Leaf Transpiration

Grade Level: Middle School, High School
Ecological Concepts: **Adaptation**
Arizona Science Standards: Science as Inquiry; Life Science

Materials:
1) Plastic wrap
2) Scissors
3) Magnifying lenses/loupes*
4) Writing/drawing materials
5) Measuring cups*, beaker, or graduated cylinder

*May be borrowed from SCENE.

BACKGROUND
This activity would fit well with a unit on plants, how they grow and produce food through photosynthesis. Provide as much of this information as is needed for the students to have a beginning grasp on the subject of photosynthesis.

Plants have green structures called leaves whose primary purpose is to collect the energy of sunlight and transform it through a chemical process called **photosynthesis** into food for the plant. Leaves come in many shapes, sizes, colors, and textures. Sometimes they do not even look like what we think of as typical leaves; for example, cactus spines are a form of leaf.

Water is necessary for photosynthesis and food transport throughout the plant. Plants wilt and will eventually die if they do not have enough water. Where does the water go that a plant takes up through its roots? Is it all incorporated into the plant's physical structure? On a typical plant, leaves are the part with the most area exposed to the air. Leaves have **microscopic stomates** to release water as vapor during photosynthesis. Carbon dioxide, a gas, is needed for photosynthesis. Carbon dioxide is taken into the leaf through the stomates. Just as we use water in our cells to survive, plants do too. We inhale oxygen and exhale water vapor in our breath as a by-product, while plants take in carbon dioxide and release water through the stomates. This water loss through the stomates is **transpiration**. (**See Energy Flow** for more details.) This creates a problem for plants in dry environments: how to conserve water.

Desert plants have adapted to environmental conditions of low water availability and high temperatures in a variety of ways, on the **macroscopic** as well as microscopic scale. Some characteristics are having a waxy **cuticle**, stomates on the under leaf surface, opening of stomates only at night, and a thick layer of **mesophyll** cells, among others.

GUIDED INQUIRY
Observation/Exploration Period: Observe the various types of plants in the habitat using eyes, magnifying lenses, flashlights, brushes, fingers, etc. Focus on leaves, but other plant structures can be observed as well. Have students categorize findings (example: plants with spines, thin leaves, oval leaves, etc., or use another scheme) as they see fit.

Group Discussion and Question Period: Guide students to look for patterns among and between different types of plants, focusing on leaves in terms of size, shape, color, texture, and other characteristics they may have noticed. What happens when a plant is in the sun all day? How much water does a plant lose through it leaves? What happens if a plant doesn't receive any water? Do plant leaves have different shapes, colors, etc? Does plant leaf color affect water loss? Which leaf size would survive the desert heat best?

Important aspects of guided inquiry are encouraging students to generate multiple hypotheses, and letting students make decisions about what data are important and create their own data sheets.

Keeping these ideas in mind, the sample in the box below illustrates how ONE OF MANY possible investigations around this topic might develop.

Sample Hypothesis: Let's use the question, "How much water do plants lose through their leaves?" Our hypothesis could be, "If plants transpire more water during the day than the night and we collect the transpired water, then we will collect more water from the plants in the afternoon than the morning." Or, "Plants transpire more water during the day than at night because the heat evaporates more water from the plant."

Sample Experiment Design: The **independent variable** is time of day, daylight versus dark. The **dependent variable** is amount of water collected. Use at least three plants for **replication**, of the same species and as close to the same size as possible. The plants also need to be in the same amount of light and shade throughout the day. By keeping these factors the same you are **controlling** variables different from the one you are testing. Use clear plastic bags or plastic wrap to completely cover all the leaves of each plant. Tie the bottom of the plastic around the main stem of the plant, leaving some droop at the bottom to collect water. Try to not crush the leaves with the bag.

Bag the plants early in the morning. Leave on all day. Check the bags at the end of the day for signs of water drops inside. If water has collected, gently shake the drops to the bottom of the bag, carefully remove the bag and pour the water into a measuring device such as a beaker or graduated cylinder. Record the amount. Dry the bags off and replace on the plants as before. Check the bags first thing in the morning and collect and measure any water.
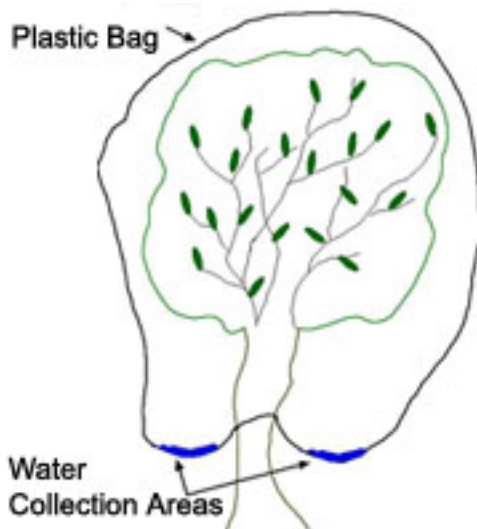
Figure 1. Plant bagged with plastic with water collection areas at bottom.

Sample Prediction: More water will be collected at the end of the day than in the morning.

Record Results: Record how much water is collected from each plant, once in the afternoon and once the next morning. A graduated cylinder marked in milliliters will be most accurate since the amounts are likely to be very small.

Sample Analysis of Data and Presentation: Make a **bar graph** with time of day (day and night) on the horizontal axis, and amount of water collected on the vertical axis. For students who can divide, calculate the **average** amount of water collected for each time period. Graph the average number on the vertical axis. If the water collected is tracked over time, make a **line graph** with time on the x-axis and

average water loss in ml on the y-axis.

Discussion: Was your hypothesis supported? If yes, go on to test other hypotheses. If not, why not? What did happen? Why? This is a great opportunity to revise your hypothesis and do another test.

MORE:
(1) Middle School:
(a) Find the **mean**, **median**, **mode** and **range** of the data.
(b) Compare transpiration rates between plants with different shaped leaves. Choose plants close to the same size, but of two different species. Run an experiment similar to the one above.

(2) High School:
(a) Calculate actual leaf surface area and evapotransipration rate per leaf area. Calculate the standard deviation of water loss for each leaf size and plot on a graph.
(b) Calculate the **variance** and **standard deviation** of the averaged data.
(c) Perform a **t-test** on water collected. (T-test is a standard statistics test comparing **means** of two treatment groups). Perform an **ANOVA** when comparing three or more treatment groups.
(d) Dissect leaf surfaces and look at stomates through a microscope. Estimate the number of stomates per leaf area. Compare different plant species.