know the source of the enzyme)
- State the effect enzyme concentration, pH, temperature, and inhibitors have on enzyme activity; explain what is occurring at a molecular level
- Make a graph based on data given and be able to interpret a graph to draw conclusions

Required prior knowledge from lecture material:

- Enzyme structure and function

Introduction

To complement the theoretical understanding of the structure and function of enzymes from lecture, students will modify the activity of an enzyme called **catalase**, which speeds up the breakdown of **hydrogen peroxide (H_2O_2)** into **oxygen gas (O_2)** and **water (H_2O):**

$$2H_2O_2\ (liq) \rightarrow 2H_2O\ (liq) + O_2\ (g)$$

Experiments are to be done in groups of four, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
  - Answer the following questions regarding this lab:

1. What **organic macromolecules** make up enzymes?

2. What is the **function** of enzymes (not just those in our digestive tract- ALL enzymes)

3. What are some possible factors that could modify an enzyme's activity?

4. What is the name of the **enzyme** that we will be investigating in this lab?

5. What is the **substrate** that will bind to the active site of the enzyme?

6. What **products** will be produced by the chemical reaction in today's lab?

Experimental Set-up

In this lab, we will observe how the enzyme **catalase** aids in the breakdown of its substrate **H_2O_2**, resulting in the production of **H_2O** and **O_2**. Our source of catalase will be a **turnip homogenate** solution (like a turnip smoothie). We will experiment with different methods to change the reaction rate, as measured by oxygen production.

Observe the experimental set-up in **Figure 1** on the next page and read its description.

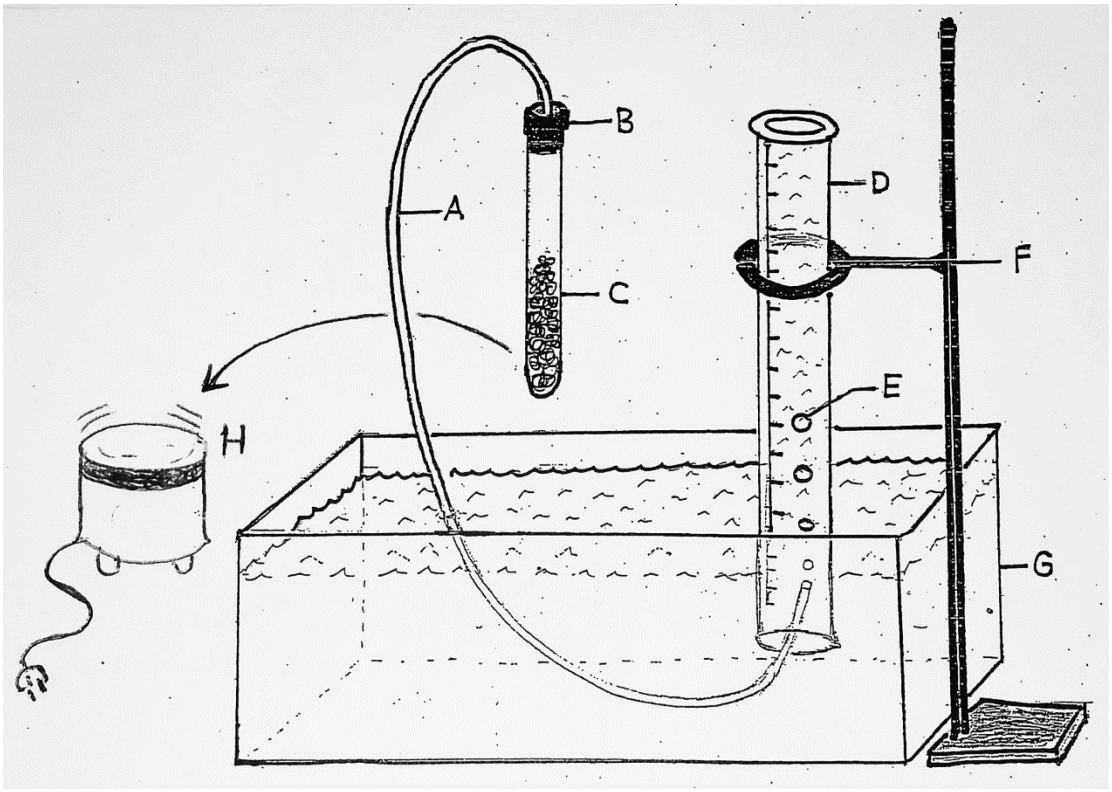


Figure 1. A specific volume of **turnip homogenate** and 3% **H_2O_2** will be added into a test tube (C) and a stopper (B) will be placed on top. The tube may be placed on a vibration mixer (H). If H_2O_2 is successfully broken down into **O_2** and **H_2O**, the O_2 gas will rise and travel through the plastic tubing (A) into a graduated cylinder (D) held upside down by a clamp (F). The cylinder will be filled with water from the basin (G), so as oxygen enters as a gas (E), it will be trapped at the top, pushing the water line lower. The increasing volume of released oxygen (mL) can easily be determined by the lowered water level of the inverted cylinder.

Part 1: Effect of Enzyme Concentration

In this experiment, you will observe the effect of catalase concentration on the breakdown of H_2O_2 by manipulating the concentration of turnip homogenate (our **independent variable)** and observing how much oxygen is produced (our **dependent variable**). All other variables (concentration of H_2O_2, temperature, pH) will remain constant (**controlled variables**).

1. Label five test tubes 1- 5.

2. Add 5 mL of 3% H_2O_2 to each tube.

   CAUTION: H_2O_2 IS REACTIVE AND CORROSIVE. AVOID SKIN CONTACT. HANDLE WITH CARE AND REPORT ANY SPILLS.

3. Add the appropriate amount of dH_2O (water) to each tube, as indicated in **Table 1**.

Table 1. Contents of test tubes used for Experiment #1

Test tube #	**Volume of 3% H_2O_2 (mL)**	**Volume of dH_2O (mL)**	**Volume of turnip homogenate (mL)**
1	5	2.0	0
2	5	1.5	0.5
3	5	1.0	1.0
4	5	0.5	1.5
5	5	0	2.0

****Do NOT add the turnip homogenate until you have read the steps 4-12****

4. Fill basin with water.

5. Lay a large graduated cylinder on its side in the water basin so that it fills with water.

6. Carefully remove any air bubbles by tilting the cylinder up slightly.

7. Turn the cylinder upside down and, keeping its mouth under water, mount it in the clamp as shown in **Figure 1.**

8. Add the appropriate volume of **turnip homogenate** to test tube 1 (see **Table 1**) and insert the rubber stopper and plastic tubing.

9. Quickly place the other end of the plastic tubing under the open mouth of the graduated cylinder (under water).

10. Press the bottom of the test tube onto the vibrational mixer and start a timer.

11. Hold the tube on the mixer for the duration of the reaction (4 minutes).

12. Measure the level of O_2 gas (mL) in the graduated cylinder at 30-second intervals for a total of 4 minutes and record the amount of oxygen produced in **Table 2**.

13. Record any general/descriptive observations in the space below **Table 2** (any human error, any colours, sounds, smells, etc.) as needed.

14. Repeat steps 5-13 for the remaining test tubes.

Table 2. Volume of oxygen gas produced (mL) from 3% hydrogen peroxide mixed with different concentrations of turnip homogenate over time (min).

	Volume of oxygen gas produced (mL) at different turnip homogenate concentrations				
	Turnip homogenate volumes (mL) with water added for a total volume of 5mL				
Time (min)	**0**	**0.5**	**1.0**	**1.5**	**2.0**
0.5					
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					

Additional observations:

15. Once the final test tube reaction has completed, empty the test tubes into the sink and wash them. Place them upside down in their racks to dry on some paper towel.

16. Answer the following questions before moving on to **Part 2**:

    a. What did you observe in **test tube 1** in terms of oxygen production? Why? Explain your reasoning using the words **enzyme, active site,** and **substrate**.

    b. Was there a general trend in oxygen production as you increased the amount of turnip homogenate present? Why do you think that is?

Part 2: Modifying Enzyme Activity

1. Before beginning the next experiment, answer the following questions with your group:

   a. How do you think a change in **pH** might alter catalase activity (and thus O_2 production)? What do you predict would occur if the reaction took place at a different pH? Why?

   b. How do you think a change in **temperature** might alter catalase activity? What would you predict to occur to O_2 production if you increased the temperature of the reaction to 40°C? 60°C? 80°C? 100°C? Why?

   c. What do you predict would occur if you lowered the temperature to 0°C?

   d. How do **non-competitive inhibitors** affect enzyme activity? What do you predict would occur if the reaction took place in the presence of a non-competitive inhibitor?

2. As a group, choose **one** environmental factor to modify for the H_2O_2 decomposition reaction (e.g. temperature, pH, or presence of inhibitor). This will be **your independent variable** in your experiment.

3. Come up with a **hypothesis** for this experimental factor- how do you expect it to affect O_2 production (your **dependent variable**)?

4. See the possible experimental set-ups for each environmental factor on the next pages. Make any specifications/modifications the group sees fit and confirm with your instructor before beginning your experiment.

Part 2A: The Effect of pH

In this experiment, the **independent variable** will be **pH.** You will use different pH buffers to assess the effect of pH on catalase activity (as measured by O_2 production). The amount of buffer, H_2O_2, and turnip homogenate will be kept **constant**.

1. As a group, decide which pH levels you would like to investigate and fill them in into **Table 3**. **Confirm your choices with instructor if different than suggested pH list.**
   Suggested pH list to attempt: 3, 5, 7, 9, 11

2. Follow the procedure of **Part 1** using the measurements from **Table 3.** Record your observations in **Table 4**.

Table 3. Contents of reactions used to examine the effect of pH on catalase activity.

Test tube #	pH	Volume of buffer (mL)	Volume of 3% H_2O_2 (mL)	Volume of turnip homogenate (mL)
1		2.5	2.5	2
2		2.5	2.5	2
3		2.5	2.5	2
4		2.5	2.5	2
5		2.5	2.5	2

Table 4. Volume of O_2 gas (mL) produced from 2.5mL 3% H_2O_2 mixed with 2mL turnip homogenate catalase at varying levels of pH buffer (2.5mL) over time (min).

	Volume of oxygen gas produced (mL) at various pH levels				
	pH				
Time (min)					
0.5					
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					

Additional Observations:

3. Once the final test tube reaction has completed, empty the test tubes into the sink and wash them. Place them upside down in their racks to dry on some paper towel.

4. As a group, answer the following questions:

   a. At which pH level(s) did catalase work **most** effectively? Why do you think that is?

   b. At which pH level(s) did catalase work the **least** effectively? Why do you think that is?

Part 2B: The Effect of Temperature

In this experiment, the **independent variable** will be **temperature (°C)**. You will assess the effect of temperature on catalase activity (as measured by O_2 production). The amount of H_2O_2 and turnip homogenate will be kept constant.

Note**:** to test the effect of temperature, both the **substrate** (H_2O_2) and the **enzyme** (catalase) need to incubate before being added together. Thus there will be two test tubes for each temperature experiment (1A and 1B, 2A and 2B, etc.) and a brief incubation period before observations.

1. Decide which temperatures your group wants to investigate and add them to **Table 5**. Set your water baths appropriately- **confirm your choices with instructor if different than suggested temperatures.**
   Suggested temperatures: 0°C, 20°C, 37°C, 87°C
   (freezing, room temperature, body temperature, and near boiling respectively)

2. Add 5mL of H_2O_2 to test tube 1A and 2mL turnip homogenate to test tube 1B (see **Table 5**).

3. Place both test tubes in the appropriate temperature water bath for 5 minutes.

4. After 5 minutes, remove both test tubes (using tongs if necessary) and pour the turnip homogenate into the tube containing H_2O_2.

5. Run the experiment to collect all the oxygen gas as in the previous set up, recording your values of oxygen gas every 30 seconds for 4 minutes in **Table 6.**

Table 5. Contents of reactions used to examine the effect of temperature on catalase activity

Test tube #	Temperature (°C)	Volume of 3% H_2O_2 (mL)	Volume of Turnip Homogenate (mL)
1A and 1B		5	2
2A and 2B		5	2
3A and 3B		5	2
4A and 4B		5	2

Table 6. Volume of O_2 gas (mL) produced from 5mL 3% H_2O_2 mixed with 2mL turnip homogenate catalase at varying temperatures over time (min).

	Volume of oxygen gas produced (mL)			
	Temperature (^{0}C)			
Time (min)				
0.5				
1.0				
1.5				
2.0				
2.5				
3.0				
3.5				
4.0				

Additional observations:

6. Once the final test tube reaction has completed, empty the test tubes into the sink and wash them. Place them upside down in their racks to dry on some paper towel.

7. Answer the following questions:

   a. At which temperature did catalase work **most** effectively? Why do you think that is?

   b. What happened to the reaction rate at the **highest** temperature? Why do you think that is?

   c. What happened to the reaction rate at the **lowest** temperature? Why do you think that is?

Part 2C: The Effect of an Inhibitor

In this experiment, the **independent variable** will be the amount (mL) of **inhibitor** (copper sulfate) added. You will assess the effect of an inhibitor on catalase activity (as a measured by O_2 production). The amount of H_2O_2 and turnip homogenate will be kept **constant**.

To test the effect of the inhibitor, both the **inhibitor** (copper sulfate) and the **enzyme** (catalase) need to incubate together before the **substrate** (H_2O_2) is added. Thus there will be two test tubes for each temperature experiment (1A and 1B, 2A and 2B, etc.) and a brief incubation period before observations.

NOTE: COPPER SULFATE IS TOXIC – HANDLE WITH CARE AND REPORT ANY SPILLS

1. Decide the various volumes of copper sulfate your group wants to investigate (0-1mL) and add them to **Table 7**. Calculate how much water should be added to make the total volume 1mL. **Confirm with instructor before continuing if different than suggested values.**
   Suggested amounts of copper sulfate: 0mL, 1 drop, 0.5mL, 1mL (water would be 1mL, 1mL, 0.5mL, and 0mL respectively)

2. Add the appropriate volume of turnip homogenate and copper sulfate to test tube 1A and the appropriate volume of H_2O_2 to test tube 1B (see **Table 7**).

3. Place both test tubes in the 20°C water bath for 5 minutes.

4. Remove both test tubes and pour the turnip homogenate/copper sulfate tube into the tube containing H_2O_2.

5. Run the experiment to collect all the oxygen gas as in the previous set up, recording your values of oxygen gas collection every 30 seconds for 4 minutes in **Table 8.**

Table 7. Contents used to examine the effects of an inhibitor on catalase activity

Test tube #	Volume of Copper Sulfate (mL)	Volume of Water (mL)	Volume of 3% H_2O_2 (mL)	Volume of Turnip Homogenate (mL)
1A and 1B	0	1	5	4
2A and 2B			5	4
3A and 3B			5	4
4A and 4B			5	4

Table 8. Volume of O_2 gas (mL) produced from 5mL 3% H_2O_2 mixed with 4mL turnip homogenate catalase at varying concentrations of copper sulfate over time (min).

	Volume of oxygen gas produced (mL)			
	Volume of copper sulfate added (mL)			
Time (min)				
0.5				
1.0				
1.5				
2.0				
2.5				
3.0				
3.5				
4.0				

Additional observations:

6. Once the final test tube reaction has completed, **empty the test tubes into the hazardous waste tub (NOT THE SINK)** and rinse/wash them out, placing them upside down in their racks to dry on paper towel.

7. Answer the following questions:

   a. What did you observe in **test tube 4** in terms of oxygen production? Explain your reasoning using the words **enzyme, active site, allosteric site,** and **substrate.**

   b. Was there a general trend in oxygen production as you increased the amount of copper sulfate present? Why do you think that is?

Part 3: Class Data

1. Your instructor will collect the class data for the average O_2 production (mL) for three different experiments. Copy this information into **Tables 9A-C** below.

Table 9A. Average O_2 production (mL) (n= _____) produced from 2.5mL 3% H_2O_2 mixed with 2mL turnip homogenate catalase at varying levels of pH buffer (2.5mL) after 4 minutes.

pH	Average volume of O_2 (mL)

Table 9B. Average O_2 production (mL) (n= _____) produced from 5mL 3% H_2O_2 mixed with 2mL turnip homogenate catalase at varying temperatures after 4 minutes.

Temperature (°C)	Average volume of O_2 (mL)

Table 9C. Average O_2 production (mL) (n= _____) produced from 5mL 3% H_2O_2 mixed with 4mL turnip homogenate catalase at varying concentrations of copper sulfate after 4 minutes.

Copper sulfate volume (mL)	Average volume of O_2 (mL)

2. Answer the questions associated with the other two experiments based on the class data collected (you will be required to explain the results of all the experiments on an exam).

Once you have completed both experiments and collected class data, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 6: Enzymes

Written Assignment (Due at the Beginning of Next Lab) 10 marks

This assignment may be typed or handwritten, and must have your full name, the full course code and section, and the date at the top right of the document. Please title it "Lab 6: Enzymes".

Students may complete this individually or in pairs, as outlined by your instructor.

1. Write an introductory paragraph that briefly outlines the structure and function of an enzyme (use the terms **active site** and **substrate** in your description). Outline the name of the enzyme investigated in this lab, its substrate, and what molecules are produced. (**2 marks**)

2. Outline the **hypothesis** that you attempted to support in your experiment. **(0.5 marks)**

3. Create a graph that demonstrates the effect your **independent variable** (x-axis) had on your **dependent variable** (y-axis). Ensure that your graph has the following qualities:

    a. Axes are labelled with appropriate titles and units **(1 mark)**
    b. Graph is neat and clean (no shadowing, shading, bar lines, etc.) **(1 mark)**
    c. Data is correctly shown (data points connected with line, NOT line of best fit) **(1 mark)**
    d. Figure title underneath that has clear descriptive title, that indicates what took place in the experiment and includes units and all required details **(2 marks)**

4. State what the graph data is showing (what is the trend observed in this graph)? **(0.5 marks)**

5. State what this trend means in terms of your hypothesis (how does it support or refute it?) **(1 mark)**

6. Finally, briefly explain what is occurring molecularly to the enzyme when you change the independent variable (e.g. what is happening to the active site? How?) **(1 mark)**

Lab 7: The Cell Cycle and Cancer

Following this lab, students should be able to:

- Recognize various phases of the cell cycle and be able to identify them on microscope slides
- Calculate the amount of time spend in a specific cell phase when given data
- Recognize the connection between the cell cycle and cancer
- Distinguish between a healthy blood smear and a leukemia blood smear, noting the difference between erythrocytes, leukocytes, and thrombocytes

Required prior knowledge from lecture and lab material:

- Cell cycle phases, cancer
- Microscope use and calculations

Introduction

To complement the theoretical understanding of the cell cycle from lecture, students will examine the cell stages in onion root cells as well as cancerous cells in human blood. Observations are to be done in pairs, though each student is to write their own notes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts
  - Draw and name each of the phases of the cell cycle (cell that is 2n=4), and label the following: **plasma membrane, nucleus, nucleolus, chromosomes, spindle fibers**
    Note: you only need to label the structures the first time you draw them, not each time!

Part 1. Examining Meristem of Onion Root Tip

In multicellular organisms, cell division occurs in specific places at specific times. In plants, continuous growth occurs at the tips of plant roots and shoots at regions called **meristems**. These regions are constantly undergoing cellular division (it takes **16 hours** to complete the cycle), and thus the phases of the cell cycle can be observed using a microscope.

1. Collect a compound microscope and set it up for use (see **Lab 4**).

2. Collect a slide containing preserved onion root tips. Find one of the root tips under low objective, then medium objective. Adjust the lighting as you go.

3. Find the meristem then increase the magnification to high (X40) objective.

   Note: the meristem region is slightly back from the end of the root tip. It is found under the **root cap** and **epidermal layer** and above the region where cells mature (see **Figure 1**).

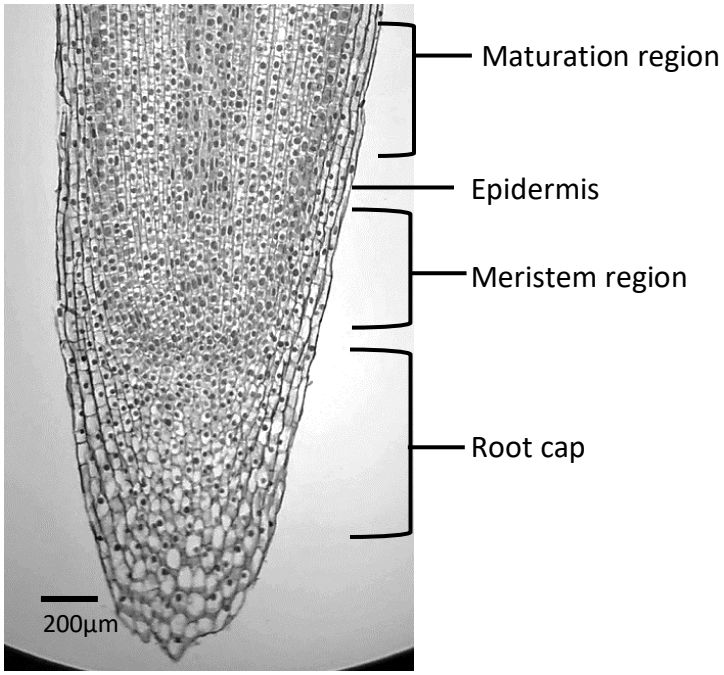


Figure 1. Preserved onion root tip (photo taken by B. Cameron, 2019).

4. Look at the cells within the meristem and answer the following questions:

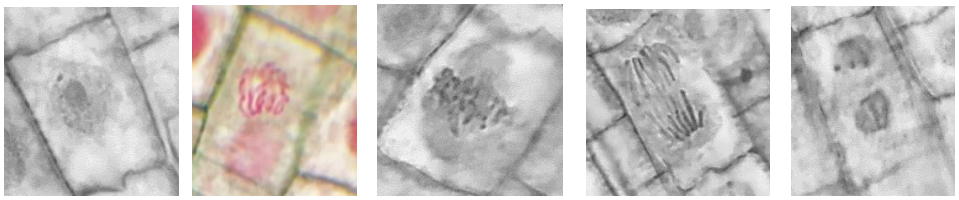
   a. What are the dark circles in most of the cells? What are the darker circles inside them?

   b. If these dark circles are foggy, what cell phase are these cells in?

c. What are the dark thick bands in many of the cells?

d. What are the thin lines that separate each cell?

5. Find a cell in each of the following cell phases**: interphase, prophase, metaphase, anaphase, and telophase**. Take a picture of each phase. Use **Figure 2** to aid in your search.



Interphase *Prophase* *Metaphase* *Anaphase* *Telophase*

Figure 2. Phases of the cell cycle as observed in the meristem of a prepared onion root tip (photo taken by B. Cameron, 2020). Each cell is approximately 20µm in length.

6. Draw what each of the cell phases look like in the onion root meristem tip (from your own slides, not **Figure 2**). Label the **cell wall, nucleus, chromosomes**, and **spindle fibers** (if visible).

7. Compare your pre-lab drawings with those of actual cells in an onion root meristem. What are some major differences between what cells actually look like and what you expected to see?

8. Examine 100 cells (50 for each) and tally which cells are in each phase (see **Table 1**).

Table 1. Number of meristem cells in an onion root tip in each cell phase.

Cell Phase	Tally	Total number of cells

9. Lower the objective lens to the lowest lens, lower the stage, then return the slide.

10. The instructor will amass the class data and provide you with totals for each. Record these totals in **Table 2**. Feel free to start **Part 2** while you wait.

Table 2. Total class number and percentage of cells in each cell phase of meristem cells in an onion root tip and time spend in each phase.

Cell Phase	Total number of cells	% of cells	Time spent (min)

Total number of cells counted: _____

11. Calculate the **percentage of cells** in each phase by taking the **total number of cells in that phase** and dividing it by the **total number of cells counted overall**. Multiply this number by 100% and fill in this column into **Table 2**.

    E.g. $\frac{\text{86 cells in metaphase}}{\text{1014 total cells}}$ *x100% = 8.5 % (round to nearest decimal) cells in metaphase*

12. Calculate the **actual time in minutes** that cells spend in each phase by multiplying the **percentage of cells in a phase** (as a fraction, so divide the number by 100) by the **total time** cells spend in a cell cycle (in this case, **16 hours**) and update **Table 2**.

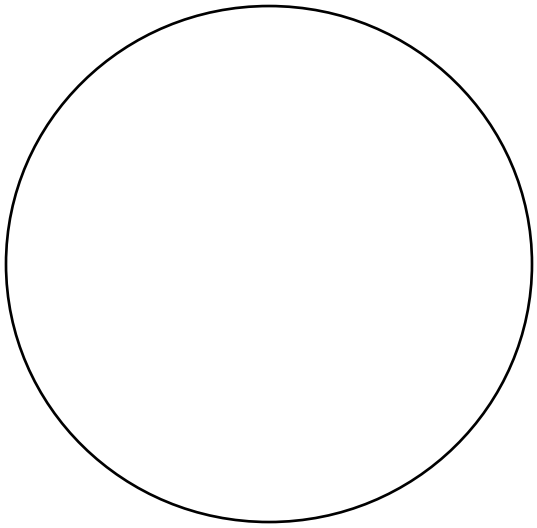
    E.g. $\frac{8.5}{100}$ *x 16 hours = 1.36 hours (round to two decimals) in metaphase*

    Note: since we do not often use fractions to write hours, we need to convert any remaining fractions of an hour into minutes (60 minutes to an hour), so in this case:

    0.36 hours x $\frac{\text{60 minutes}}{\text{1 hour}}$ *= 22 minutes (round to full minute)*

    Thus, the cells spend 1 hour and 22 min in metaphase.

13. Create a sketch of a **pie chart** using the circle provided below, demonstrating the percentage of time spend in each cell phase. Use a ruler to make the lines neat.



14. Review your pie chart. Which phase do meristem cells in onion root tips spend the most time in?

15. What are some activities that occur during this phase that are important for cellular division?

Part 2: Examining Cancerous Cells

In this observation, we will compare a healthy blood smear with a blood smear of someone with leukemia (a type of cancer) to compare cell count and morphology. Since blood cells are so small, we will be using the highest objective lens (X100) to see the cells more clearly. The 100X lens is also called the **oil immersion lens**, as an oil droplet is added between the slide and the lens to improve magnification.

1. Collect a slide of a human blood smear. Using the microscope procedure outlined in **Lab 4**, bring the blood cells into view and increase the magnification to medium, then high (X40), adjusting light as you go.

2. Carefully move the high objective (X40) lens out of the way towards X100, with **neither facing down** towards the slide.

3. Collect an oil dropper and add one drop of oil to the slide.

4. Slowly and carefully move the X100 objective lens onto the slide. It may look like a tight fit, but since you have not moved the coarse focus since you were using the X4 lens, it will not touch the lens. Instead, the oil droplet will touch both the slide and the lens.

5. Slightly adjust the fine focus (**NOT THE COARSE FOCUS**) until the cells are in focus. They are now magnified X1000!

6. In human blood, there are three major blood cell types: **erythrocytes** (red blood cells), **leukocytes** (white blood cells), and **thrombocytes** (platelets). Observe each in your slide:

    a. **Erythrocytes** are the smallest cells in the body. They are red and lack a nucleus. They are thinner in the middle and will be the most abundant cell that you see.

b. **Leukocytes** are larger than erythrocytes. They often have more than one nucleus and can come in many shapes and sizes. There will be far fewer of them than erythrocytes.

c. **Thrombocytes** are small cell fragments. They will look like very small specks compared to the others (or may be impossible to see altogether).

7. Take a picture of the blood smear and draw each of the cells below, estimating their sizes using the calculations from **Lab 4**.

8. When observations are complete, lower the objective lens to the low objective lens (X4), lower the stage, and remove the blood smear slide.

9. Wipe off the oil from the slide using a tissue and some alcohol and return it to its tray. Wipe the lens as well.

10. Collect a leukemia slide and set it up so you can view the blood cells at low, then medium, then high objective lens (X40).

11. Carefully move the high objective (X40) lens out of the way towards X100, with neither facing down towards the slide.

12. Add one drop of oil to the slide.

13. Slowly and carefully move the X100 objective lens onto the slide.

14. Slightly adjust the fine focus (**NOT THE COARSE FOCUS**) until the cells are in focus.

15. Observe the leukemia blood smear. What differences do you observe when compared to the regular blood smear? Which cells are different in terms of their shape and abundance?

16. What does leukemia mean (what type of cancer is this? What cells are dividing too rapidly)?

17. Take a picture of the leukemia blood smear, then lower the objective lens to the lowest objective lens (X4) and lower the stage.

18. Wipe and return the leukemia slide.

19. Wipe off the oil completely from the X100 lens using tissue and alcohol. Return the microscope to storage set-up and have your instructor look over the scope before you put it away.

Once you have completed all the observations, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 7: Cell Cycle and Cancer

Written Assignment (Due at the Beginning of Next Lab) 10 marks

This assignment must be typed and must have your full name, full course code and section, and date at the top right of the document. Please title it "Lab 7: Cell Cycle and Cancer".

Students may complete this individually or in pairs, as outlined by your instructor.

1. State why cells in the meristem of an onion root tip are constantly undergoing mitosis, while the cells in the maturation zone and epidermis are not. Think: what is the purpose of mitosis? (**1 mark**).

2. Create a figure (or 5 separate figures) that shows cropped pictures of cells in each of the cell phases that you identified in the onion root cell. The figure title(s) should indicate the estimated size of a cell and each phase should be clearly labelled, as well as who took the photos and when. (**4 marks**- see **Figure 1** as a great example)

3. Create a high quality pie chart figure to indicate the % of cells in each cell phase from the class total. Ensure each region of the pie chart is properly labelled and include a detailed figure title underneath. (**2 marks**)

4. State which cell phase takes the longest time (show your time calculations for that one phase and include units) and explain why this is the case (what are the cells doing during this time?). (**2 marks**).

5. State, in brief terms, what leukemia is and how you would be able to distinguish between a typical blood smear and a blood smear of an individual with leukemia. (**1 mark**)

Lab 8: Genetics

Following this lab, students should be able to:

- Apply genetic terminology such as phenotype, genotype, heterozygous, homozygous, dominant, and recessive, gene, allele, and chromosome
- Consider potential genotypes if phenotypes and dominant/recessive alleles are given
- Recognize the probability of particular genotypes and phenotypes based on parental or offspring information provided
- Complete simple Punnett squares with completely dominant and co-dominant traits
- Interpret and create pedigree charts to demonstrate understanding of dominant and recessive trait inheritance within families
- Complete complex (two trait) Punnett squares
- Contrast discontinuous with continuous traits and give examples of polygenetic traits

Required prior knowledge from lecture material:

- Genetics (alleles, genes, Punnett squares, pedigrees)

Introduction

To complement the theoretical understanding of genetics from lecture, students will explore various traits that show complete dominance and co-dominance by considering their own phenotypes and inheritance patterns. Students will also learn how blood typing is performed, and how their phenotype indicates their potential genotype. Questions are to be done in pairs, though each student is to write their own notes in their lab manuals.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
  - Fill in the blanks using the following words: **alleles, genes, homologous chromosomes, sex chromosomes, genotype, phenotype, dominant, recessive, homozygous, heterozygous.**
    - Humans have 22 pairs of _____ and 1 pair of _____ (XY) in the nuclei of our cells.
    - Each chromosome contains a variety of _____ at specific loci (locations) that will code for particular characters, such as hair colour or eye colour.

- Variants of these characters are referred to as _____. Depending on which is present, we may express a particular trait for that character (e.g. brown or black hair).

- In general, we have two copies of each chromosome and thus two copies of each gene. Which alleles we have for a particular gene determines our _____ (e.g. Bb).

- If these two alleles are the same, we are _____ (e.g. bb or BB) for that gene. If they are different, we are _____ (e.g. Bb).

- How these alleles interact and express themselves will relate to our _____, the physical expression of those traits (e.g. brown or black hair).

- If two parents do not express a trait but their child <u>does</u>, then the trait must be _____ (e.g. two non-blond parents have a blonde child).

- If two parents express a trait but their child <u>does not</u>, then the trait must be _____ (e.g. two black haired parents have a non-black haired child).

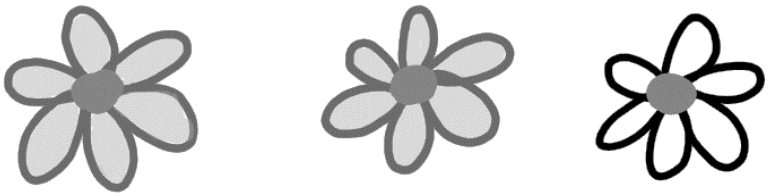
<u>End of Pre-Lab</u>

<u>Part 1: Complete Dominance</u>

In the situation of **complete dominance**, a person's **phenotype** is based on the presence or absence of a **dominant allele**.

Two identical recessive alleles (**homozygous recessive**) must be present to express the recessive trait, while only one is needed to express the dominant trait (see **Figure 1**).

In a **heterozygous** individual, the **dominant** allele is expressed (written as a capital letter), while the **recessive** allele is not (written as a lowercase letter).



AA **Aa** **aa**

Figure 1. For the gene that codes for petal colour, the purple trait (A) is complete dominant over the white trait (a). For a flower to have a white phenotype, it must have a homozygous recessive genotype (aa). For a flower to have a purple phenotype, it may have a heterozygous genotype (Aa) or be homozygous dominant (AA).

Most human traits are determined by both our genetics and the environment in which we develop and grow. Some traits, however, are easy to map in terms of heritability and expression. Your instructor may ask students to demonstrate any of their fun genetic "human tricks" that some students may be able to perform (e.g. double jointed, high flexibility, tongue rolling, ear wiggling, smelling asparagus metabolites).

1. Work in pairs to identify the following heritable traits expressed in both yourself and your lab partner and determine your phenotypes and possible genotypes.

   a. **PTC Taster:** Place a piece of PTC (phenylthiocarbamide) paper on your tongue. If the paper has a bitter taste, you are a "taster" and you are expressing the dominant trait (P). If the paper tastes bland, you are a "non-taster", and are expressing the recessive trait (p).

   b. **Sodium Benzoate Taster:** Place a piece of sodium benzoate paper on your tongue. If the paper has a salty taste, you are a "taster" and you are expressing the dominant trait (S). If the paper tastes bland, you are a "non-taster", and are expressing the recessive trait (s).

   c. **Widow's Peak:** If you have a pointed hairline (forms a V at the front centre- even a slight little notch counts), you are expressing the dominant trait (W). If you do not have the widow's peak (straight hairline), you are expressing the recessive trait (w).

   d. **Detached Earlobes:** If your earlobes are even partially detached from the side of your head, you are expressing the dominant trait (E). If your earlobes are attached to the side of your head, you are expressing the recessive trait (e).

   e. **Mid-Digital Hair:** Each finger on your hand has 3 segments. If any hair is present on the middle segments, you are expressing the dominant trait (H). If you do not have any hair on any of your middle segments of your fingers, you express the recessive trait (h).

   f. **"Non-Blue" Eye Colour:** If your eyes are any colour other than blue-grey, you are expressing the dominant trait (I). If you have blue-grey eyes, you are expressing the recessive trait (i). *Note: technically, eye colour is much more complex than this as it is controlled by multiple genes to give an array of colours (etc. hazel, green).*

   g. **Dimples:** If you have small depressions in your cheeks when you smile or purse your lips, you are expressing the dominant trait (D). If you have flat cheeks (no depressions, not even one) when you smile, then you are expressing the recessive trait (d).

   h. **Freckles:** If you develop freckles (small darker coloured patches of skin) when your skin is exposed to the sun, you express the dominant trait (F). If your skin does not form freckles when exposed to the sun, you express the recessive trait (f).

2. Enter your findings in **Table 1**.

   a. Recall that phenotype means the appearance (e.g. "Widow's Peak" or "No Widow's Peak"), while genotype means the two alleles for that trait (E.g. WW, Ww, or ww).

   b. Remember that if someone expresses the dominant trait, there are two possible genotypes, but if they express the recessive trait, there is only one (homozygous recessive).

   c. Use the letters outlined on the previous page for each character's genotype.

Table 1. Phenotypes and possible genotypes for eight traits in Person #1 (_____) and Person #2 (_____).

Trait (Phenotype)	Person #1 Phenotype	Person #1 Possible Genotype(s)	Person #2 Phenotype	Person #2 Possible Genotypes(s)
PTC Taster				
Sodium Benzoate Taster				
Widow's Peak				
Detached Ear Lobes				
Mid-Digital Hair				
"Non-Blue" Eye Colour				
Dimples				
Freckles				

3. Once all students have filled in their expressed traits, your instructor may run a quick activity with the class to mimic how DNA testing functions in forensic science.

4. Answer the two questions below using your understanding of complete dominance.

   a. Is it possible for two individuals <u>without freckles</u> to have a child <u>with freckles</u>? Explain.
   <u>Hint:</u> first determine the parental genotypes, then create a Punnett Square to see the possible genotypes of the offspring.

   b. Two <u>heterozygous</u> individuals for the freckle character plan to have a child. What is the likelihood that they will have a child <u>with freckles</u>? Explain**.**
   <u>Hint</u>: first, determine the parental genotypes, then create a Punnett Square to see the potential offspring. Finally, calculate the fraction of offspring that have freckles.

   c. Two parents with <u>cleft chins</u> (a dimple in their chin) have a child <u>without a cleft</u> chin.

      i. Is trait of a cleft chin <u>dominant</u> or <u>recessive</u>? How do you know?

      ii. Using the letters H and h, indicate the genotypes of the parents and the child.

      Parent #1: Parent #2: Child:

d. Two healthy parents have a child with cystic fibrosis.

   i. Is cystic fibrosis dominant or recessive? How do you know?

   ii. Using the letters C and c, indicate the genotypes of the parents and child.

   Parent #1: Parent #2: Child:

Part 2. Inheritance Patterns

If we want to determine whether a trait is dominant or recessive, we can often look at how it is inherited and passed on through generations using a pedigree chart (see **Figure 2**).

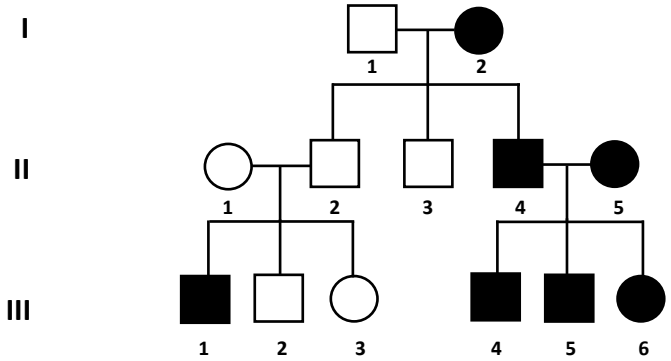


Figure 2. A pedigree chart demonstrating the inheritance pattern of a trait (black) across three generations (I, II, and III). Horizontal lines between symbols represent the creation of offspring. Siblings all branch from one pair of symbols in the generation above (thus, persons 2, 3 and 4 of generation II are the children of persons 1 and 2 of generation I).

If two individuals who do NOT express the trait create a child who DOES express it, this demonstrates that the trait is **recessive** (it was hidden in the heterozygous parents).

If two individuals who EXPRESS the trait have a child who does NOT, then this demonstrates that the trait is **dominant** (the parents must have been heterozygous).

1. Based on your understanding of the inheritance pattern of traits that express complete dominance, answer the following questions.

   a. Is the trait shown in **Figure 2 dominant** or recessive? Explain your reasoning based on its inheritance pattern
   Hint: see if you can find a pattern mentioned above

b. Use the alleles B and b to answer the following questions about **Figure 2**:

i. What is the **genotype** of person 1 in generation II? How do you know?
(*Hint: consider the offspring that this person was able to create with person #2*)

ii. What is the genotype of person #4 in generation III? How do you know?

2. Observe **Figure 3** below and answer the following questions.

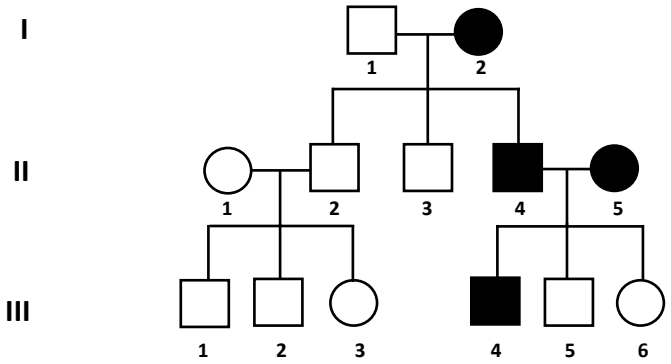


Figure 3. A pedigree chart demonstrating the inheritance pattern of a trait (black) across three generations (I, II, and III).

a. Is the trait shown in **Figure 3** dominant or recessive? Explain your reasoning based on its inheritance pattern
Hint: see if you can find a pattern mentioned previously

b. Use the alleles A and a to answer the following questions about **Figure 3**:

i. What is the **genotype** of person #1 in generation I? How do you know?

ii. What are the **genotypes** of person #4 in generation II?

Part 3. Multiple Alleles and Co-Dominance

Some human characters have more than two possible alleles, and sometimes these alleles are co-dominant to each other. In the case of **co-dominance**, both alleles are equally expressed in heterozygotes, rather than one being repressed by the other.

An excellent example of this phenomenon is human blood types which are determined by just one gene that has three possible alleles**: I^A, I^B,** and **i.** These alleles code for the presence or absence of **antigens** (tags) found on our **erythrocytes** (red blood cells) (see **Figure 4**).

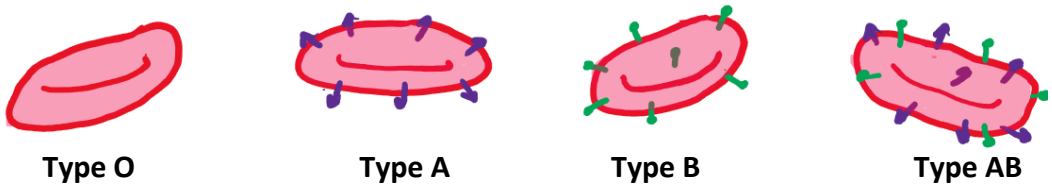


Figure 4. Co-dominance as demonstrated by human blood types. Individuals with type O have no antigens on their red blood cells, individuals with type A have A antigens, individuals with type B have B antigens, and individuals with type AB have both A and B antigens.

The alleles that code for either type A or type B are **co-dominant** to each other and are written with capital letters (**I^A** and **I^B**). If someone has both the I^A and I^B alleles, they are blood type AB and express both antigens on their blood cells (see **Figure 4**).

The A and B alleles are **completely dominant** over the allele that codes for blood type O, which is symbolized by the lowercase letter (**i**). This means if someone is blood type A, their genotype could be $I^A I^A$ or I^A i.

If someone is blood type O, they have NO antigens on their red blood cells and must have a homozygous recessive (ii) genotype.

1. If supplies are available and health regulations allow, you may choose to determine your blood type following the steps below.

    a. Put a glove onto ONE hand and collect a microscope slide, auto lancet, Band-Aid, alcohol swipe, tooth pick, crayon, and strip of paper towel.

    b. Draw three small circles (1.5cm in diameter) on the microscope slide, labelling one A, another B, and another D.

    c. Prick a finger with the auto lancet. Squeeze several drops of blood into the circles. When finished, wipe your finger with the alcohol wipe and put on a Band-Aid.

d. Add a few drops of anti-A serum into the A circle, anti-B serum into the B circle, and anti-D serum into the D circle. Use a toothpick to mix the blood with the anti serums- **be careful not to contaminate**.

e. If your blood clumps in the presence of the anti-serums, then you possess those antigens (D refers to the Rh factor, so whether you are A+ or A-). Take a picture of your results.

f. Place the auto lancet in the sharps container, the slide into a glass container, and all other wrappers/papers into the biohazard bag. Wipe down the space with the 10% bleach solution.

2. Enter your blood types in **Table 2** and determine the possible genotypes based on the information above. If you do not know your blood type, you may choose one at random (choose different types). Recall the possible alleles are I^A, I^B, and i.

   Note: do not include the Rh factor, D antigen, yet!

Table 2. Phenotypes and possible genotypes for ABO blood for Person #1 (_____)

and Person #2 (_____)

Trait (Phenotype)	**Person #1 Phenotype**	**Person #1 Possible Genotypes**	**Person #2 Phenotype**	**Person #2 Possible Genotypes**
A, B, or O Blood Type				

3. Answer the questions below:

   a. If an individual with the genotype $I^A I^A$ had a child with an individual with the genotype I^B i, what is the likelihood that they will have offspring with blood type AB? Explain. *Hint: create a Punnett Square to see the genotypes and phenotypes of the offspring, then calculate the fraction of offspring that are AB.*

b. Marie is <u>blood type O</u>, but her parents are <u>blood type A</u> and <u>blood type B</u>. What must be the genotypes of her parents for this to be possible?
<u>Hint:</u> think about Marie's genotype, and then consider what alleles her parents must have in order to be their blood types and in order for Marie to be blood type O

<u>Part 4: Multiple Genes and Crossing Over</u>

Recall that **meiosis** is required for **sexual reproduction**. In prophase I, alleles will swap with one another on non-sister chromatids, meaning that genes along a chromosome are <u>randomly assorted</u> to newly formed sex cells, regardless of which chromosome they were initially on.

This means if an individual is **heterozygous** for **two genes** (e.g. Rr and Yy), they will have **four** possible unique sex cells due to crossing-over and random assortment (see **Figure 5**).

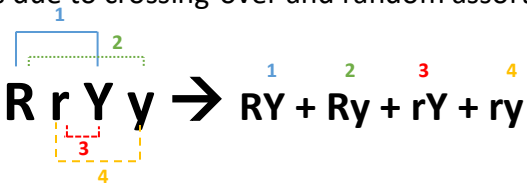


Figure 5. A pea plant that is <u>heterozygous</u> for <u>two traits</u> (Pea shape (R for round, r for wrinkled) and pea colour (Y for yellow, y for green)) will create <u>four possible sex cells</u> due to the random assortment of each allele during meiosis.

When creating Punnett Squares considering TWO genes, there are <u>16 possible outcomes</u> (see **Table 3**. <u>Note</u>: the alleles for the same gene are always written together.

Table 3. A cross between two dihybrids where both parents are RrYy, and thus each will create four possible sex cells (RY, Ry, rY, or ry). There are 16 possible outcomes for their offspring.

	RY	**Ry**	**rY**	**ry**
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

This concept of two discrete genes and their inheritance can be explored with blood types.

We technically have another gene that dictates a separate antigen on our red blood cells in addition to A, B, and O: this gene codes for the presence of absence of the **D antigen**, also called **Rh factor**.

If we have the Rh factor, we express the **dominant trait** (D). Our blood cells have the **D antigen** on their surface, and our phenotype is **positive** (+) (e.g. A+, O+).

If we lack the Rh factor, we express the **recessive trait** (d). Our blood cells would **lack** the D antigen, and our phenotype would be **negative** (-) (e.g. B-, AB-).

Thus, if an individual was O-, they must be homozygous recessive for both traits (ii dd) and would have no antigens on their red blood cells. If a person was AB+, they would have the A, B, and D antigens on their red blood cells and have multiple possible genotypes (e.g. I^AI^A DD, I^Ai Dd, etc.)

1. Re-enter your blood types from **Table 2** into **Table 4** and write your possible genotypes, this time including Rh factor. If you do not know whether you are positive or negative, randomly select one (select different ones!). Recall the possible alleles are **I^A, I^B** and **i** for the first gene, and **D** or **d** for the second gene.

Table 4. Phenotypes and possible genotypes for ABO and Rh blood for Person #1 (_____) and Person #2 (_____)

Trait (Phenotype)	Person #1 Phenotype	Person #1 Possible Genotypes	Person #2 Phenotype	Person #2 Possible Genotypes
A, B, or O as well as + or -				

2. Answer the questions on the next page using your understanding of co-dominance and multiple genes.

a. If an individual with the genotype $I^A I^B$ dd had a child with an individual with the genotype $I^A I^B$ dd, what is the likelihood that they will have a child that is blood type A+?
*Hint: do a Punnett Square similar to the one featured in **Table 3** and calculate the fraction of offspring who are A+.*

b. What are the possible genotypes of two parents who are blood types A+ if they have a child who is O-? Explain your reasoning using key terms.
Hint: think about what alleles each parent MUST have in order for their offspring to have their specific genotype

Part 5: Polygenic Inheritance

Many human traits are not Mendelian in nature, meaning one single gene does not control a single trait. Instead, many human traits are **polygenic**, which means many genes will contribute to a single trait. In addition, the environment often plays a role in how these various genes are expressed. Some examples of polygenic human traits are skin colour, IQ, height, and finger print patterns. Your instructor may have more data and a small activity to accompany this section.

Once you have completed all the questions, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 8: Genetics

Written Assignment (Due at the Beginning of Next Lab) 10 marks

This assignment may be typed or handwritten and must have your full name, the full course code and section and the date at the top right of the document. There is a specific title for this lab, as stated below.

Students may complete this individually or in pairs, as outlined by your instructor.

For this assignment, you will create a pedigree of your family and track a single trait back three generations to determine its inheritance pattern (either dominant or recessive).

1. Survey a family (your own, a friend's, or one in fiction) for the following traits and find one which appears differently in at least two people in the family

   Potential traits: cleft chin, straight hair, genetic disorders (colour blindness, sickle cell anemia, cystic fibrosis), male pattern baldness, freckles, dimples, detached earlobes, farsightedness, widow's peak, mid-digit hair.

2. Create a pedigree with all family members back three generations (recall **Figures 2 & 3** of **Part 2**). Follow the outline below for full marks.

   a. Use a blank white piece of paper; the pedigree should take up the entire page (**1 mark**)

   b. Use circles for females, squares for males, diamonds for undisclosed **(0.5 mark)**

   c. For each generation, use capital roman numerals (I, II, III) **(0.5 mark)**

   d. Number each individual from each generation (1, 2, 3, etc.) **(1 mark)**

   e. Place a "?" for each person not tested for the trait

   f. Include a legend which indicates what the shaded symbols and non-shaded symbols represent (e.g. black = expresses the trait, white = does not express trait) (**1 mark**)

   g. Determine if it is possible to recognize if the trait is dominant or recessive (recall **Figure 2** of **Part 2**) based on the inheritance pattern. On the back of the page, write a clear sentence indicating if it is possible to tell if this trait is dominant or recessive, and which it is (how do you know?). **(2 marks)**

      OR If you cannot determine the dominance of the trait from your pedigree, research the genetic inheritance of the trait and include this in your second sentence, and state briefly why you cannot determine it (what would you need to see in order to do so?).

h. Come up with letters to represent the alleles for the trait and add them to the legend (e.g. W = widow's peak, w= no widow's peak) **(1 mark)**

i. Determine the possible genotypes of each individual and write them beneath their symbol (it may be possible to determine the phenotype/genotype of family members with ? symbol, but if it is not, leave them blank) **(2 marks)**

j. Title your pedigree ""PEDIGREE OF THE (last name) FAMILY, FOR THE TRAIT OF (trait)". **(1 mark)**

If available, see past examples as inspiration. Note that you must follow the outline's instructions, as previous examples may lack specific qualities.

Lab 9: Nutrition

Following this lab, students should be able to:

- Given a food nutritional label, calculate the % of Calories from a specific macronutrient
- Distinguish between Calories and nutrients
- Recognize how the body digests complex carbohydrates and predict results to iodine and Benedict's tests when starch is in the presence or absence of amylase
- Interpret a meal based on the New Canada Food Guide in terms of proportion of meal, types of macronutrients present, and eating habits

Required prior knowledge from lecture and lab material:

- Nutrition and digestive system anatomy
- Enzymes
- Macromolecules (carbohydrates, lipids, and proteins)
- Starch and simple sugar reagent tests

Introduction

To complement the theoretical understanding of nutrition and digestion from lecture, students will explore how amylase breaks starch into sugars and how Calories and nutrients are important for a healthy diet. Experiments and calculations are to be done in pairs, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- **For five days prior to this lab**, keep a food journal. Consider an app like *My Fitness Pal*.
- Before arriving to the lab:
    - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
    - Answer the following questions:
        - What type of macromolecule is starch? _____
        - What reagent tests for the presence of starch? _____
        - What enzyme breaks starch down into its monomers? _____
        - What are the monomers of starch? _____
        - What reagent tests for the presence of these monomers? _____

- What is the difference between Calories and nutrients?

- Is it possible for food to have Calories but not be nutritious? Provide an example.

- What type of food do you consider "healthy"? Why?

- What type of food do you consider "unhealthy"? Why?

End of Pre-Lab

Part 1: Digestion

When you ingest macronutrients, your body will digest them into smaller polymers and monomers before they are absorbed. The digestion of **complex carbohydrates** begins in the mouth. Your saliva contains the important enzyme **amylase** which hydrolyses complex carbohydrates into their **simple sugar** monomers and dimers.

In this experiment, students will test the effect of **amylase** on the hydrolysis of **starches** into simple **sugars**.

1. Recall the two tests used to test for starches and simple sugars and fill in the blanks:

   a. We use **iodine solution** to test for the presence of **starches**. This solution is _____ in colour when starches are **present**, and _____ in colour when starches are **absent**.

   b. We use **Benedict's reagent** to test for the presence of **simple sugars**. This reagent is _____ in colour when simple sugars are **present**, and _____ in colour when simple sugars are **absent**.

Testing the impact of amylase on starch and glucose presence

1. Label six test tubes 1-6. Fill test tubes 1-4 with 1mL of 0.2% starch solution and 5-6 with 1mL of glucose solution.

2. In test tubes 3-4, add 10 drops of amylase.

3. Incubate all the test tubes in a water bath set to body temperature (37°C) for 10 minutes.

   a. Why are we incubating for 10 minutes and not testing right away? Why at that temperature?

4. While the test tubes incubate, predict what you expect the results will be in terms of the iodine test (colour, +/-), and Benedict's test (colour, +/-) by filling in those columns in **Table 2** below.

Table 2. Predicted and actual results for iodine and Benedict's tests for test tubes containing 0.2% starch, 0.2% starch + 10 drops amylase, and glucose solutions. All test tubes were incubated for 10 minutes at 37°C prior to testing.

Test Tube Contents	Predicted iodine result (+/-)	Actual iodine result (+/-)	Predicted Benedict's result (+/-)	Actual Benedict's result (+/-)
Starch				
Starch + amylase				
Glucose				

5. After 10 minutes has elapsed, remove all test tubes from the water bath.

6. To test for simple sugars, add 10 drops of Benedict's solution to test tubes 1, 3, and 5 (one tube with just starch, one with starch and amylase, one with glucose).

7. Gently flick the test tubes to mix them fully. Incubate test tubes 1, 3, and 5 in a water bath at 87°C for 5 minutes to activate the reagent.

8. While you wait for the Benedict's solution to heat, test the other three test tubes for starch. Add 5 drops of iodine to test tubes 2, 4, and 6 (one with starch, one with starch and amylase, one with glucose).

9. Gently flick the test tubes to mix them fully. Observe and record the results in **Table 2**.

10. Once the test tubes in the water bath have finished incubating, remove them from the water bath and gently flick the tubes to ensure full mixing. Observe and record the results in **Table 2**.

11. Compare your iodine test results and explain WHY you observed what you did for each test tube (starch, starch + amylase, glucose). What occurred in the tube with starch and amylase?

12. Compare your Benedict's test results and explain WHY you observed what you did for each test tube (starch, starch + amylase, glucose). What occurred in the tube with starch and amylase?

13. Considering this experiment, explain why a soda cracker tastes sweet if it is left in the mouth for 30 seconds before chewing.

14. When observations are complete, take a picture and empty the tubes into the labelled waste bins (**DO NOT POUR THEM DOWN THE SINK**).

15. Wash/scrub and rinse the tubes and place them upside down in the racks to dry on paper towel.

Part 2: Calories

One of the important functions of diet is to supply the body with molecules that will eventually be converted into **glucose** and used in **cellular respiration**. The energy that is stored in food is converted into **ATP** by mitochondria in our cells and eventually used by the cells to do work. The energy stored in food is measured in **Calories**.

One Calorie of energy is equal to the energy required to heat 1 kg of water by 1°C. The average Canadian requires 1500-2500 Calories a day, depending on a variety of factors.

Each food item has its own unique range of chemical constituents, three of which are what are considered **macronutrients**. These are chemicals that can be broken down by the body and used as energy. Each macro-nutrient can give the body a different amount of energy (Calories) (see **Table 1**.)

Table 1. Caloric equivalent of carbohydrates, proteins and fats

Nutrient	**Cal/g**
carbohydrates	4
proteins	4
fats	9

From **Table 1**, we can see that for 1g of carbohydrate we consume, we gain 4 Calories. For 1g protein, we gain 4 Calories, and for 1g of fats, we gain 9 Calories.

We can calculate the **percentage of Calories** coming from these macro-nutrients in the food we eat to ensure our Calories are coming from different sources.

1. Find a nutritional label on a food package
2. Find the total number of Calories for one serving for that food item: _____Cal
3. Choose a macronutrient: _____
4. Find the amount of the macronutrient in one serving for that food: _____g
5. Calculate how many Calories will be coming from that specific macronutrient using **Table 1**.

   _____g x _____Cal/g = _____

6. Calculate the **percentage of Calories** by dividing the **number of Calories from the macronutrient** by the **total amount of Calories** for one serving. Multiply by **100%**.

   _____Cal x 100% = _____

   _____ Cal

7. Repeat steps 1-5 for a different macro-nutrient and write down your calculations for each step below.

8. State which food would give you more energy (Calories): a spoonful of peanut butter (mostly fat), or a spoonful of pasta (mostly carbs), and explain why (2 marks)

9. Explain why simply "counting Calories" is not a healthy way to evaluate your diet. (1 mark)

Part 3: Nutrients

Food is not just an energy source. What you eat is a complex mixture of hundreds of different chemical constituents in order to provide your cells with the building blocks they need to create organelles, hormones, proteins, DNA, and more. **Nutrients** such as **fats, carbohydrates, and proteins** are important to take in, in addition to **vitamins** and **minerals** that act as co-enzymes or help build tissues.

Section A: Balanced Meals

1. Look at the new Canada Food Guide online: https://food-guide.canada.ca/en/

2. Note that the new food guide has switched the focus from **serving sizes** (old Food Guide) to **eating balanced meals**. It recommends that for each meal, half of the meal is vegetables and fruit, a quarter of the meal is proteins, and a quarter of the meal is whole grain foods.

3. Choose one day's worth of food from the days that you recorded and compare it to this recommendation. What are your observations in terms of **proportions**?

Section B: Food Choices

1. On the left hand side of the food guide website click on the 'Food Choices' link.

2. Start by clicking the link **'**Eat plenty of vegetables and fruits, whole grain foods and protein foods'. What are some benefits of healthy eating and of eating more plant-based food?

3. On the left hand side click the tab/link 'Eat plenty of vegetables and fruits'**.** What important nutrients are found in vegetables and fruit?

4. Now go to the link 'Eat whole grain foods'. Read about the important nutrients found in whole grains. Why might it be important to eat whole grains rather than refined grains? What are examples of whole grains?

5. Now go to the link 'Eat protein foods'. Read about why proteins are good for you, and why it is important to eat more plant-based protein. Can you list 3 plant-based proteins?

6. Now go to the link 'Choosing foods with healthy fats' (on left hand side of page). What is the difference between a **saturated** and **unsaturated** fat (hint: think back to our macromolecule lecture)? What are some examples of some healthy fats? What are some foods that contain saturated fat?

7. Now spend a bit of time looking at the other links- 'Limit highly processed foods', 'Make water your drink choice', 'Use food labels' and 'Be aware of food marketing'. Record your notes below:

Section C: Healthy Eating Habits

1. Go back to the home page and go to 'Eating habits' (left hand side). In the new food guide healthy eating is not just about what you eat, but it is about *mindful eating habits*, placing emphasis on home cooking, enjoying your meals and the importance of eating with others.

    a. Once you have reviewed the information there, list two take away messages that you learned regarding your eating habits and the recommendations provided.

Once you have completed all the experiments and questions, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Lab 9: Nutrition

Written Assignment (Due at the Beginning of Next Lab) 10 marks

As always, this may be typed or handwritten and must have your full name, the full course code and section, and the date at the top right of the document. Title your document "Lab 9: Nutrition"

Reflect on this week's lab by writing a reflection piece (~250 words- **2 marks**):

1. Comment on any or all of the following (or similar ideas) in your reflection (**6 marks**):
    a. What surprised you about your own diet after recording it for 5 days? How was that experience for you?
    b. What key pieces about nutrition did you learn that you may apply to your diet moving forward?
    c. What key pieces about eating habits (mindful eating, etc.) might you apply to your lifestyle moving forward?
    d. How was your experience navigating the new Canada Food Guide (what did you like, what didn't you like)?
    e. Any other comments regarding this lab, how your diet and eating habits may change moving forward, etc.
2. As with any written assignment, please edit your work to ensure good sentence structure, grammar, and spelling (**2 marks**)

Lab 10A: Anatomy Part I: Digestive and Urinary Systems

Following this lab, students should be able to:

- Recognize the three planes of bilateral organisms and the six directions
- Identify and locate organs from the digestive and urinary systems and state their functions
- Identify gross and microscopic anatomical structures of the kidney and describe the path of filtrate and urine through these structures
- Given a tissue slide that relates to the digestive and urinary systems, identify the structure at the pointer under a microscope and state which organ system the slide belongs to

Required prior knowledge from lecture material:

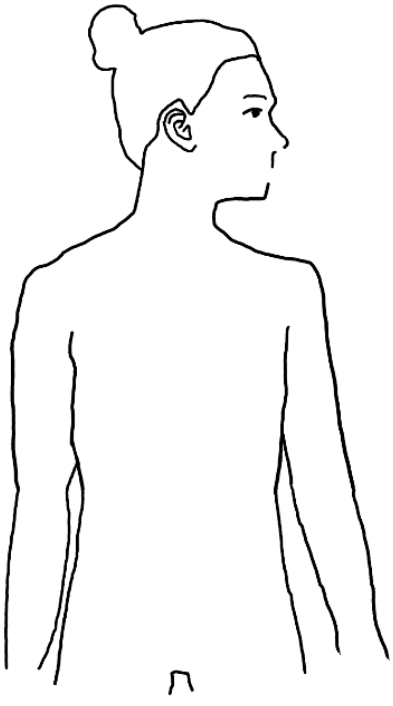
- Digestive and urinary system anatomy

Introduction

To complement the theoretical understanding of the digestive and urinary systems from lecture, students will explore the various organs of these systems via models as well as fresh and preserved samples and microscopic slides. Observations are to be done in pairs, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
  - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
  - Draw and label the digestive system organs on the drawing below: **oral cavity, pharynx, esophagus, stomach, small intestine, large intestine, colon, liver,** and **pancreas.**



Part 1: Anatomical Planes and Directions

Humans are **bilaterally symmetrical**, which means we have nearly identical right and left halves of our body. Our bodies are also filled with various organs in a three dimensional space, thus we have **planes** and **directional terms** to locate and identify them in medicine and anatomy.

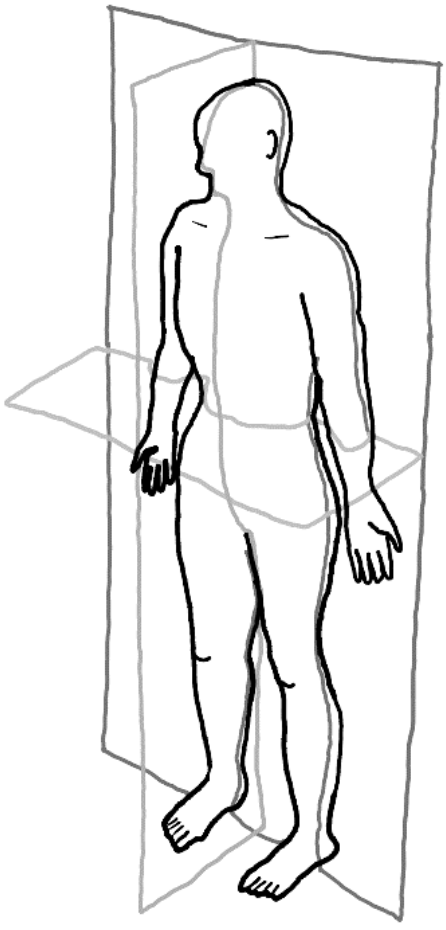
The **mid-sagittal** plane runs from our heads to our tailbones and separates our body into right and left. If an organ is closer to this plane than another, it is **medial**. If it farther right or left, it is **lateral**.

The **frontal plane** (aka coronal plane) also runs from our heads to our tailbones, but it separates our body into a front and back. If an organ is closer to the front than another, it is **anterior** (aka ventral). If it is closer to the back, it is **posterior** (aka dorsal).

The **transverse plane** runs across our bodies, separating it into a top and a bottom. Organs that are closer to the top (closer to your head) than others are **superior**. Organs that are lower (closer to the tailbone) are **inferior**.

Arms and legs are a little different; rather than inferior and superior, the structures in them are either **proximal** (closer to the body's attachment point) or **distal** (farther away from the attachment point). We won't use these two terms much in this lab, though.

1. Label the 3 **planes** and 6 **directions** (not proximal and distal) on the drawing below:



2. Fill in the following blanks with the appropriate **directional term** (use a nearby torso model, if needed).
   <u>NOTE</u>: Each directional term will only be used ONCE, so if there are two possible answers, choose the one that has not yet been used.

   a. Lungs are _____ to the heart.

   b. Hips are _____ to shoulders.

   c. Eyes are _____ to ears.

   d. The head is _____ to the neck.

   e. The belly button is _____ to the stomach.

   f. The spine is _____ to the esophagus.

3. Come up with three other phrases using other organs/structures of the body below:

   a. The _____ is/are _____ to the _____

   b. The _____ is/are _____ to the _____

   c. The _____ is/are _____ to the _____

4. Fill in the **plane** that would separate the following organs and structures:

   a. The _____ plane would separate the right and left lungs

   b. The _____ plane would separate the lungs from the liver

   c. The _____ plane would separate the trachea from the esophagus

Part 2: Human Torso Anatomy

1. Observe a torso model and identify the following **digestive** and **urinary system organs**. *Note: Numbers and letters below refer to hose on the model(s) provided. Different models may have different numbers.*
2. Fill in the blanks for the functions of each organ as you go and take pictures of the models.

Digestive System

16. (56) **esophagus** pushes food from pharynx to _____ via peristalsis

19. (70) **liver** produces _____, among many other functions

20. (e) **gall bladder** stores and secretes _____ into duodenum

22. (22) **stomach** temporarily stores _____, secretes acid, mucus, and pepsin

23. (74) **pancreas** secretes digestive enzymes and buffers into _____

25. (61) **small intestine** digests and _____ food

26. (60) **duodenum** major site of digestion, first 25 cm of small _____

30. (X) **cecum** receives chime from ileum of small intestine, sends to _____

30a. (y) **appendix** reservoir for beneficial _____

29/31. (65-67) **colon** absorbs _____, compacts feces, houses beneficial bacteria

c. (65) **ascending colon**

d. (66) **transverse colon**

e. (67) **descending colon**

32. **sigmoid colon**

33. (69) **rectum** temporarily stores _____

3. Test your partner on the location and function of each organ before continuing.

Urinary System

34. (78ab) **kidneys** filter blood and produce _____

52. / 92 (80) **ureters** send urine from kidneys to _____

51. (88) **bladder** temporarily _____urine

57. (65) **urethra** excretes urine from body (in males, also excretes _____)

Part 3A: Kidney Models

1. Observe a kidney model and find the following structures.
   Note: Numbers and letters below refer to hose on the model(s) provided.
2. Trace the path that **blood** would take in and out of the kidney, as well as the path that **filtrate/urine** would take out of the kidney.
3. Fill in the blanks for the functions of each structure.

A. **renal medulla** inside portion of kidney *(note: on one of our models (A and B both refer to parts of the medulla: A = **renal pyramid**, B = **renal column**)*

B. **renal cortex** outside portion of the kidney

1. **renal vein** returns filtered _____ from kidney to inferior vena cava

2. **renal artery** supplies kidney with blood to be _____

3. **ureter** collects urine from renal pelvis and sends to _____

4. **renal pelvis** collects urine from collecting ducts and sends to _____

8. **collecting duct** collects urine from multiple nephrons and channels into _____

10. **loop of Henle** reabsorbs additional _____ and _____ from urine

11/12. **Bowman's capsule** collects filtrate from _____

Test your partner on the location and function of each structure and take pictures before continuing.

Part 3B: Nephron Model

1. Observe the middle part of the model represents an enlargement of a kidney model, highlighting nephron anatomy and identify the various nephron structures.

2. Trace the path that **filtrate/urine** travels.

1. **Bowman's capsule with glomerulus**	pressure-filters blood
2a. **proximal convoluted tubule**	reabsorbs water, salts, and nutrients

2b **descending** and 2c **ascending limbs of loop of Henle** (see previous description)

2d. **distal convoluted tubule**	secretes wastes from capillaries into nephron
6. **collecting duct**	(see previous description)
11. **peritubular capillaries**, **vasa recta**	take up water and solutes; secretes additional waste (Note – vasa recta surrounds loop of Henle, peritubular capillaries surround the convoluted tubules)

Test your partner on the location and function of each structure and take pictures before continuing.

Part 4: Microscopic Slides

1. Observe the slides provided that demonstrate the **epithelium** of various digestive and urinary system organs. Take pictures and draw what you see.

2. Record the type of epithelium that is present at the surface (is it **simple** or **stratified**? **squamous, cuboidal,** or **columnar**?).

Esophagus

This is slide is a **transverse** section of both the **esophagus** and the **trachea**. The pointer is indicating the esophagus.

Type of epithelium: _____

Drawing:

Stomach

Focus on the types of cells closest to the lumen.

Type of epithelium: _____

Drawing:

Duodenum

Type of epithelium: _____

Drawing:

a. *What are the small finger-like projections in the epithelial lining called?* _____

b. *What are the even smaller finger-like projections that are found in the epithelial cells themselves?* _____

Frontal Section of Kidney

Dissecting Scope

Observe the slide of a **frontal section** of a kidney on the **dissecting scope**. Note the kidney's **renal capsule**, the difference between the **cortex** and **medulla**, and the **renal pelvis** and **hilum**. Draw it below and label those structures.

Objective Scope

Observe the slide of a **frontal section** of a kidney on an **objective scope.** Starting at X40, then X100, then X400, view the tissues inside. In the cortex, identify the **Bowman's capsules** (surrounding **glomeruli**).

Part 5: Preserved and Fresh Organs

Observe the various preserved and fresh organs from the digestive and urinary systems, trying to see the structures that were highlighted on the models. Consider taking pictures for studying purposes.

Once you have completed all of your observations, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Written Assignment (due at the beginning of next lab)

- See D2L for a virtual tutorial/quiz (to be completed individually)

Lab 10B: Anatomy Part II: Respiratory and Circulatory Systems

Following this lab, students should be able to:

- Apply the three planes of bilateral organisms and the six directions
- Identify organs and tissues from the respiratory and circulatory systems and note their locations in the body and any specific functions or structures associated with them
- Identify anatomical structures of the heart and describe the path of blood (oxygenated and deoxygenated) through the heart and associated vessels and valves
- Given a tissue slide that relates to the respiratory or circulatory system, identify the structure under a microscope and state which organ system the slide belongs to

Required prior knowledge from lecture material:

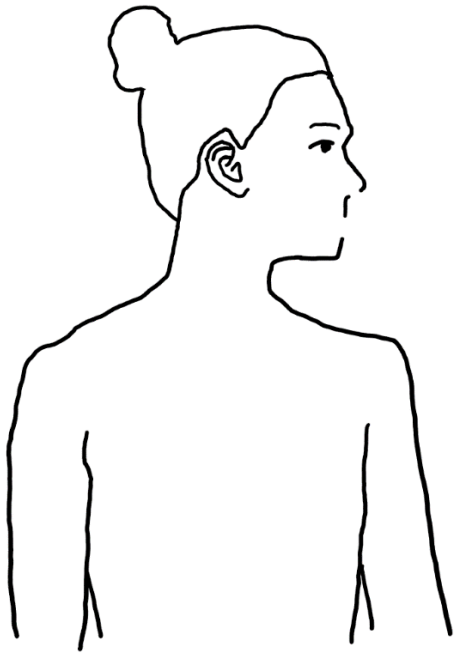
- Respiratory system and circulatory system anatomy

Introduction

To complement the theoretical understanding of the respiratory and circulatory systems from lecture, students will explore the various organs of these systems via models as well as fresh and preserved samples and microscopic slides. Observations are to be done in pairs, though each student is to write their own notes in their lab manuals for studying purposes.

Pre-Lab:

- Before arriving to the lab:
    - Read the lab manual for this session, highlighting important concepts and noting confusing sections.
    - Fill in the following blanks using directional terms learned in the previous lab.
        - The esophagus is_____ to the trachea.
        - The liver is_____ to the diaphragm.
        - The abdominal aorta is _____ to the kidneys.
        - The urinary bladder is _____to the rectum.
        - The pancreas is _____ to the left kidney.
    - Draw the respiratory system on the following page and label the following organs: **nasal cavity, nasal conchae, oral cavity, pharynx, epiglottis, larynx, trachea, primary and secondary bronchi, alveoli, and diaphragm.**



End of Pre-lab

Part 1: Human Torso Anatomy

1. Observe a human torso model and identify the following **respiratory** and **circulatory system organs**.
   Note: Numbers and letters below refer to hose on the model(s) provided. Different models may have different numbers.
2. Fill in the blanks for the functions of each organ as you go and take pictures of the models.

Respiratory System

1/2. (48) **larynx**	voice box, contains vocal _____
4. (49) **trachea**	wind pipe, has C-shaped _____ to keep it open
13. (55ab) **bronchi**	send air to and from trachea and _____
10/11 **lungs**	contain millions of _____ for gas exchange
18. (58) **diaphragm**	contracts down to _____ lungs, forcefully pulling air into lungs

Circulatory System

17. **Heart** _____ blood to and from body and lungs

c. **superior vena cava** sends deoxygenated blood from _____to right atrium

d. **inferior vena cava** sends deoxygenated blood from _____to right atrium

h. **pulmonary trunk** sends deoxygenated blood from right ventricle to _____

i. **aorta** sends oxygenated blood from left ventricle to _____

*Where are the **renal** arteries and veins in the body?* _____

*Where are the **hepatic** arteries and veins in the body?* _____

*Where are the **pulmonary** arteries and veins in the body?* _____

Part 2: Human Split Head Model

1. Observe a split head model and find the following organs.
2. Indicate if they are part of the digestive system (D), respiratory system (R), or both (DR).

60. **nasal cavity** _____

57/58/59 **nasal conchae** _____

72. **pharynx** _____

73. **larynx** _____

74. **epiglottis** _____

81. **trachea** _____

84. **esophagus** _____

What plane has this model been sectioned by? _____

Test your partner and take pictures before continuing.

Part 3: Heart Model

1. Observe a heart model and find the following structures.
   Note: Numbers and letters below refer to hose on the model(s) provided. Different models may have different numbers.
2. Trace the path that **blood** would take through the circulation of the heart, noting the **chambers, valves,** and **vessels** it passes through.
3. Fill in the blanks for the functions of each structure.

Ia. (128) **right atrium** receives oxygenated blood from the inferior & superior _____

II b. (129) **left atrium** receives _____blood from the pulmonary veins

III (130) **right ventricle** receives deoxygenated blood from the _____

IV. (131) **left ventricle** receives oxygenated blood from the_____

1. (132) **superior vena cava** receives _____ blood from the upper body

2. (133) **inferior vena cava** receives _____ blood from the lower body

3&6 (135&136) **atrioventricular valves** prevent back-flow of blood from ventricles to atria

b&d. (140) **semi-lunar valves** prevent back-flow of blood from aorta and pulmonary trunk to ventricles

pulmonary trunk receives _____ blood from right ventricle

a. (137a&b) **pulmonary arteries** receive deoxygenated blood from _____

5. (134) **pulmonary veins** receive oxygenated blood from_____

7. (139) **aorta** receives oxygenated blood from _____

8&9a (141, 142,143) **coronary arteries** supply cardiac (heart) muscle with _____ blood

B. **interventricular septum** separates left and right _____

Test your partner and take pictures before continuing.

Part 4: Microscopic Slides

1. Observe the slides provided that demonstrate the tissues and cells of various respiratory and circulatory organs.

2. Take pictures and draw what you see.

Trachea

This is slide is a **transverse section** of both the **esophagus** and the **trachea**.

Which one is **posterior**? _____

Note the **ciliated pseudostratified columnar epithelium** and **hyaline cartilage** on the trachea.

Drawing:

Blood Vessels

This is a slide of tissue with blood vessels inside, magnified X100.

a. Distinguish between **arteries** (thick-walled) and **veins** (thin-walled).

b. Estimate their diameter in µm using calculations from **Lab 4**.

Drawing:

Blood Smear

This is a blood smear slide (seen before in **Lab 7**) magnified X1000.

a. Distinguish between **erythrocytes** (red blood cells), **leukocytes** (white blood cells), and **thrombocytes** (platelets). Recall the descriptions from **Lab 7**.
b. Draw each below again as a refresher and write their functions next to their drawing.

Part 5: Fresh and Preserved Specimens

Observe the preserved and fresh samples of various organs from the respiratory and circulatory systems. Take photos as needed, and pay attention to whichever specific organs and systems your instructor has indicated.

Once you have completed all the observations, have one student from the group show their lab manual to the instructor for verification and the rest can tidy and clean the lab bench and equipment. Don't forget to push in your chairs!

Written Assignment (due before lab exam #2)

- See D2L for a virtual tutorial/quiz

Lab Exam #2

Instructors typically finish the end of the lab term with a second lab exam, scheduled during regular lab time.

These lab exams will assess your understanding of the concepts, methods, and calculations from Labs 6-10 and will typically take 1-2 hours to complete (they are NOT cumulative unless otherwise stated by your instructor).

Each instructor offers their own version of the lab exam, but typically there are ~20 stations with questions and challenges that relate to previous lab material.

Use the "**Following this lab, students should be able to**" sections of the labs to prepare, as well as reviewing the lab manual and any previously completed assignments.

Reminder: lab exams CANNOT be rescheduled due to the complicated set-up of the exams.

Your instructor may provide more information on the weeks leading up to your second lab exam.

Good luck!