**Plant Form and Function: Transpiration**

A vascular plant must overcome the force of gravity to transport life-sustaining water from the soil throughout its tissues. The particular cohesion-adhesion properties of water are what allow plants to pull water up from the roots against gravity and to distribute it to the leaves and other parts of the plant. This process is known as **transpiration**, the movement of water and minerals through the xylem. Transpiration is a central mechanism by which plants deal with external conditions and internal needs.

Transpiration occurs when the drier air outside pulls out the water vapor inside the leaf. The water vapor from the air spaces inside the leaf is replaced by the evaporation of water from the mesophyll cells. As water molecules evaporate, they exert a pulling force on the rest of the water in the cells. This pulling force is due to two unique properties of water: water molecules tend to stick to one another (cohesion) and they also tend to stick to the sides of the cells (adhesion). Thus, evaporation pulls water out from the cells, creating tension on the xylem cells to replace this lost water. In this manner, water is pulled up through the xylem as explained by the **cohesion-tension hypothesis**.

Transpiration rates are affected by a variety of factors. For one, specialized cells called **guard cells** surround leaf pores called **stomata** that open and close depending on the environmental conditions surrounding the plant. When water is in excess, light is low, and the temperature is cool, the stomata remain open; when water is scarce, light is in abundance, and the temperature is warm, the stomata are closed. Stomata help regulate water loss from the plant and are critical parts of the transpiration process. Plants in different environments experience different conditions thus have different adaptations that prevent excessive water loss, while still allowing for transpiration to occur.

In this lab you will design, and your TA will carry out, an experiment in which you ask how do transpiration rates differ in “condition x” compared with “condition y”? By comparing transpiration rates among plants and among environmental conditions, we can understand the process of transpiration and the adaptations involved in transpiration. Your TA will collect the data, but you will analyze the data and write an illustrated summary describing your findings.

**Learning Goals of this Lab Activity**

1. Design an experiment that allows you to identify the effect of a manipulation of your choosing on the rate of transpiration.
2. Convey findings by authoring an abstract that summarizes your study using references, and includes a figure, caption, and statistics.

**WORK: Designing and choosing the experiment**

1. With your breakout groupmates, discuss some ideas and decide on a question you are interested in testing. Think first about what abiotic or biotic factor you are interested in manipulating. The possible tools you can use to manipulate transpiration rate will be listed in the PowerPoint presentation. Then, derive the hypotheses and prediction associated with the question you ask about the manipulation. Record them below.

**Breakout Group Study Question**

**Breakout Group Null Hypothesis**

**Breakout Group Research Hypothesis**

**Breakout Group Prediction**

1. Propose your study question and design to the entire class. When you have heard everyone’s proposal, we will take a vote on which study question we will address.
2. Write the final study question we have decided on here, including the null hypothesis, the research hypothesis, and the predictions associated with the research hypothesis.

*NOTE*: You do not need to share the same research hypothesis or prediction as your classmates, but it is possible you will! The important thing is to write your hypothesis and predictions *entirely in your own words.*

**Class Study Question**

**Class Null Hypothesis**

**Class/Individual Research Hypothesis**

**Class/Individual Prediction**

1. Discuss as a class the experimental design needed to answer the study question we have chosen. Record notes on your design below; take care to list how you will control for all other factors, except your manipulation. Also note precisely how the manipulation will be applied.

|  |  |
| --- | --- |
| Treatment 1 description (control) | Treatment 2 description (experimental) |
|  |  |

**TA Procedure**

So that you are aware how your TA will conduct this study on your behalf, here are the instructions they will follow:

**Set-up**

1. Gather 24 flat-bottom vials, 24 plants, 10 2 x 1 square pieces of Parafilm, and whatever material you need to apply your treatment to half of the plants.
2. Follow the instructions in the booklet with the balance on how to calibrate the device using the 200 g weight provided.
3. Gently remove the plant from the paper towel, keeping the roots intact, and place the plant into a flat-bottom vial. Do not let the plant sit out for too long with the roots exposed.
   1. Position the plant so that the base of the stem is at the surface of the water and the roots are entirely submerged.
4. Use DO water to fill the vials. Keep the water levels no higher than 45 mL (that is, 45 mL when the plant is in the vial). Top off the water in the vials using the squirt bottle on your table to get it to precisely 45 mL.
5. Stretch a 2 x 1 square piece of Parafilm against the edge of the vial to wrap the Parafilm around the stem of the plant like a tie or collar. This will reduce evaporation from the surface of the water so that any observed mass loss is due to transpiration through the plant. Blot to dry off the surface of the Parafilm and the outside of the container.

*NOTE:* Be sure all of the Parafilm sits well above the surface of the water in the vial. Otherwise it is possible for water to wick up and out of the vial.

1. Repeat steps 4-6 for all 24 plants. If you are applying a treatment to the water itself, be sure to do so to half the plants before you seal them with parafilm.
2. After a short period of time, use a paper towel to confirm that the outside of the vials is still dry and that you do not have any water wicking up and outside the Parafilm. Clearly label your vials with labelling tape on which you write your group name, section number, and a unique vial identifier, and place them off to the side of the classroom to sit for one week.
   1. Do not write the treatment on the vial but be sure to record in the in the class data table linked on ReggieNet what treatment each vial experienced.
3. When all plant set-ups are complete, tare the balance before use by pressing the "ZERO" button. This should be repeated throughout the lab period to ensure zero reads out as 0.00 g.
4. Take the initial mass of each set-up (24 plants--12 controls, 12 experimental) and record the mass in g, as well as the “start” time at which you took the mass for each sample and record in the class data table linked on ReggieNet.

**Collecting the Data**

1. Calibrate the balance.
2. Tare the balance.
3. Record the “stop” time of the experiment for each sample.
4. Take the mass and simultaneously record the “stop” time of all 24 samples in the table linked on ReggieNet.
5. Next week (week 11) we will analyze the data and interpret our findings by creating a figure and caption that includes the output of the statistical analysis.
6. You will convey your findings by authoring an abstract outline (due in week 12, week of March 29) and a complete abstract (due in week 13, week of April 5).