PlantingScience Mentor Tip Sheet: Celery Challenge Curricular Module

The **purpose of this tip sheet** is to help you as a scientist mentor **anticipate and respond** to students as they post online about their investigations on how water moves through plants, using celery.

Expect teachers to adapt the module for their students:

Teachers purchase **fresh celery from the grocery store** for investigations on the forms and functions of cells that are adapted for **middle school through college** students. Basic **equipment** includes hand lens, protractor, scalpel, balance, salt, and coloring to add to water sources. Students may have access to dissecting microscopes, biological stains, refrigerator, and cameras.

- Connect with your teams' teacher via the **Class Discussion Forum** for details on modifications for the class.
- See the **Celery Module Guide** for suggested learning goals and activities.
- General hints for talking with students are in the **Mentor Guide**.

A challenge to cause and explain celery bending frames this module. A series of successive iterations of observations and manipulations with celery help students build general understandings of anatomy and physiology. Students first receive a real world scenario about placing cut celery in the fridge overnight as part of party preparations. Their observations of cut celery are intended to trigger questions about celery **cell and tissue types** and **osmosis**. Students may examine characteristics such as ridges, pithy versus stringy sections, toughness and record both qualitative and quantitative data. A second guided activity on **transpiration** involves placing celery sticks in food coloring overnight to examine how colored water moves through the xylem. From these initial experiences, students are challenged to design experiments to bring about maximum bending of celery stalks and to explain what happened.

The open inquiry offers diverse avenues to investigate structural, physiological, and environmental relationships. Expect student wonderings along the lines of: ***What happens if we remove all the ridges, if we cover all the stomata, or if we soak celery in a salt solution/distilled water/hot water?***

Juicy questions for student investigations.

- Are all parts of a celery stalk the same? Are stalks in one bunch the same?
- How can you tell one cell from another?
- How does a plant maintain its shape and form?
- What effects do the environment have on how water moves through a plant?
- What causes a plant to bend or move? What influences how it bends?
- Does water move the same way in all parts of a plant? How far does it go?

What are students thinking when it comes to osmosis and transpiration?

As students blog about their investigations, they reveal their ideas. It is common for students to think….

- The terms iso-, hypo- and hypertonic refer to water content not the solutes in the solution.
- All plant species have similar numbers of stomata. Stomata occur only on lower surface of leaves.
- Most water taken in through roots is used by the plants, rather than lost through transpiration.
- High humidity increases transpiration.

Attending to students' ideas and thinking

Students may learn by rote the definition of xylem. Yet, answering **How does water get inside and move through a plant** reveals much about their ideas, By attending to students' thinking, attention

shifts from a right-answer orientation to uncovering reasoning. As experts, we often make assumptions about students' ideas and connect concepts in ways novice learners cannot. Assumptions may be upturned when probed. Also, responding as a naïve mind opens up discussion possibilities.

Anticipating technical problems and conversation threads

Students will likely take on the challenge to bend celery with gusto, and succeed. The greater challenge in this inquiry comes from explaining what is happening. If students do encounter experimental set up troubles, don't let them get overly bogged down in technical debugging at the expense of **thinking about the big ideas**.

- **Student background and experience.**
  Middle school students will have encountered basics of the water cycle and introduction to cells. High school students will have greater experience with transpiration. Students in both grade levels may have difficulty identifying what they see when examining cells under a microscope, as well as interpreting bending in light of differentiated cell types. Collenchyma, sclerenchyma, and parenchyma may be familiar terms only to Advanced Placement biology students.
- **Making sense of bending.**
  Students' first-hand experience with cell differentiation in celery may come from getting the "strings" of tissue caught between their teeth when eating celery. While they might notice these strands are toward the ridged side and absent from the pithy smooth side, students will likely not consider how the tensile strength of the xylem resists stretching and relates to osmosis. And in contrast, the parenchyma cells of a stalk soaked in water will expand as they fill, and the stalk bends as a result. See the Teacher Guide for additional explanations based on effects of osmosis related to various solutions, celery epidermis, cross-sectional shapes, age and position of the celery sections.
- **What's cool to kids?**
  Connecting the turgor pressure of celery bending to plant movements, such as the Venus fly trap "jaws" closing around prey, taps into a common interest in carnivorous plants. This opens the door to broader understandings of how the diurnal opening and closing of some flowers also relates to mechanisms that make leaf petioles stiff enough to hold a leaf out from a stem. Water movement in redwoods taps into student interest in the "biggest." How transpiration relates to current events such as climate change will interest some students.

Teachers say it is hard to find accessible, scientific accurate background information for students. Are there resources you recommend?

Resources and References

Perhaps useful to you as a mentor

•Plant Physiology online, fifth edition by L. Taiz and E. Zelger
http://5e.plantphys.net/

•Article on transpiration and global water vapor levels
http://www.plantphysiol.org/cgi/content/full/143/1/3

•Activity that connects osmosis and transpiration
http://lesson-plans-materials.suite101.com/article.cfm/investigating_osmosis_in_plants

Meir, E., Perry, J., Stal, D., Maruca, S, and E. Klopfer. 2005. How effective are simulated molecular-level experiments for teaching diffusion and osmosis? *Cell Biology Education* 4:235-248.

Ruszala, E.M., Beerling, D.J., Franks, P.J., Chater, C., Casson, S.A., Gray, J.E., and A.M. Hetherington. 2011. Land plants acquired active stomatal control early in their evolutionary history. *Current Biology* 21:1030-1035.

Markin, V.S., Volkov, A.G., and E. Jovanov. 2008. Active movements in plants: mechanisms of trap closure by *Dionea muscipula* Ellis. *Plant Signaling and Behavior* 3: 778-783.

Koch, G.W., Silett, S.C., Jennings, G.M., and S.D. Davis. 2004. The limits to tree height. *Nature* 428: 851-854.

Perhaps useful to student teams

•Water Transport in a Plant by David Attenborough
http://www.youtube.com/watch?v=w6f2BiFiXiM

•Eurekalert press release on climate change connection
http://www.eurekalert.org/pub_releases/2011-03/iu-rci030311.php

•Science and Plants for Schools' Microscopy – looking at xylem
http://www.saps.org.uk/secondary/teaching-resources/770

•Transpiration from Plant and Soil Science eLibrary
http://plantandsoil.unl.edu/croptechnology2005/soil_sci/?what=topicsD&informationModuleId=1092853841&topicOrder=6&max=8&min=0&

•Osmosis in plant cells animation:
http://www.college-cram.com/study/biology/cell-membranes/osmosis-in-a-plant-cell/

•Capillary Action / Water Properties
http://www.uni.edu/~iowawet/H2OProperties.html

•BioCoach student self quiz on plant tissue types
http://www.phschool.com/science/biology_place/biocoach/plants/tissue.html