

Stomata and Transpiration

OBJECTIVES

Students observe stomata and experiment to determine their role in passing water through plants.

The students

- ▶ observe stomata on the underside of a leaf
- ▶ observe transpiration through leaves
- ▶ discover that blocking stomata inhibits transpiration
- ▶ relate the transpiration of water from leaves to the uptake of water from the soil

SCHEDULE

Session I About 40 minutes

Session II About 30 minutes, 1 day after Session I

VOCABULARY

guard cells
leaf
stoma
stomata
transpiration

MATERIALS

For each student

- 1 Activity Sheet 4

For each team of four

- 2 bags, reclosable, plastic, 15 × 15 cm
- 1 pc paper, scrap*

For each team of eight

- 1 microslide strip
- 1 microslide viewer

For the class

- 3 geranium plants*
- 1 roll paper towels*
- 2 tubes petroleum jelly
- 1 roll tape, masking

*provided by the teacher

PREPARATION

Session I

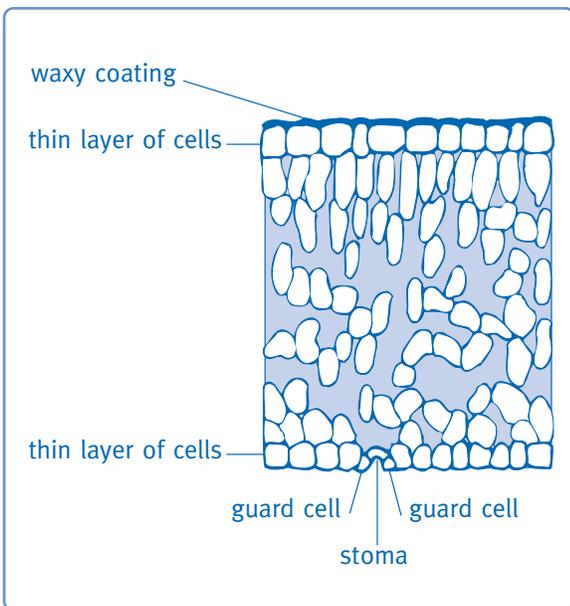
- 1 Make a copy of Activity Sheet 4 for each student.
- 2 Preview the microslide images of the lower epidermis of a leaf with stomata (image 6) and a close-up of a stoma (image 7).
- 3 For each team, squeeze about 1 tablespoon of petroleum jelly—enough to cover both sides of one leaf completely—onto a scrap of paper.
- 4 Each team of four will need two pieces of masking tape, two reclosable plastic bags, two geranium leaves, a paper towel, and some petroleum jelly on a piece of scrap paper.
- 5 Students will need to work in teams of eight when using the microslide viewers and strips.

Session II

Each team of four will need its bags of geranium leaves from Session I.

BACKGROUND INFORMATION

Figure 4-1 is a simplified diagram of the cross-section of a **leaf** as it appears under a microscope. The upper and lower surfaces of a leaf are covered by a thin layer of cells that lack chlorophyll. This layer of cells is called the epidermis. In some plants, a layer of waxy substance covers the epidermis, to help prevent water loss. Scattered throughout the epidermis are **stomata** (s. **stoma**), tiny openings into the leaf similar to the pores in skin. The two cells on either side of a stoma, called **guard cells**, open and close the stoma.



▲ **Figure 4-1.** A cross-section of a leaf as it appears under a microscope.

When the stomata are open, carbon dioxide, oxygen, and water vapor can all pass in and out of the leaf. In general, stomata are open during the day, when photosynthesis is occurring, and are closed at night. However, when a leaf stands to lose a lot of water, such as on a very warm and sunny day, the stomata will close during the hottest part of the day. More stomata are located on the underside of a leaf because it is not as likely to be exposed to direct sunlight. This also helps to minimize water loss—the process of **transpiration**.

▼ Activity Sheet 4

Stomata and Transpiration

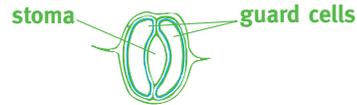
1. Observe microslide image 6 of the underside of a leaf.
How many whole stomata can you find? six

2. Observe microslide image 7, a close-up of a stoma. Compare the guard cells—the two cells that open and close the stoma—with the surrounding cells that cover the underside of the leaf. What differences do you notice?

The guard cells are smaller and bean-shaped.

The surrounding cells that cover the leaf are larger and irregularly shaped.

3. Draw and label the stoma and guard cells.



4. Use masking tape to label one bag *Covered*, which will hold a leaf covered in petroleum jelly, and the other *Uncovered*, and write your team's name on both bags. Cover both surfaces of one geranium leaf with petroleum jelly. Be sure to spread the jelly over the entire surface of both sides. Place each leaf into its corresponding bag.

5. Gently press each bag to let most of the air out, seal it, and set the bags aside overnight. What do you predict will happen in each bag?

Answers will vary.

6. The next day, observe the bags. What do you see?

The bag with the leaf covered with petroleum jelly stayed dry; the bag with the uncovered leaf showed tiny drops of moisture.

7. How does your prediction compare with what actually happened? How can you account for any differences?

Answers will vary. Students may have observed some moisture in the bag with the covered leaf. If so, the leaf was not entirely sealed off by the petroleum jelly.

Guiding the Activity

Additional Information

Session I

- 1 Show the students the geranium plants. Ask, **What plant parts are visible?**

Write the word *leaf* on the board. Explain to the students that a **leaf**, or the broad, flat part of a plant, is made up of several layers of cells. Draw a simple diagram on the board like the one in Figure 4-1. Next to it write the words *stomata*, *stoma*, and *guard cells*.

Point out that the upper and lower surfaces of a leaf are made up of a thin layer of cells, and that in these thin layers there are openings into the leaf, called **stomata** (s. **stoma**). Explain that two cells, one on either side of the opening, act like double doors to open and close the stoma. These cells are called **guard cells**.

- 2 Tell the students that they will now observe microscopic views of the underside of a leaf. Give each student a copy of **Activity Sheet 4**. Divide the class into teams of eight and distribute one microslide viewer and one microslide strip to each team. Tell the students to follow the directions in Steps 1 through 3 on the activity sheet, where they view image 6 and draw what they see in image 7.

Discuss the students' observations. Ask, **What do you think is the function of the stomata?**

The stem and leaves, and probably flowers, are visible.

Note: *Students should leave the microslide strip in its sleeve to pass it through the slot in the microslide viewer eyepiece.*

Explain that the label S on the microslide indicates stoma. The GC indicates guard cell.

Accept reasonable answers. Students may suggest that air can pass in and out of the leaf through the stomata.

Guiding the Activity

Additional Information

- 3** Divide the class into teams of four. Distribute to each team two leaves from the geranium plants, two reclosable plastic bags, two pieces of tape, a paper towel, and a piece of scrap paper with about a tablespoon of petroleum jelly on it. Tell the students they will discover the importance of stomata by comparing what happens to geranium leaves with and without petroleum jelly spread over them. Ask, **What does the petroleum jelly do when spread over a leaf?**

Tell the students to follow the directions in Steps 4 and 5 on the activity sheet. Instruct them to wipe off their hands with the paper towel after spreading the petroleum jelly.

Have the students place the labeled plastic bags in light—but not in direct sunlight or bright light—and leave them overnight.

Note: For best results, set the bags near light from a fluorescent bulb.

Have the students discard the scrap paper and paper towels. Return the microslide viewers and strips, petroleum jelly, and tape to the kit. Save the geranium plants for use in Activity 8. (See the Materials Management section at the front of this teacher's guide for instructions on how to care for the plants.)

Session II

- 4** Have the students retrieve their plastic bags and complete Steps 6 and 7 on the activity sheet. Discuss the students' answers to the questions in Steps 5 through 7. Ask, **Where did the water in the bag containing the uncovered leaf come from?**

Ask, **How did the water get out of the leaf?**

The petroleum jelly coats the leaf surfaces and blocks the stomata.

If the bags are left where it is too warm or too sunny, both bags will become cloudy with water vapor, making it difficult to distinguish between what has happened in the two bags. If the bags are left where it is cold, water vapor in the bags may condense out and form droplets, again making it difficult to distinguish between what has happened in the two bags.

It came from inside the leaf.

It escaped as water vapor through the stomata of the leaf.

Guiding the Activity

Ask, **What happens to a leaf when it is covered with petroleum jelly?**

Ask, **What can you conclude from this experiment?**

5 Write the word *transpiration* on the board. Explain that the process they just observed—the escape of water through the stomata—is called **transpiration**. Continue by telling students that as the water escapes through the stomata in the leaves, more is pulled from the soil through the continuous set of tubes that runs all the way down the plant to the roots. Thus, even as water is leaving the plant, more is being drawn into it.

Ask, **What kind of cells make up the tubes that carry water up a plant during transpiration?**

Ask the students, **How can you summarize the function of stomata?**

6 Tell the students that the microslide images they viewed in Session I are from the underside of a leaf. Tell them that this is because there are many more stomata on the underside of a leaf than there are on the upper side. Ask, **Based on what you know about stomata, how can you explain this?**

Additional Information

The petroleum jelly blocks the stomata, so that water cannot escape from the leaf. Students may have observed some moisture in the bag containing the covered leaf. If so, the leaf was not entirely sealed off by the petroleum jelly.

Students should be able to conclude that leaves contain water and that water escapes from the leaves through tiny openings, called stomata.

This process can be compared to sipping a beverage through a straw. As liquid leaves the top of the straw, more is drawn in through the bottom.

xylem cells

Students may answer that the function of stomata is to allow water to pass out of a plant through the leaves.

Students may be able to suggest that the stomata on the underside of plant leaves are in the shade. As a result, less water is lost from these stomata than from those on the upper surface of leaves. This helps prevent excess water loss from the plant.

REINFORCEMENT

The transpiration of water from a plant can also be demonstrated using an entire plant. Water a geranium or other land plant and then cover the entire plant with a clear plastic bag. Close the bag around the bottom of the stem, near the soil. Let the plant sit for several hours or overnight until water droplets form on the inside of the bag. The condensation that occurs inside the bag is due to transpiration.

SCIENCE NOTEBOOKS

Have students place their completed activity sheets in their science notebooks.

CLEANUP

Have the students discard the geranium leaves and the plastic bags.

Connections

Science Challenge

Have students repeat the activity sheet investigation using four identical potted plants instead of just leaves and treating the leaves on each plant as follows: plant 1, coat only the upper surfaces with petroleum jelly; 2, coat only the lower surfaces; 3, coat both surfaces; and 4, leave both surfaces uncoated. Tell students to put a labeled plastic bag over each plant and tape it closed around the stem just above the soil level. The plants should be watered well and placed near light from a fluorescent bulb. After two or three days, ask students to examine each bag carefully and sequence the plants from most to least water vapor released. (4, 1, 2, 3) Encourage students to devise a method for measuring the amount of water collected in each bag—for example, by weighing each bag with a sensitive balance scale and subtracting the weight of a dry bag.

Science Extension

Make sure students understand that during transpiration, plant leaves release water vapor, not liquid water, and that the water droplets they observed in the bags used in the activity sheet and Science Challenge investigations did not come directly from the plant leaves but condensed from the water vapor they released. To demonstrate this, have students seal a small, shallow dish filled with water in a plastic bag and place it and an identical water-filled but uncovered dish in direct sunlight for several hours. Water will evaporate from both dishes. With the enclosed dish, water vapor condenses again to form liquid water droplets on the inside of the bag. With the uncovered dish, the water vapor simply dissipates into the surrounding air—just as it does with transpiration from plant leaves.

Science and the Arts

Encourage students to research the parts of a typical leaf—the petiole, the midrib, the large and small veins, the margin, and the apex—and then draw a leaf and label the parts. Tell students they may copy drawings in books or create their own drawings based on leaves they have collected.

Science and Language Arts

Have students look up the derivation of the term *transpiration* and add it to the class vocabulary list. (from the Latin *trans*, “across or through,” and *spirare*, “to breathe”) Also ask students to list as many other words as they can think of that begin with the prefix *trans-* and define each one in their own words.

Science and Math

Give each team a small twig with several leaves on it. Tell them to trace around one average-size leaf on a sheet of graph paper and then count the number of squares inside the outline. Have them multiply this count by 2 to determine the total area of the leaf’s upper and lower surfaces. Then have them multiply that result by the number of leaves on the twig to find the total leaf area. Next, have each team fill a graduated cylinder with water to the 150-mL mark, add a thin layer of cooking oil on top of the water (to prevent evaporation), put the twig in the cylinder, and leave the set-up in a sunny location for one or two days or for as long as it takes for the water level to decrease noticeably. Have students note the new water level and calculate the amount of water lost through transpiration. Then have them divide this amount by the total surface area to determine the water loss per unit of leaf area.