Growing with Plant Science:
Framing K-12 science curricula to support plant-based inquiry in the classroom

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Abstract

The University of Missouri Division of Plant Sciences and Office of Science Outreach are working with Missouri teachers to enhance the role of plant sciences in K-12 science curriculum through the program "Growing with Plant Science". Plant-based lessons are being developed using the 5-E instructional model to engage students with scientific inquiry. Teachers learn how to use plants as a focus for investigations which stimulate collaboration, critical thinking, data collection, and evidence based explanations. In turn, greater emphasis on plant biology in the classroom increases student knowledge on the importance of plants and future opportunities in plant sciences. Lessons and supporting materials are being disseminated through teacher workshops including the Science Teachers of Missouri fall conference, Interface Conference, and on-campus programs with future plans to develop a "Growing with Plant Science" program website.

The 5-E Instructional Model

The 5-E Instructional Model was developed by the Biological Sciences Curriculum Study (BSCS) to actively engaging students in learning science.

It is a departure from the traditional, teacher-centered approach to science teaching and instead focuses on student-centered engagement in an exploration of a scientific concept and challenges students to construct meaning while developing evidence-based explanations.

The 5-E Instructional Model has five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

Engage	• Activity which will focus student's attention, stimulate their thinking ,and assess prior knowledge.
Explore	• Students conduct inquiry-based investigations, facilitated by teachers.
Explain	• Students reflect and work together to make meaning from their experiences and formulate explanations supported by their observations and experiences.
Elaborate	• Students are challenged to apply their understandings with the concept to new investigations to construct deeper understanding.
Evaluate	• Both students and teachers reflect on the concept and determine the level of learning and understanding that has taken place. This may be ongoing throughout the four phases.

Lesson Example

Plant-based investigations are developed to be classroom ready for the teacher, giving them background information, including the grade-level and course-level expectations (GLEs and CLEs) met by the lesson and formatted in the 5-E design.

Below is one of several activities presented during workshops for high school and middle school biology teachers at the 2011 Science Teachers of Missouri Conference and the 2012 Interface Conference.

Several activities were presented in a unit called "Water in Plants: In, Through, Out and Without". The example below is using Napa cabbage leaves to visualize water movement in xylem.

Teachers were given activities to explore how seeds imbibe water for germination, how water escapes plant tissues through stomata, and the importance of water in plant growth as students explore the effects of water stress on plants.

Xylem of Napa cabbage leaves stained with red food coloring. The stained xylem tissue characteristics may also be visualized under higher magnification.

Photo courtesy of Carol Robertson, Fulton, MO H.S.

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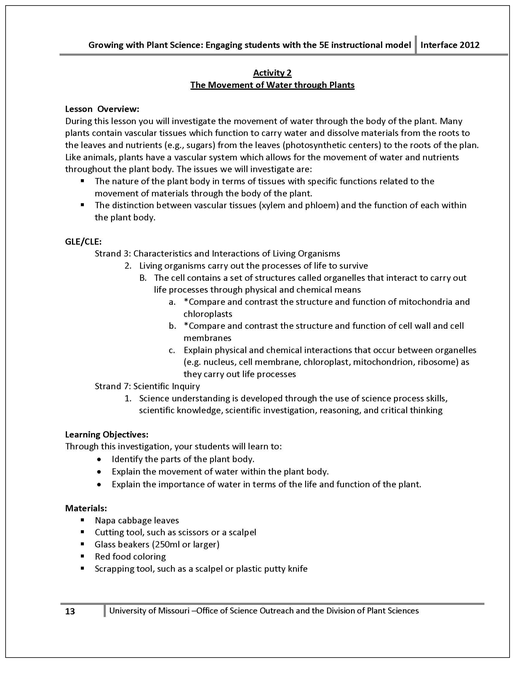
High school science teachers getting hands-on experience in the Science Teachers of Missouri workshop (2011).



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Activity 2
The Movement of Water through Plants

Lesson Overview:
During this lesson you will investigate the movement of water through the body of the plant. Many plants contain vascular tissues which function to carry water and dissolve materials from the roots to the leaves and nutrients (e.g., sugars) from the leaves (photosynthetic centers) to the roots of the plan. Like animals, plants have a vascular system which allows for the movement of water and nutrients throughout the plant body. The issues we will investigate are:

- The nature of the plant body in terms of tissues with specific functions related to the movement of materials through the body of the plant.
- The distinction between vascular tissues (xylem and phloem) and the function of each within the plant body.

GLE/CLE:
Strand 3: Characteristics and Interactions of Living Organisms
2. Living organisms carry out the processes of life to survive
   B. The cell contains a set of structures called organelles that interact to carry out life processes through physical and chemical means
      a. *Compare and contrast the structure and function of mitochondria and chloroplasts
      b. *Compare and contrast the structure and function of cell wall and cell membranes
      c. Explain physical and chemical interactions that occur between organelles (e.g. nucleus, cell membrane, chloroplast, mitochondrion, ribosome) as they carry out life processes

Strand 7: Scientific Inquiry
1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking

Learning Objectives:
Through this investigation, your students will learn to:

- Identify the parts of the plant body.
- Explain the movement of water within the plant body.
- Explain the importance of water in terms of the life and function of the plant.

Materials:

- Napa cabbage leaves
- Cutting tool, such as scissors or a scalpel
- Glass beakers (250ml or larger)
- Red food coloring
- Scrapping tool, such as a scalpel or plastic putty knife

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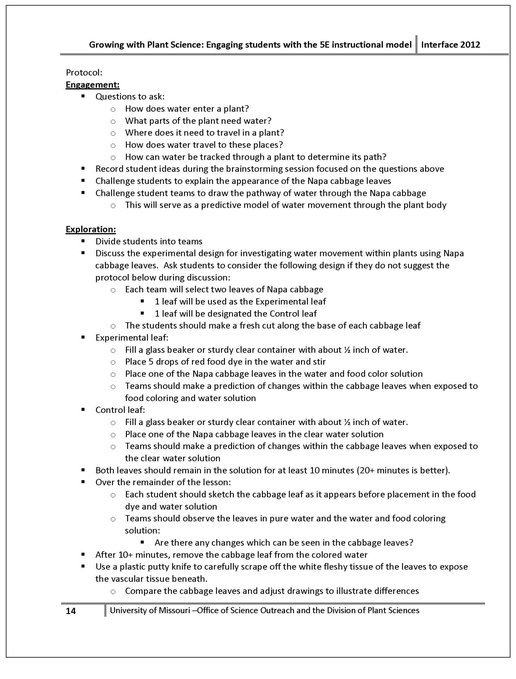

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Protocol:
Engagement:

- Questions to ask:
  - How does water enter a plant?
  - What parts of the plant need water?
  - Where does it need to travel in a plant?
  - How does water travel to these places?
  - How can water be tracked through a plant to determine its path?
- Record student ideas during the brainstorming session focused on the questions above
- Challenge students to explain the appearance of the Napa cabbage leaves
- Challenge student teams to draw the pathway of water through the Napa cabbage
  - This will serve as a predictive model of water movement through the plant body

Exploration:

- Divide students into teams
- Discuss the experimental design for investigating water movement within plants using Napa cabbage leaves. Ask students to consider the following design if they do not suggest the protocol below during discussion:
  - Each team will select two leaves of Napa cabbage
    - 1 leaf will be used as the Experimental leaf
    - 1 leaf will be designated the Control leaf
  - The students should make a fresh cut along the base of each cabbage leaf
- Experimental leaf:
  - Fill a glass beaker or sturdy clear container with about ½ inch of water.
  - Place 5 drops of red food dye in the water and stir
  - Place one of the Napa cabbage leaves in the water and food color solution
  - Teams should make a prediction of changes within the cabbage leaves when exposed to food coloring and water solution
- Control leaf:
  - Fill a glass beaker or sturdy clear container with about ½ inch of water.
  - Place one of the Napa cabbage leaves in the clear water solution
  - Teams should make a prediction of changes within the cabbage leaves when exposed to the clear water solution
- Both leaves should remain in the solution for at least 10 minutes (20+ minutes is better).
- Over the remainder of the lesson:
  - Each student should sketch the cabbage leaf as it appears before placement in the food dye and water solution
  - Teams should observe the leaves in pure water and the water and food coloring solution:
    - Are there any changes which can be seen in the cabbage leaves?
- After 10+ minutes, remove the cabbage leaf from the colored water
- Use a plastic putty knife to carefully scrape off the white fleshy tissue of the leaves to expose the vascular tissue beneath.
  - Compare the cabbage leaves and adjust drawings to illustrate differences

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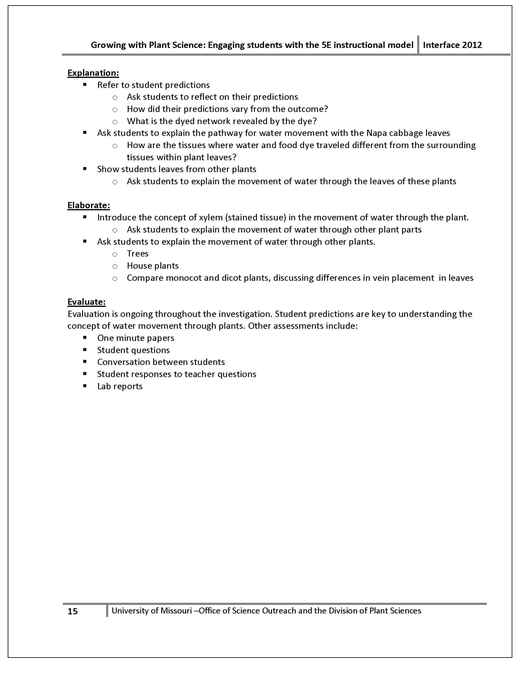

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Explanation:

- Refer to student predictions
  - Ask students to reflect on their predictions
  - How did their predictions vary from the outcome?
  - What is the dyed network revealed by the dye?
- Ask students to explain the pathway for water movement with the Napa cabbage leaves
  - How are the tissues where water and food dye traveled different from the surrounding tissues within plant leaves?
- Show students leaves from other plants
  - Ask students to explain the movement of water through the leaves of these plants

Elaborate:

- Introduce the concept of xylem (stained tissue) in the movement of water through the plant.
  - Ask students to explain the movement of water through other plant parts
- Ask students to explain the movement of water through other plants.
  - Trees
  - House plants
  - Compare monocot and dicot plants, discussing differences in vein placement in leaves

Evaluate:
Evaluation is ongoing throughout the investigation. Student predictions are key to understanding the concept of water movement through plants. Other assessments include:

- One minute papers
- Student questions
- Conversation between students
- Student responses to teacher questions
- Lab reports

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Future Directions

Additional plant-based investigations are being developed integrating the Next Generation Science Standards.

Materials will be disseminated through state-wide teacher programs and well as on-campus workshops.

Development of a program website entitled "Growing with Plant Sciences" is underway.

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