**Lesson Plan: Plant Cells That Can TALK! Microscopy and Modeling of Stomata**

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Topics: Life Science, Engineering

Grade range: 6-9

Time: 60-90 minutes

Objectives: To introduce students to stomata, which are small pores in the surface of plants that open and close to help them absorb carbon dioxide (CO2) and release water (H2O) and oxygen (O2), and to allow students to develop and apply engineering knowledge to model how cellular pressure (simulated by air pressure) and cell wall mechanics (simulated by balloons reinforced with tape and yarn) allow stomatal guard cells to expand and contract to control the size of stomatal pores.

Microscopy Supplies:

- Compound light microscopes (note: this lesson presumes that students have the ability to use the microscopes; if that is not the case, it would be advisable to train the students how to use the microscopes as a pre-activity, which will take 45-60 minutes)

- leaves of *Tradescantia zebrina* (other plants work as well)

- scissors

- water droppers, water

- coverslips

- slides

Modeling Supplies

- long and narrow balloons

- balloon pumps (optional)

- masking tape

- yarn

- binder clips

**Introduction (5-10 minutes)**

**Background**: **Stomata** are special pores in the surface of plants that open and close to allow plants to exchange carbon dioxide (CO2) and water (H2O) with the atmosphere. They are essential for photosynthesis (the process by which plants convert sunlight, water, and CO2 into sugars) and water movement in plants, and allow plants to respond to changes in the environment, such as increasing or decreasing levels of light and water. **Guard cells** are special cells that surround each stomatal pore. Guard cells can inflate and deflate to control the size of the stomatal pore, and like almost all plant cells, they are surrounded by a **cell wall** that contains carbohydrates such as cellulose. The cell wall is both very strong and very flexible, and it determines guard cell shape and size.

**Activity 1: Observing stomata in Zebrina (*Tradescantia zebrina*) plants (30-40 minutes)**

**NOTE: For this protocol, we will work in groups of two.**

- Using scissors, cut a 1 cm x 1 cm square of the thin part of a Zebrina leaf, avoiding the central vein

- Place a drop of water on a slide and add the leaf piece, green-side-up, to the drop

- Place a coverslip against the edge of the drop and lower it carefully onto the drop

- Plug the electrical cord of the compound microscope into an outlet

- Turn on the light source

- Confirm that the 5x objective lens is directly above the stage

- Clip your slide onto the stage

- Position the stage so that the leaf on the slide is above the light

- Look through the eyepiece lenses (adjust the distance between the eyepiece until you see only one image)

- Turn the coarse adjustment until the leaf is in focus

- Switch to the 10x objective

- Turn the fine adjustment until the leaf surface is in focus

- Switch to the 40x objective and turn the fine adjustment until the stomata are in focus

1) Make a drawing of what you observe on the microscope under the 40x objective:

2) With your partner, think of a scientific question about stomata (also think about **how** you would answer your question using an experiment!):

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**Activity 2: Building a working model of a stoma (30-40 minutes)**

**Note: For this activity, we will work in teams of four.**

Stomata can open and close because they are surrounded by guard cells that have special cell walls, which are composed of cellulose and other flexible but strong carbohydrates (fun fact: cellulose has about the same tensile strength as steel!). In this activity, we will work in teams of four to build working models of stomata, using the scientific knowledge we gained through our microscopy observations and our engineering skills. At your table, you will find balloons, a balloon pump, yarn, tape, rubber bands, and pipe cleaners. You can use any or all of these materials to construct your model. As you build your model, think about how you would describe how it works to other people.

1) What materials did you use to construct your model, and why?

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2) In what ways does your model resemble and work like a real stoma? In what ways is it different?

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3) From an engineering perspective, how could you improve stomata in plants to make them function better?

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**Wrap-up: Science and Engineering in Plants for Sustainable Agriculture**

Plants provide many items that are essential for human society, such as food, clothing, building material, and paper. Scientists and engineers are currently working hard to be able to cheaply and efficiently convert the cell walls of plants into biofuels, which will serve as a renewable resource to power our cars, trucks, boats, and airplanes. If this effort is successful, it will help reduce the amounts of greenhouse gasses that we are adding to our atmosphere. It will also provide farmers with an additional source of income, especially if they are able to grow biofuel crops on land that is unsuitable for food crops.

If you have questions about stomata, plant biology, engineering, and/or sustainable agriculture, as well as careers in science and engineering, feel free to contact me by email: Dr. Charles T. Anderson: cta3@psu.edu