Stomata Printing: Microscope Investigation

GRADE LEVEL APPROPRIATENESS	Appropriate for 3rd-12th grade students; Next Generation Science Standards for 5th, 6th, 7th and 8th California Content Standards for 5th , 6th & 7th
SUBJECTS	Life Sciences, Investigation and Experimentation
DURATION	Activity: 45 minutes
SETTING	Classroom or Lab

Objectives

In this activity, students will:

1. Observe the structures that make up the surface of a leaf.
2. Find the pores, called stomata, that let gasses in/out of a leaf.
3. Explore the ways that plants gain mass.

Materials

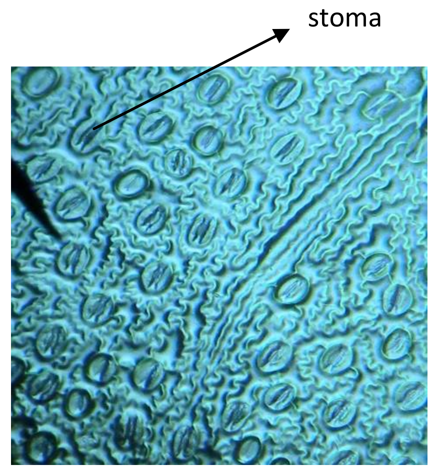
- Student Data Sheets (1 per person)
- Preparing Your Specimen Sheet (1 per lab team)
- Computer and Projector for video clips (optional)
- Plant Leaves (Ferns, or any leaf with a smooth surface, work well)
- Clear tape (Packing tape or transparent tape, not scotch tape)
- Clear Nail polish (Sally Hansen InstaDri "Quickly Clear" color works well)
- Microscope slides
- Microscopes
- Trays (to hold the materials, optional)

Vocabulary

- **Stoma** (singlular)/**Stomata** (plural): a structure on the surface of a leaf that modulates gas exchange between the plant and its environment.
- **Carbon Dioxide**: a colorless, odorless gas that is present in the atmosphere, breathed out during animal respiration, produced by decaying plants, used by plants in photosynthesis, and formed when any fuel containing carbon is burned.

Teacher Background Information

Stomata



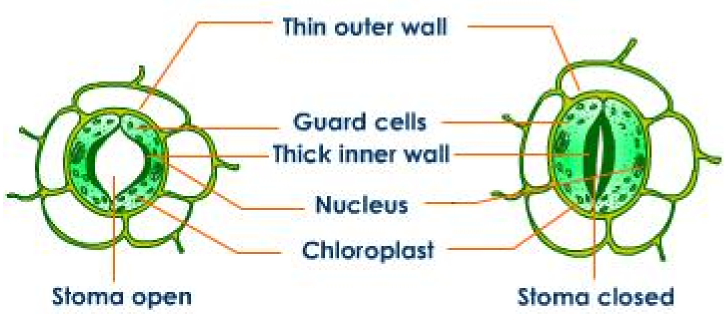
Stomata are responsible for allowing gas exchange between the inside of the leaf and the atmosphere. *Stoma* is the singular and *stomata* is the plural form. When viewed with a microscope, they often look like coffee beans. There are more than 32 stomata in the image of the Western Sword Fern leaf, to the right. Carbon dioxide (CO_2), oxygen (O_2) and water (H_20) commonly move in or out via the stomata.

While gas exchange occurs, carbon (C) stays inside the leaf as a building block for the plant. Often, stomata are open during the day when photosynthesis is taking place and closed at night when it stops. By doing so, plants don't lose too much water. If the stomata are open, gasses diffuse from areas of higher concentration to lower concentration. If photosynthesis is occurring the CO_2 higher concentration is outside the leaf. For H_20 and O_2 the area of higher concentration is inside the leaf. This process is depicted in an animated clip prepared by Carnegie Institute for Science at http://www.youtube.com/watch?v=TuwAtfBk6NI.

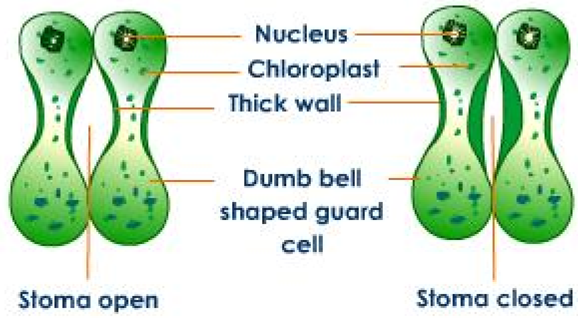
A common misconception that students have is that the stoma's size can keep out large molecules and just let in the little molecules like CO_2 and H_20. A stoma is on the order of 10^{-6}m, while a CO_2 molecule is on the order of 10^{-10}m. If we pretend that a stoma opening is one meter across, then the CO_2 molecule would be one tenth of a millimeter in size.

Each stoma is made of two guard cells. When these guard cells are swollen with water, they create an opening between them, the stomatal pore. Gas exchange occurs via the pore. When the guard cells are flaccid they lay close together, thus closing the stomatal pore. Plants that are "dicots" have kidney shaped guard cells and plants that are "monocots" have dumbbell shaped guard cells.

Stomata structure of dicots



Stomata structure of monocots



Images from: http://www.tutorvista.com/content/biology/biology-iv/plant-water-relations/stomatal-mechanism.php

Normally stomata open in the morning and close during the night. However, not all plants open their stomata during the day. Some plants such as cacti and succulent plants open their stomata at night and close them during the day, in order to prevent losing too much water.

Stomata are usually found on both the top and the bottom of a leaf. Many plants have more stomata on the underside of the leaf. However there are exceptions, monocots, like grasses, have similar numbers on both the top and the bottom. Plants whose leaves rest on the surface of the water, like water lilies, often have very few stomata on the wet underside of their leaves.

Lenticels

Stomata are not the only way for plants to exchanges gases with the air. Plant roots, stems, bark, and fruits have lenticels on their outer surface. These allow oxygen in and carbon dioxide out, as the plant respires. They do not open and close, the way that stomata do. Examples of lenticels are the little spots on pears and the horizontal stripes on cherry tree bark.

Stomata Printing

Scientists make prints of stomata in order to easily see the surface of a leaf under the microscope. This video, http://www.youtube.com/watch?v=XcLhuLONQZg , shows the process that we outline below. If you want to make the stomata or the locations of the stomata a surprise for your students, do not show it to the students before they begin, as it contains spoilers. The video also incorrectly states that the cells from the surface of the leaf are pulled off. Instead the nail polish is removed from the surface of the leaf. It is an impression of the leaf surface. The nail polish is just like plaster poured into a footprint in sand.

Some leaves work better than others for making prints. We find that smooth, sturdy leaves work well. We run into difficulty if leaves are very delicate or are covered by lots of hair. For this reason we suggest that you try your leaves out first or let students know that the method may not work for every leaf. You can also try this method with dried leaves.

Activity

Introduction

- Begin by showing students a time-lapse video of plants growing, and asking them to think of how plants grow, and gain mass.
- After giving them time to think and discuss let them know that this lab will involve looking close at the surface of plants' leaves to examine ways carbon dioxide enters a leaf.
- Ask students, "what do you think the surface of a leaf will look like, when you look at it with a microscope?"
- Have them examine leaves up close and brainstorm where they think most of the carbon dioxide will enter the leaf.

Procedure

1. Students can work singly or in pairs. Pass out the data sheets first and have students answer questions 1 and 2 on their own, or in small groups.
2. Then, pass out the instruction sheets or display it on an overhead. Have students complete the first two steps, and then wait for the nail polish to dry. If you are using the Sally Hansen InstraDri the nail polish will need **5 minutes to dry**. If you are using other nail polish it can take up to **15 minutes to dry**.
3. While the nail polish is drying have students watch the NASA video: Watching the Earth breathe: http://svs.gsfc.nasa.gov/goto?3947 , and have students discuss their observations. Ask questions such as: What patterns do you notice? Why do you think those patterns exist?
4. If this is the first time students will be using microscopes, introduce students to the parts of a microscope, and how to use them. If you are on a time crunch, you can speed things up by pre-focusing the scopes ahead of time.
5. Finish preparing the specimens by completing the rest of the steps. Then, have students complete the rest of the investigation.
6. Have the students draw the structures that they see. Then circle the structure that they think might let air in/out of a leaf. They should be prepared to share their reasoning for their choice.

   Note: some leaves are quite large and can take a lot of time to try and see the whole leaf. To speed things up, have students examine only what appears in one frame of the microscope.

Discussion

- As a class, have students bring up their sketches and show the class the structures that they believe might let air in/out of a leaf and their reasons for making that choice.
- Then, show them the pictures of the stomata and reveal the ways that these structures work.

- On average, how many stomata were found on the topsides of leaves? How many were found on the bottom sides of leaves? Why do you think the results show this?
- Were the stomata open, or closed? Why do you think that is?
- If you used multiple types of plants, were there any similarities or differences?
- What other questions do you have about stomata?

Extension

Keep a parking lot with questions that arise during the discussion. Then as a class, see if you can answer some of those questions with further investigation using the microscopes, leaves and nail polish.

References

"Convenient method for studying grass leaf epidermis." Khidir W.H. and J.L. Randall. Taxon. 33(3): 413-415. August 1984. Retrieved on July 22, 2013 from http://www.jstor.org/stable/1220980

Lenticels. Retrieved on July 22, 2013 from http://www.botgard.ucla.edu/html/botanytextbooks/generalbotany/barkfeatures/lenticels.html

Correlated California State Content Standards

Grade Five
Life Sciences

2a. Students know many multicellular organisms have specialized structures to support the transport of materials.

2f. Students know plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.

Grade Six
Ecology

5b. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.

Grade Seven
Cell Biology

1. All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope.

Next Generation Science Standards

Grade Five

Performance Expectation

5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.

5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

DCI

LS1.C Organization for Matter and Energy Flow in Organisms

LS2.B Cycles of Matter and Energy Transfer in Ecosystems

Middle School

Performance Expectation

MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

DCI

LS1.C Organization for Matter and Energy Flow in Organisms

LS2.B Cycles of Matter and Energy Transfer in Ecosystems