Outdoor Classroom: Gillespie Museum

How Much Water is in a Leaf?

Big Picture:

Plants need water, but it can be hard to hold onto. The same holes (stomata) that allow carbon dioxide to enter for photosynthesis, also let water out. How quickly can water move (transpire) out of the leaves? How do leaves of different species differ in the rate at which water is lost?

Core Science:

Levels 1-2

- Observe Nature: Observe differences in thickness, area, and surface characteristics (e.g., waxiness, hairiness) of leaves of different species. Watch leaves release water, through their stomata, when exposed to sunlight.
- Collect Information: Record rate at which leaves lose water.
- Explanations of our world: Observe the effect of various leaf traits on transpiration rates.

Levels 3-5

- Observe Nature: Observe great diversity in leaf traits among species. Watch energy exchange through transpiration.
- Collect and Record Data: Calculate rate of transpiration. Quantify differences in transpiration rates between different types of leaves.
- Develop Theories: Use a basic understanding of the role of stomata in photosynthesis and transpiration to explain differences in transpiration rates among leaf types.

Materials:

500mL Beaker
Plastic cups
Leaves (at least 2 species)
Scissors
Lamp
Parafilm (M Bemis Laboratory)
Graduated 10mL test tube
Clay
Pin
Permanent marker
Water
Graph paper
Tape

Preparation/Set Up:
Ask students to gather leaves from a variety of species that differ in a variety of ways (i.e. different sizes, thickness, shape); however, make sure that the leaves can fit inside the plastic cup without being cut. In a 500mL beaker, place a small piece of clay in the bottom that can be used to secure a small test tube in an upright position.

Next, fill a graduated 10mL test tube with water and place it upright in the clay. The top of the test tube should be at exactly the same height as the top of the beaker in which it sits. Stretch a piece of Parafilm® across the top of the test tube and beaker and poke a small hole in the middle of the Parafilm® through which you will insert the leaf petiole, making certain that the petiole reaches into the water (Fig. 1a). It is important that the Parafilm® is sealed tightly around the edge of the test tube as well as around the leaf petiole so that water from the test tube cannot evaporate. Only water that is transpired through the leaf should be captured in the chamber you create.

Once the leaf is positioned in the test tube with Parafilm® sealing it in place, place the plastic cup over the leaf onto the edge of the beaker (Fig. 1b) and use additional Parafilm® to seal any gaps between the top of the beaker and the rim of the plastic cup. For most efficient light capture, try to ensure that the upper surface of the leaf is facing up. Center the lamp approximately 50 cm above the chamber you have created. Note: If the weather permits, the beakers can simply be put in a sunny spot outside.

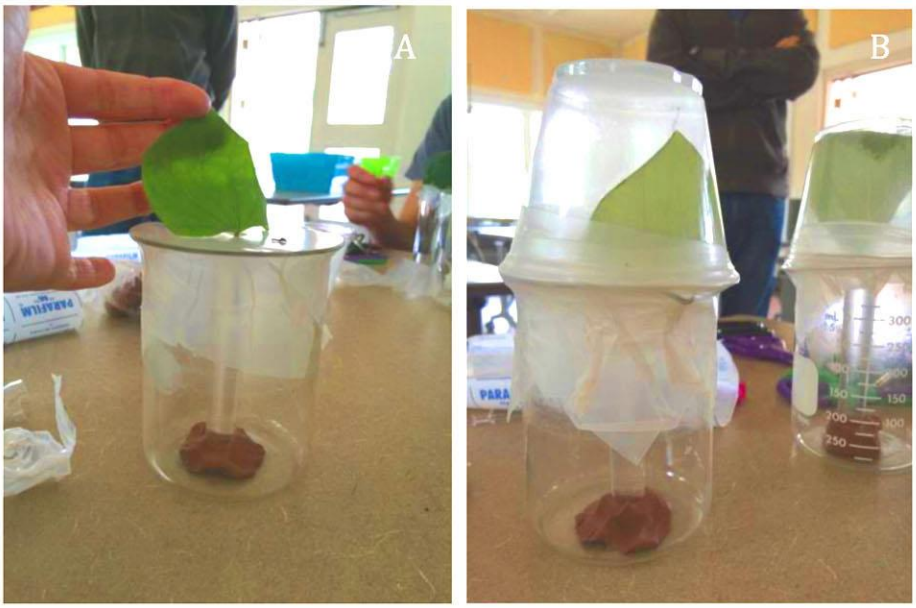

Fig. 1. Making a chamber to measure transpiration of a single leaf. A) Left photo shows setup with the stem of the leaf in the test tube and the rest above the beaker. B) Right photo shows set-up with the addition of the cup sealed with Parafilm® to capture transpiration.

Activity:
Once the leaves are sealed in the chamber, turn on the light or expose chambers to direct sunlight and have students start a timer. Ask the students to check their cups every 5 min. The water that condenses on the sides of the cup is the result of transpiration, where water has been drawn up through the leaf's petiole and out through its stomata. In order to measure differences in transpiration, leaves should be removed from direct light before the inside of any individual cup is completely covered in water. This may take 5 to15 minutes depending on the species.

Once the leaves have been removed from the light source, stop the timer and take the cups off the beaker. Draw a line, tracing the edge of the condensation, and then cut the cups vertically so that they lie flat. Tape the flattened cup to a piece of graph paper (copies of Appendix A work nicely because the squares are 1 x 1 cm) so that students can calculate the area (number of squares) of condensation as a measure of the amount of water lost in a given amount of time.

Ask younger students to visually compare the sizes of the leaves and the heights of the water lines. They should see that the largest leaves have the greatest loss of water in a given amount of time.

Ask older students to measure the area of the leaves and then measure the area of the condensation on the cup; this data can then be placed in a scatterplot that should show a positive relationship between leaf size and the amount of transpiration. Advanced students may want to calculate the amount of water lost per unit leaf area to compare transpiration rates between leaves that differ noticeably in, for example, their thickness or waxiness of their cuticle.

Take Away:

In sunlight, leaf stomata must open to allow carbon dioxide to enter and photosynthesis to occur. Open stomata, however, also allow water to leave through transpiration. By comparing transpiration rates between leaves of species that are adapted to different environments, students will have a better understanding of: a) plant physiology generally and transpiration specifically and b) adaptations that allow plants to inhabit a diversity of environmental conditions. For example, plants that grow in shady, wet sites (e.g., swamps) typically have large leaves with high transpiration rates because the availability of sunlight, not water, tends to limit their growth. Conversely, plants in dry, sunny sites, like Florida sandhills, tend to have small leaves with modifications that reduce water loss (e.g., hairs on the undersurface of the leaf, waxy cuticles, thick leaves) as their growth is rarely limited by sunlight, but often limited by water availability. The most important thing is to get students thinking about why there are so many different types of leaves and how they are all specialized for different functions.

Appendix A. Grid with 1 x 1 cm squares. Students can trace both the area of condensation on cups as well as the area of the leaf to quantify transpiration rate per unit area of leaf.