Investigating Science

Plant Response to Stimuli

5E Lesson Plan

Source Material: Plants in Space Activity Guide (attached at end of LP)
Mission Focused Area: Earth's Moon/Earth Science/Solar System and Beyond

Lesson Overview

In this lesson, students will use a simple experimental setup to test plant response to different wavelengths of light. Students will practice making predictions and observations as the experiment progresses. Students will ultimately observe that plants respond preferentially to certain wavelengths of light. Understanding this fact is key to growing plants in space where the gravitropic response is lessened or not a factor. After explaining the results of their experiment, students will engage in a Claim-Evidence-Reasoning writing exercise using a write up of a plant science experiment that was conducted on Space Shuttle mission STS-121.

NASA Connection

Human beings have lived continuously in space for over 20 years aboard the International Space Station. Its proximity to Earth allows for frequent resupply missions to maintain and supply this orbiting laboratory. However, as humans look towards long-term habitation of the Moon and Mars such resupply will not be as feasible. Aboard the International Space Station, astronauts have done critical research in understanding how plants grow and behave in space. The stimuli plants are subjected to and exposed to are significantly different on orbit. Understanding the plant responses to different light conditions and reduced gravity will help ensure that long term Moon and Mars missions can grow steady supplies of food and reap the myriad other benefits of live plants.

Objectives

- Construct an experiment from low cost materials
- Record observations using their experimental set up
- Make simple predictions based on their experimental set up
- Identify the wavelength of light that plants prefer based on student observations during the experiment

Guiding Questions

- How do plants respond to light?
- How do plants respond to different wavelengths of visible light?
- How does understanding phototropism help astronauts grow plants in space (where gravitropism does not play a factor)?

National STEM Standards

NGSS

- **Science Practice: Planning and Carrying out Investigations:** Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions

5E Instructional Model

Materials (per group of students)

- 35 mm black film can with lid
- Two extra film can lids
- Clear adhesive tape
- 2 cm wide white masking tape
- Four grid strips, 0.5 cm x 4 cm pieces cut from millimeter square graph paper photocopied onto overhead transparencies
- Four wick strips, 1 cm x 4.5 cm strips of soft paper towel
- One floral foam disc, 28 mm in diameter 2 to 4 mm thick
- Four brassica or other medium size seeds (turnip, lettuce, or alfalfa)
- Water bottle
- Hand-held single hole punch
- Forceps to handle seeds
- Ultrafine permanent black marker

Teacher Action

Engage - Growing Plants in Space Video

- Show “Growing Plants in Space” video from PBS and discuss content with students using guiding questions

Scripted CFU questions

- What types of stimuli are plants exposed to in their environment here on Earth?
- Can you identify all four plant tropisms?
- How are those stimuli different on the International Space Station?
- What are the benefits of growing plants and studying plant growth on the International Space Station?

Explore - Do Plants Prefer the Blues?

- Using attached instructions, guide students through the experimental set up
- Model an exemplar observation for students and describe process to record observation (in a science notebook for example)
- Discuss predictions with class; push students to be as specific as possible: “Plants will grow preferentially towards the green wavelengths of light” rather than “Plants will grow towards the light”

Note for Teacher: There is significant materials prep required for this activity; please see activity guide at the bottom of this LP for detailed instructions.

Explain - Explain Results from Experiment

- Monitor student responses and address any misconceptions (plants should respond to the blue light the most and use that wavelength to tell which way is up)
- Use guiding questions to connect the experiment to plant growth in space: in the absence of gravity plants must have a source of light to respond to and grow properly

Scripted CFU questions

- Do plants respond to all wavelengths of light differently or the same?
- How does understanding phototropism help astronauts grow plants in space (where gravitropism does not play a factor)?

Elaborate - TROPI (STS-121) Phys.org write up

- Outline TROPI experiment with students: What is the purpose of the experiment? (Students will need help with some of the vocab.)

Scripted CFU questions

- “The experiments provide a detailed characterization of root phototropism, provide insight into how red light enhances blue-light dependent phototropism, and provide a better understanding of how plants integrate sensory input from multiple light and gravity perception systems” (Purpose of experiment from article.)

Evaluate

- Specific criterion to look for when evaluating CER write ups: Is evidence directly from source material?? Is the reasoning tying the claim and evidence together, not simply restating evidence? Is claim specific?

Student Action

Engage - Growing Plants in Space Video

- Watch short video with class
- Respond to teacher discussion questions regarding content in the video

Explore - Do Plants Prefer the Blues?

- Create experimental set up for phototropism activity using provided materials and instructions
- Every 60-72 hours, record detailed observations on the growth of the seedlings
- Using observations, identify the wavelength of light that plants prefer

Explain - Explain Results from Experiment

- Students answer the concluding questions (found at the end of attached activity) using specific references to their results
- Students can answer in writing, or discuss in their lab groups

Elaborate - TROPI (STS-121) Phys.org write up

- Using sources provided, construct a Claim Evidence Reasoning write up of the plants growth in space experiments using the provided prompt — How do plants respond to the stimuli of light and gravity when growing in space?
- Write findings on a poster or whiteboard
- Claim should be a complete sentence
- Evidence is listed from the articles
- Reasoning ties the two together and does not simply restate evidence

Evaluate

- Students present their CER posters to the class, or if time is short, just to another group
- State claim and evidence clearly and explain how evidence supports the claim

Work adapted by NASA from PBS Learning. We thank PBS Learning for collaboration efforts. https://aptv.pbslearningmedia.org/resource/npe11.sci.phys.energy.plants/growing-plants-in-space/

ACTIVITY 10

Phototropism: Do Plants Prefer the Blues?

Introduction

This activity will deal mainly with phototropism, illustrating how plants use various colors of light for different tasks. Unlike the gravitropism activity in which light was excluded, experiments in the classroom on Earth are done in the ever-present 1 g force. This fact can provide fascinating questions and design challenges for students.

Question: A Phototropic Riddle

If you were a plant
Or a plant were you,
Which hue would you choose
To tie your shoe?
Is it red, green or blue?

Sample Hypothesis:

My leaves are green,
Could it be green?
Or is it the red?
I'll guess blue,
And test if it's true.

Design

- Give germinating seedlings a choice of red, green or blue light, each coming from a different direction, and see if they bend toward one color more than toward the others.

Time Frame

Construction of the phototropism chamber will take approximately half of one 50 minute class period. The observational activities will take place over a period of 60 to 72 hours, with the actual time of observation and recording data requiring about 15 minutes at each interval.

Learning Objectives

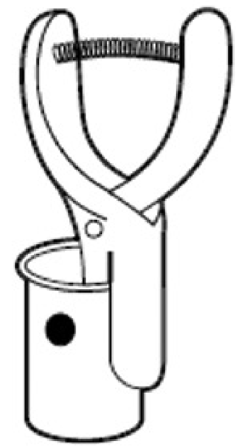
In participating in the activity students will:

- learn to construct their own experimental equipment from low-cost materials;
- learn to set up a simple experiment, make a prediction and observe results; and
- understand that blue wavelengths of visible light affect the bending of plants more than red or green, demonstrating the partitioning of various energy levels of light to different growth functions.

Materials

- 35 mm black film can with lid
- one floral foam disc, 28 mm diameter and 2 to 4 mm thick
- three grid strips, 0.5 cm x 4 cm (page 49)
- three wick strips, 1 cm x 4.5 cm, made of soft paper toweling (page 49)
- three brassica or other medium-sized seeds (turnip, lettuce or alfalfa)
- water bottle
- forceps to handle seed
- hand-held hole punch
- 2 cm wide clear adhesive tape
- 2 cm wide black vinyl electrical tape
- three 1.5 cm squares, 1 each of red, green and blue transparent plastic mylar (Roscolux® films red #26, green #89 and blue #69, work well) or colored acetate from art stores or theatre departments

Procedure



1. With a hand-held hole punch, make three windows about 1.5 cm from the rim of the black film can at approximately 120 degree intervals.

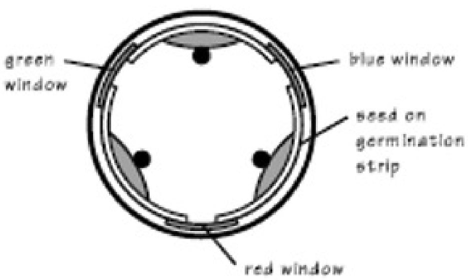
2. Use a 10 cm strip of clear adhesive tape to cover each window with a red, green and blue square.

3. As with the gravitropism chamber, place a floral foam disc in the chamber and wet it with water.

4. Set up three germination strips. The germination strips should be aligned vertically, each spaced between two windows (Figure 4). Be sure that the germination strips are below the chamber rim and that there is sufficient, but not excess, water in the floral foam disc.

5. Place a seed, oriented with micropyle down, 2 cm down on each strip.

Figure 4: Film can phototropism chamber, view from above.



6. Snap the lid tightly onto the film can and place the phototropism chamber under a light bank where light will enter all three windows.

7. Make a top view drawing of your chamber, predicting how the plants will appear after 48 to 72 hours of germination.

8. After 48 to 72 hours, open the lid and indicate whether or not your prediction is to be accepted or rejected. As evidence, draw what you observe and compare it with your prediction.

Concluding Activities and Questions

In this activity students will have observed the effects of light in orienting the growth of seedlings in the presence of gravity. Have students consider the following:

- Within the mix of colors making the white fluorescence of your plant lights, which color tells the plant which way is up? Is this the same for humans? Are you sure?

- What has been the influence of gravity on the phototropic response? How would the seedlings respond to light if this experiment were carried out in microgravity?

- What will happen to the seedlings if you darken the windows? What will happen if you darken only the blue window?

- Recently plant physiologists have isolated minute amounts of a yellow molecule called *flavochrome* that absorbs blue light and is active in the signal transduction pathway that transmits energy from the blue light to the bending response.