Biology **Activity: Science Process; Measurements; Tools; Data Presentation and Analysis**

Purpose: Review scientific practices, the use of measuring tools and microscopes, data collection, and the proper units to use in science, through an investigation of possible physical differences in leaves found at different locations on the same tree.
Question: Do the physical characteristics of leaves differ based on their location on a tree?

Background: The function of leaves is to carry out photosynthesis. The process is complicated, but can be summarized as follows:

Carbon Dioxide + **Water** + **Energy** **(produces)** **Sugar** + **Oxygen**
(from the air) (from the roots) (from the sun) ⟶

So, plants are converting light energy into the chemical energy we use as food, and the oxygen we need to breathe! If you think about it, they are also taking a gas and water (with minerals) and making new plant cells – which provide us with the energy we need!
Photosynthesis occurs in the leaves of a plant. By looking at the equation above we know that leaves must be able to:

1. Collect **sunlight**
2. Get **carbon dioxide** from the air
3. Get **water** into the leaf from the roots

In addition to sunlight, leaves need water and carbon dioxide in order to create simple sugars. Water is taken up by the roots and brought to the leaves in tube-shaped cells (called xylem). There are holes, called stomata, on the back of the leaf to let in CO_2. However, while the stomata are open to let CO_2 in, they are also letting H_2O out. Leaf structure should reflect a balance between the need for light, CO_2 and retaining water, so variations in surface area, thickness and stomata are a result of their environmental conditions.

For this activity we will investigate how plants manage the tradeoff between light capture, carbon dioxide collection, and water loss. Depending on the environmental conditions around leaves, they may change their shape or structure to achieve the balance between water, light and carbon dioxide.

Materials:

pole cutter	card stock	balance
clippers	ruler	microscope
plastic bags	scissors	nail polish, tape, slide
marker		

Procedure:

1. Gather leaves; place them in a plastic bag; mark it with the location on the tree and your name
2. Make a data table to keep track of the measurements you will be making. Don't forget you have 2 types of leaves. Create enough columns so you can enter your classmate's data as well.

3. Gather data on both of the leaves
   Make observations about their characteristics (texture; veins; # lobes; petiole; etc.).
   Mass them; (you need this information to calculate surface area and thickness).
   Carefully trace their outlines on a piece of card stock; carefully cut out the leaf outline

4. Determine the surface area of the leaf. Instead of trying to measure an irregular area, you can use a ratio of the mass of the leaf outline on card stock to the mass of a known area of card stock.
   Cut out a section of card stock with a known surface area (4cm X 4cm). Mass it; mass each leaf outline.
   Set up a ratio for each leaf – its surface area over its mass = X over the mass of the outline; solve for X.

5. Determine the relative thickness of each leaf by calculating the Specific Leaf Weight (leaf mass / area).

6. Determine the relative number of stomata by making a mold of the **back** of each leaf.
   On the bottom of each leaf, cover an area about $2cm^2$ with a thin layer of clear nail polish; when it has dried, place a piece of clear tape over the area, press gently, then remove the tape and polish; stick the tape to a clean microscope slide. Label the slide with the leaf location and your initials.
   View the slide under the microscope; count the number of stomata in the field of view on **high** power. Move the slide and count 2 more times. Calculate the average of your counts.

Biology **Name _____**

Activity: Sci. Process; Plant Ecophysiology **Per. _____** **Date _____**

Pre - Investigation questions: (answer "top" or "bottom")

1. Where on a tree would the most light be available to leaves? _____

2. Where on the tree would light be most limited? _____

3. Where on a tree would the potential for water loss be greatest? _____

4. Where on a tree would the potential for water loss be the lowest? _____

Consider the tradeoff between the leaf's need to gather light and CO_2 , and the need to conserve H_2O and other resources – then answer the questions below.

5.a. What would be an advantageous surface area for a leaf to have in an environment where there is little light?

b. Where there is abundant light?

6.a. What would be an advantageous thickness for a leaf to have in an environment where there is the potential for a great deal of water loss?

b. Where there is the potential for very little water loss?

7.a. Where on the tree would it be advantageous for leaves to have many stomata?

b. To have very few stomata?

Forming a Hypothesis

Based on your answers from above, develop hypotheses for how leaf size (surface area), thickness, and stomata density would differ between leaves at the top of the tree and leaves at the bottom of the tree. (Remember hypotheses are written in an "if… then…" format, and followed by a justification statement.)

Size:

Thickness:

Stomata:

Name:_____

DATA SHEET

All data must include correct units!!!!

1. Observations: (list)

2. Leaf masses:

	Top of tree	Bottom of tree
Mass of leaf		
Mass of leaf tracing		

3. Paper square data

Mass of paper square	
Area of paper square	

4. Stomata counts

	Top of tree	Bottom of tree
Stomata 1st FOV		
Stomata 2nd FOV		
Stomata 3rd FOV		
Average		

5**.** Leaf Area and thickness

	Top of tree	Bottom of tree
Leaf Area		
Thickness of leaf		

Calculations

Surface Area (How big is the leaf?)
Determine the surface area of the leaves using the outline you traced. Since the shape is irregular, we will use a ratio between the mass of a known area (the square) and the mass of the leaf cut out, according to the following formula:

$$\frac{\text{Area of paper square}}{\text{Mass of paper square}} = \frac{\mathbf{X}}{\text{Mass of leaf outline}}$$ (**X**= area of leaf)

What is the correct unit for area? _____ Show your work below and record your answers on the Data Sheet.

Top leaf:

Bottom leaf:

Thickness of Leaf
Since we cannot measure the thickness of the leaf, we will calculate it using the Specific Leaf Area (a ratio of leaf area to leaf mass)

Divide your leaf mass by the actual area of the leaf (calculated above). Use actual leaf mass NOT the cut out. Show your work below and record your answers on your data sheet

$$\frac{\text{Mass of leaf}}{\text{Area of Leaf}} = \text{Specific Leaf Area (the larger the number, the thicker the leaf)}$$

Top leaf:

Bottom Leaf:

Class Data
Record your data and class data in a table. Calculate class averages once all data has been collected. Graph the class data. You will need three graphs: area, thickness and stomata. Include error bars on the graph. Error bars are based on the standard deviation for each of the averages. Follow teacher instructions for calculating standard deviation.
Results:
1. Calculate **class averages** once all data has been collected. Record the averages in a table.

2. Create 3 separate graphs comparing the information on the 2 types of leaves. Use the class averages. Include error bars on the graph. (See instruction provided by teacher.)

Analysis and Conclusions:

1. Based on class data, where are the leaves (top or bottom)
   Larger? Thicker? Have a greater number of stomata?

2. Do these results support your hypotheses? Explain.

3.a. Does the class data agree with your results? List the similarities and differences.

b. Provide at least 3 reasons why differences may exist between your data and your classmates. Do NOT speculate- make statements that can be supported with observations; consider constants & measuring; consider your understanding about variation among individuals.

c. Why is it better to draw conclusions based on class data as opposed to using just your own?

4. Draw a conclusion (based on class data) as to whether or not there are any meaningful differences between leaves on the top and the bottom of a tree. You must cite data and do calculations to compare the differences, AND you must discuss what the standard deviation tells you about those differences.

5. How is this investigation an example of how scientists solve problems?

Summary

Write a short reflection on this lab addressing the following points:

- What would help you understand this lab better?
- What new things did you learn in this lab?
- How did this lab help you to remember or better understand the scientific process?