

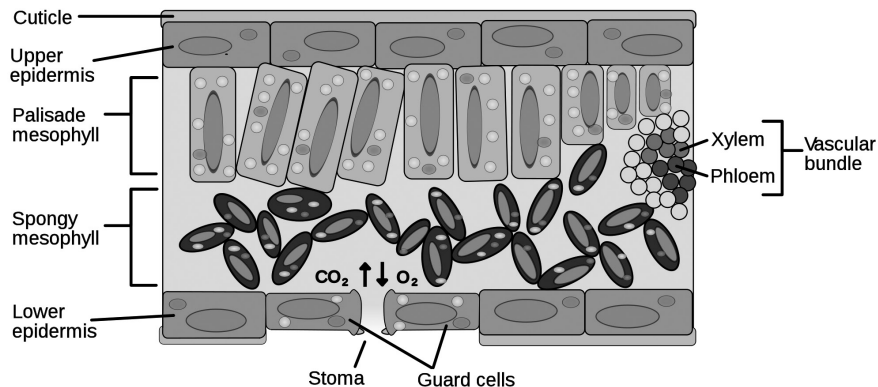
Lab 7. Transpiration: How Does Leaf Surface Area Affect the Movement of Water Through a Plant?

Introduction

Plants, just like other organisms, must be able to transport materials from one part to another. Plant transport systems consist of two large tubes made of vascular tissue that run from the roots through the shoots and to the tips of the plant. Sugars produced through the process of photosynthesis are transported through plants from leaves to roots via the vascular tissue known as the phloem. Cells use these sugars to produce the energy needed for the rest of the plant's functions. Sugars move through the plant because they are in highest concentration in the leaves, where photosynthesis takes place, and in lowest concentration in the roots. Many plants will store excess sugars in specialized root structures called tubers.

Water is transported in plants from the roots to the leaves through the vascular tissue known as the xylem. The water then enters the leaf and is used in the process of photosynthesis. In a tree such as the giant redwood of California, water must ascend over 300 ft. to reach the highest leaves. The water moves through the plant because the concentration of water is highest in the roots of a plant and lowest in the leaves. Transpiration, or loss of water from the leaves due to evaporation, helps to create a lower concentration of water (or lower osmotic potential) in the leaf. The differences in water concentration are also responsible for the movement of water from the xylem to the mesophyll layer of the leaves and subsequently out to the atmosphere (see the figure below).

The structure of a leaf featuring the major tissues: the upper and lower epidermis, the palisade and spongy mesophyll, and the guard cells of the stoma.



Vascular tissue (veins), made up of xylem and phloem are also shown. The light green circles within cells represent chloroplasts and indicate which tissues undergo photosynthesis.

The transpiration rate of a plant (or how quickly water is lost from the leaves due to evaporation) is influenced by a number of environmental factors. One of the most important factors is air temperature; evaporation rates increase as the temperature goes up. Plants that live in hot locations, therefore, can lose large amounts of water from their leaves because of transpiration. When there is plenty of water in the soil, like after a heavy rain, replacing the water that is lost from the leaves because of transpiration is not a problem. However, when water is scarce and the temperature is high, plants can quickly dry out and die. Some plants, therefore, have specific adaptations that enable them to help control water loss. One such adaptation could be the number or size of leaves found on a plant.

Your Task

Determine if there is a relationship between leaf surface area (i.e., the total number of leaves or the size of the leaves found on a plant) and transpiration rate.

The guiding question of this investigation is, **How does leaf surface area affect the movement of water through a plant?**

Materials

You may use any of the following materials during your investigation:

- 6 Test tubes (150 mm × 15 mm)
- Test tube rack
- Graduated cylinder (25 ml)
- 6 Bean plants (about 3 weeks old)
- Graph paper
- Ruler
- Beaker (600 ml)
- Electronic balance
- Floodlight or plant stand with light
- Glass stirring rod
- Safety goggles and aprons

Safety Precautions

1. Safety goggles and aprons are required for this activity.
2. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires, and shock hazards. Use only GFI-protected circuits.
3. Lightbulbs can get hot and burn skin. Use caution and handle with care!
4. Wash hands with soap and water after completing this lab.
5. Follow all normal lab safety rules.

Getting Started

To answer the guiding question, you will need to design and conduct an experiment. To accomplish this task, you must be able to measure the transpiration rate of a plant. You can use the following procedure to measure a transpiration rate (see the figure to the right):

1. Pour 15 ml of tap water into a test tube.
2. Place one plant without soil on the roots into the test tube of water (be careful not to damage the roots).
3. Gently push the roots to the bottom of the tube. (The eraser end of a pencil works well for this, as does a glass stirring rod.)
4. Place this tube into a test tube rack in a warm and lighted place in the room for at least 24 hours (48 hours is better).
5. Remove the plant from the tube.
6. Remove leaves and trace on graph paper to determine total surface area.
7. Measure the amount of water left in the test tube.
8. Calculate the transpiration rate using the following equation:

$$\text{Transpiration rate} = \frac{\text{original amount of water} - \text{amount of water left}}{\text{minutes}}$$

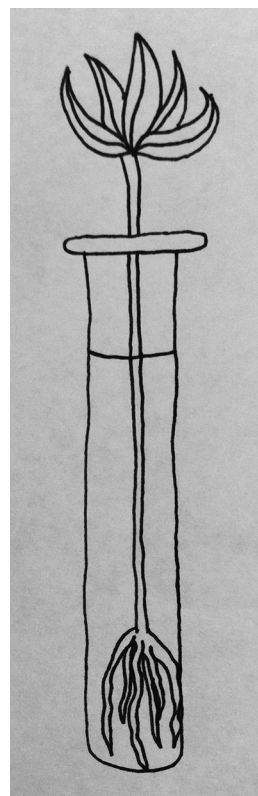
This procedure will allow you to measure the rate at which water moves through the plant. Now you must determine what type of data you will need to collect, how you will collect it, and how will you analyze it for your actual investigation. To determine *what type of data you will need to collect*, think about the following question:

- What type of measurements will you need to record during your investigation?

To determine *how you will collect your data*, think about the following questions:

- What will serve as a control (or comparison) condition?
- What types of treatment conditions will you need to set up and how will you do it?
- How many trials will you need to do?
- How often will you collect data and when will you do it?
- How will you keep track of the data you collect and how will you organize the data?

Plant setup



To determine *how you will analyze your data*, think about the following questions:

- How will you determine if there is a difference between the treatment conditions and the control condition?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

Investigation Proposal Required? Yes No

Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of identifying the underlying cause for observations,
- what is and what is not relevant at different scales or time frames,
- how matter moves within or through a system,
- how structure determines function in living things,
- the difference between observations and inferences in science, and
- the different methods scientists can use to answer a research question in science.

Argumentation Session

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did you decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!