Travis Lick

Pedagogy

Plant Tropisms

Enduring Understandings:

1. ***Plant tropisms are not always positive, stems emerge due to a negative gravitropic response while a root elicits a positive gravitropic reponse.***

   In order for a plant to successfully grow from a seed, the roots and the shoots need to differentiate between up and down. The reaction of the pre-emergent stems and roots is the result of gravitropism, or the directional growth caused by the gravitational pull on the seed. Just as the shoot and the root have opposite reactions to light, they also have opposite reactions to gravity's pull. Roots exhibit positive gravitropism and therefore grow in the downward direction with gravity while the shoot has negative gravitropism and grows against gravity.

2. ***Phototropism is the directional growth of a plant in response to a change in available light.***

   Plants are extremely sensitive to light and respond to it in a positive and a negative way. The stems and leaves of a plant have positive tropism which means they grow in the direction of light, while roots exhibit negative tropism in that they grow in the opposite direction of light.

Student Misconceptions:

Students often have difficulty understanding most of the processes that plants undergo, from photosynthesis and respiration to water uptake and tropisms. At the elementary level, students often have the misconception that plants absorb "food" and water with their roots. Having done experiments with children before, they often fail to correctly predict tropic responses by both the root and stem systems. Hershey says, "There is "a recognized tendency, even for knowledgeable biologists, to overlook, underemphasize or neglect plants when teaching introductory biology courses" (Wandersee, 1999). Too often, biology is "botany taught by a zoologist," leaving students with "the popular delusion that biology is the study of animals" (Nicoles, 1919). This results in widespread ignorance about and under-appreciation of plants" (Bozniak, 1994). The lessons that were developed for this unit plan were created to stimulate student interest in plants through the use of exciting, hands-on, inquiry based lessons. Carter says, "new teachers coming out of our universities and colleges are very poorly trained in basic botany." This is something that can be avoided if activity based enrichment is used in early education and continued throughout.

Content Standards:

NS.5-8.1 Science as Inquiry:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Through inquiry based activities, students will see how roots and stems will grow properly regardless of their orientation in the soil or the position of a light source.

NS.5-8.3 Life Science:

- Diversity and adaptations of organisms

Through inquiry, students will observe plant tropic responses and their usefulness in helping plants adapt and survive.

NS.5-8.7 History and Nature of Science:

- Science as a human endeavor
- Nature of science
- History of science

Students will understand the history of phototropic and gravitropic experimentation and how it lead to the development of the current scientific method.

NA-VA.5-8.3 Choosing and Evaluating a Range of Subject Matter, Symbols, and Ideas:

- Students use subjects, themes, and symbols that demonstrate knowledge of contexts, values, and aesthetics that communicate intended meaning in artworks

Based on observations, students will create visual representations of plant growth and response to different environmental stimuli.

NL-ENG.K-12.7 Evaluating Data:

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience

Students will construct procedures and experiments based on previous activities to test their hypotheses.

NL-ENG.K-12.8 Developing Research Skills:

- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

At the conclusion of observational activities, students will perform a webquest that furthers understanding and combines aspects of lecture and inquiry knowledge.

NL-ENG.K-12.12 Applying Language Skills:

- Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information)

Students will construct procedures and experiments based on previous activities to test their hypotheses.

NT.K-12.3 Technology Productivity Tools:

- Students use technology tools to enhance learning, increase productivity, and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

At the conclusion of observational activities, students will perform a webquest that furthers understanding and combines aspects of lecture and inquiry knowledge.

Classroom Activities:

Enduring Understanding 1: Plant tropisms are not always positive, stems emerge due to a negative gravitropic response while a root elicits a positive gravitropic response.

Activity One[1]: Which Way Is Up?

Pre-Activity Thought Questions:

1. "How does a developing seed "know" which way is "up" and which way is "down?"
2. How will the roots and stems of seeds oriented in different ways grow? Sketch a drawing on your activity sheet (appendix A).

Background information:

When a germinated seed begins to grow, the seed coat cracks and an embryonic root emerges from the seed and starts to gather nutrients and water. At this point, the hypocotyl (stem) elongates and helps to push the cotyledons (seed leaves) upward toward the surface where the cotyledons will expand and provide a source of energy for the plant until the true leaves grow.

The orientation of seeds is not critical to proper root and stem growth due to the root's response to positive gravitropism and the shoot's response to negative gravitropism. The detection of gravity is undertaken by cells at the tip of a root, in a tissue called the root cap, inside a pre-developed seed. Inside the cells of the root cap, there are sensors called statocytes that contain starch granules. These statocytes settle on the bottom-most side of cells in the root cap and indicate to the root cells the direction they need to grow. The coleoptile (stem tip) is responsible for detecting the force of gravity and in turn, growing away from it towards the surface and more importantly, light!

Time Frame:

Construction of the seed germinator and placing the seeds properly will take one 50 minute class period. The observation portion of the activity will take place over a three day period.

Learning Objectives:

- Students will determine whether their hypotheses about plant growth were correct about seed orientation and root/stem growth.

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[1] Modified Lesson from Williams, 2007

- Students will understand that plant roots and stems reorient in the direction of their growth to conform with the direction of gravitational force.

Materials:

- two soda bottle caps
- plastic wrap
- paper towel
- plant seeds
- forceps
- hand lens
- elastic band
- hypothesis/data sheet

Procedure:

1. Cut two layers of paper towel into circles that will fit into the bottom of a soda bottle cap.
2. Place the towel in the cap and moisten it with water.
3. Orient the four seeds in a north-south-east-west position on the moist towel surface, making sure that the brown area of the seed is facing the center of the cap.
4. Make a mark on the bottle cap that indicates the direction of north, or up.
5. Cover the open cap with plastic wrap and secure the wrap with an elastic band.
6. Position the bottle cap germinator so the seeds are in a vertical orientation by standing it in a second bottle cap.
7. Make a drawing of the seeds in the germinator, including the orientation of the brown area toward the center of the circle. Mark this in circle 1 on your data sheet.
8. When the roots begin to emerge, record the direction of the emerging root from each seed with a drawing on circle 2. Use the hand lens for detail.
9. Be sure to keep the paper towel moist each day. After 48 hours, make a third drawing showing the roots and hypocotyls and cotyledons.
10. Reorient the germinator 90 degrees and predict what the seedlings will look like after 24 hours in circle 4.
11. 24 hours after reorientation, draw the seedlings on the data sheet in circle 5.

Concluding Group Discussion or Independent Activity:

- What changed from data circle 4 to data circle 5?

- Compare the outcome of the orientation with what you predicted would happen.
- In response to gravity, which direction will roots and stems grow?

Question for future lesson:

- What might be the possible influence of light in this experiment?

Activity Two[2]: Gravitropism

Pre-Activity Thought Questions:

1. How responsive are germinating seedlings to Earth's gravity?

Time Frame:

Construction of the gravitropism chamber and placement of the seeds within, will take on 50 minute class period. Observations need to be conducted for three consecutive days after construction.

Learning Objectives:

- Students will learn that seedling hypocotyls orient in the direction opposite the force of gravity.
- Each student will construct a gravitropism chamber.
- Students will make predictions and confirm the accuracy of them based on four different pieces of observational data (appendix B).

Materials:

- 35 mm black film container with lid
- double stick tape
- mm graph paper (.5cm x 4cm)
- 4 strips of paper towel (4.5cm x 10cm)
- foam disc (size of canister)
- water bottle
- two additional film can lids
- white masking tape
- permanent marker
- plant seeds
-forceps
- permanent marker

Procedure:

Preparing the gravitropism chamber---

1. On each extra film can lid place a 3 cm strip of double stick tape and then attach the lids to the outside wall of the film can so that each lid is opposite the other.

[2] Modified Lesson from Williams, 2007

-Mark the film can using a permanent marking pen to draw arrows on the film can lid and one of the mounted lids to indicate "FRONT".

-With the front facing you, stick a white label on the right side of the chamber and draw a compass on the label, marked with angles of 0˚/360˚, 90˚, 180˚ and 270˚, corresponding to north, south, east and west.

2. Place the floral foam disc in the bottom of the film can.

3. With a water bottle, add enough water to saturate the floral foam and just a little more free water in the bottom

4. Dip the end of a germination strip into the bottom of the can, touching the water until it wicks up some of the free water.

-Align the germination strip vertically inside the film can, with grid strip against the inner wall and the wick strip overlapping it and adhering d to the wall.

5. Align the germination strip with the front orientation of the chamber. At this stage you may let the strip extend above the rim of the film can chamber.

6. Repeat the procedure with the other germination strips, aligning them to create four strips opposite each other aligned at 90 degree angles.

7. Now remove one strip pair from the chamber and with your finger or using seed forceps to pick up one seed, place it about 2 cm down the strip. The seed will adhere to the wet paper towel.

8. With a forceps or a pencil point align the seed so the micropyle points down.

9. Replace the strip with seed to its original position in the can, but this time push the germination strip down so that the bottom of the wick strip connects with the wet floral foam disc and the top of the strip is below the rim of the film can chamber.

10. Repeat steps 8 to 10 until all four seeds are on the four wick strips in the chamber.

11. Make a final check on the amount of water in the bottom of the chamber.

12. Gently place the film can lid on, sealing the chamber. Be sure that the arrow on the lid is aligned with the arrow on the front cap of the chamber.

13. Put a white tape label on the top lid of the film can with the following information recorded: your name, the date, the time on a 24 hour clock, and the symbol "0˚" indicating the initial orientation of the chamber (upright). Add the information from the chamber label into the first three columns on the Data Sheet (Appendix B).

14. Place the chamber in the upright, 0˚/360˚ position, where a relatively uniform temperature between 22˚C and 30˚C can be maintained.

15. The chambers should be viewed every 12 to 24 hours, noting any elongation of the seedling hypocotyls.

16. Sometime between 24 and 48 hours, the seedling hypocotyls will be between 1 cm and 2 cm long. Make a drawing of the vertical seedling on each strip in the appropriate box in the first row of the Data Sheet. Record the date, time (on a 24 hour clock) and total cumulative hours from hour zero.

17. At this time rotate the chamber by 90˚. As the chamber is rotated, think about the possible outcome of reorienting the four seedlings.

-What will the seedling on each strip look like after 12 to 24 hours? Students should make a drawing on the Data Sheet of how they predict each seedling will appear.

18. Record the date, time and total cumulative hours of your first 90˚ rotation on the Data Sheet, and each rotation thereafter.

19. After 3 to 12 hours or 24 hours observe the chamber. Mark the time and date on the Data Sheet and next to the predicted sketch, make a sketch of how the plant on each strip appears.

-The chamber should then be rotated another 90˚ to the 180˚ position. A drawing should be made on the Data Sheet, predicting behavior and after 3 to 12 hours, repeat the cycle of observation, drawing and rotation. Be sure to record the date, time and total hours.

20. Continue rotating, observing and drawing until the chambers have completed 360˚ of rotation.

21. When the rotations have been finished carefully remove each strip with its seedling attached and make a final drawing.

-Stretch out the seedling to straighten it, then accurately record the length of the hypocotyl.

-On the Data Sheet, record the length of the hypocotyl in millimeters.

Concluding Group Discussion or Independent Activity:

-Discuss the outcome of the experiment relative to the original hypothesis. Was the hypothesis verified? How strong is your evidence? Were you able to successfully predict how the seedlings would respond to successive reorientation of the chamber?

-What is the average length of the hypocotyls in your chamber after X hours of germinating in the dark?

-Is there a limit to how long it would grow? If there is, what is it?

-When it is elongating, how is the hypocotyl actually growing longer? By what mechanism?

-Is there a limit to how much bending a hypocotyl can undergo?

Enduring Understanding 2: Phototropism is the directional growth of a plant in response to a change in available light.

Activity One[3]: Phototropism

Pre-Activity Thought Questions:

- How much light is needed to bend a seedling?

Background Information:

Plants are extremely sensitive to light and respond to it in a positive and a negative way. The stems and leaves of a plant have positive tropism which means they grow in the direction of light. Auxin is a chemical that promotes the rapid elongation of growth cells in the shoots of a plant. Auxin also helps the plant to remember where it has branched off in the past and also in which direction it needs to grow. In the figure, you can see the auxin gathering on the left side of the coloptile, which is the covering of a plant shoot that enables it to grow. As auxin moves down the shoot, the redistribution stops when it has evenly distributed itself along the shaded portion. Once this happens, the auxin stimulates cell growth and cell division only in the region opposite the light source. The plant cells react to the high auxin levels by transporting Hydrogen ions into their cell walls and raising the pH. Due to this, the plant elongates more rapidly on the auxin rich side causing the overall result, the extension of the plant in the direction of the light source.

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[3] Modified Lesson from Williams, 2007

Time Frame:

The phototropism chamber will take approximately one 50 minute class period to construct. Observations will then take place for 4 consecutive days at specific intervals.

Learning Objectives:

- Students will construct their own experimental equipment.
- Students will use observational data and their knowledge of geometry to interpret the effect of light on a seedling.
- Students will graph observational data.

Materials:

- Four 35 mm black film containers with lids
- tape
- mm graph paper (.5cm x 4cm)
- 4 strips of paper towel (4.5cm x 10cm)
- foam disc (size of canister)
- water bottle
- scissors
- hole punch
- two additional film can lids
- electrical tape
- permanent marker
- plant seeds
- forceps
- pencil
- four 1.5 cm squares of foil
- protractor

Procedure:

1. Make a single hole about 1.5cm from the rim of each of the four film containers and cover it with clear tape to make a window.
2. Puncture the center of a piece of foil with a pencil, on another make a slightly larger hole (2mm), the third a large hole (6mm) and the last piece no puncture.
3. Measure the size of each hole and record it on data sheet 1 (Appendix C).
4. Place each of the foil pieces over the "windows" of each film container.
5. Cover each of these with a small piece of electrical tape.
6. Cover the bottom of each chamber with a small amount of water and place one seed on a germination strip.
7. Place the seed and the strip in the container opposite the window.
8. Place each chamber is a position where light can enter the window once the electrical tape is removed.

9. Let the seeds germinate (in the dark) for 48 hours and then remove the window covers.
10. Open the lid of each chamber and observe the orientation of each seedling. Place the seedling on data sheet 2 (Appendix D) and draw a line indicating the curvature of the seedling.
11. Use data sheet 2 and a protractor to measure the angle of the curvature of each stem and note it on data sheet 1, under T_1. Also record the amount of time that has passed.
12. Repeat steps 10 and 11 after 6, 24 and 48 hours.

Concluding Group Discussion or Independent Activity:

- Students will create a graph using the data collected. The x-axis will be the diameter of the hole in the "window" and the y-axis, the degree measure of the stem curvature.
- A follow-up lesson to this is observing a plant's phototropis response to different colors of light (Appendix E).

Assessment of Student Learning

In order for assessments to be effective, they must align to current standards and curriculum as well as incorporating a variety of assessment techniques. Assessments need to be on-going, provide snap-shots of student learning and be formative and summative in design (Brough, 2005). Assessment needs to guide instruction and be varied in scope. These guidelines were used in the development of the classroom activities show earlier. The students will be given a pre-assessment prior to beginning the unit on tropisms, will be evaluated formally and informally through teacher observation as well as written and verbal lab question reports and finally will be given a post-assessment after the completion of the unit.

Additional Resources:

Plants in Motion Webquest:
http://www.scasd.us/hs/science/Vitkauskas/Biology/Ch25PlantResponsesWebquest.htm

Plant processes self-check quiz 1:

http://highered.mcgraw-hill.com/sites/0078617022/student_view0/unit2/chapter11/section_2_self-check_quiz-eng_.html

Plant processes self-check quiz 2:
http://highered.mcgraw-hill.com/sites/0078693896/student_view0/unit4/chapter13/chapter_review_quiz.html

Potato Maze Lab:
http://www.conservatoryofflowers.org/education/potato_maze.htm

Germinating Seeds in Gelatin:
http://www.all-science-fair projects.com/science_fair_projects/50/625/4611fe1a62e1961d454c65c351aeabdd.html

Gravitropism lab:
http://starryskies.com/try_this/plant_growth.html

The Importance of Tropisms:
http://school.discovery.com/lessonplans/programs/tropisms/

Plants in Motions: Videos
http://plantsinmotion.bio.indiana.edu/plantmotion/starthere.html

References:

- Bozniak, E.C. 1994. Challenges facing plant biology teaching programs. Plant Science Bulletin 40: 42–46.

- Carter, J. L. 2004. Developing a curriculum for the teaching of botany. Plant Science Bulletin 50: 42–47. http://www.botany.org/bsa/psb/2004/psb50-2.pdf

- Hershey, D. R. 2005. Plant Content in the National Science. Action BisoScience. http://www.actionbioscience.org/education/hershey2.html

- Nichols, G.E. 1919. The general biology course and the teaching of elementary botany and zoology in American colleges and universities. Science 50: 509–517.

- Wandersee, J.H., and E.E. Schussler. 1999. Preventing plant blindness. American Biology Teacher 61: 82,84,86.

- Williams, P. 2007. Fast Plants. http://www.fastplants.org/activities.php

Appendix

Item A: Data sheet for **Which Way Is Up?**

Item B: Data sheet for **Gravitropism**

Item C: Data sheet 1 for **Phototropism**

Item D: Data sheet 2 for **Phototropism**

Item E: Lesson testing a plant's response to different colored light sources

Item F: Pre/Post Assessment

Launching the Seed Student Sketch Sheet

Circle 1:
Sketch and label your bottle cap seed germinator at time of placement of seeds.

Circle 2:
Sketch and label your bottle cap seed germinator as the roots emerge from the seeds.

Circle 3:
Sketch and label your bottle cap seed germinator 24 to 48 hours after placement of seed.

Circle 4:
Sketch and label your bottle cap seed germinator with your prediction of the effects of reorientation on your seedlings.

Circle 5:
Sketch and label your bottle cap seed germinator 12 or 24 hours after reorientation to compare with sketch in Circle 4.

Write about what you have learned about germination and orientation.

Williams, 2007

Gravitropism Data Sheet

Student Name 1 ______________________________
Student Name 2 ______________________________
Student Name 3 ______________________________
Student Name 4 ______________________________

Environment

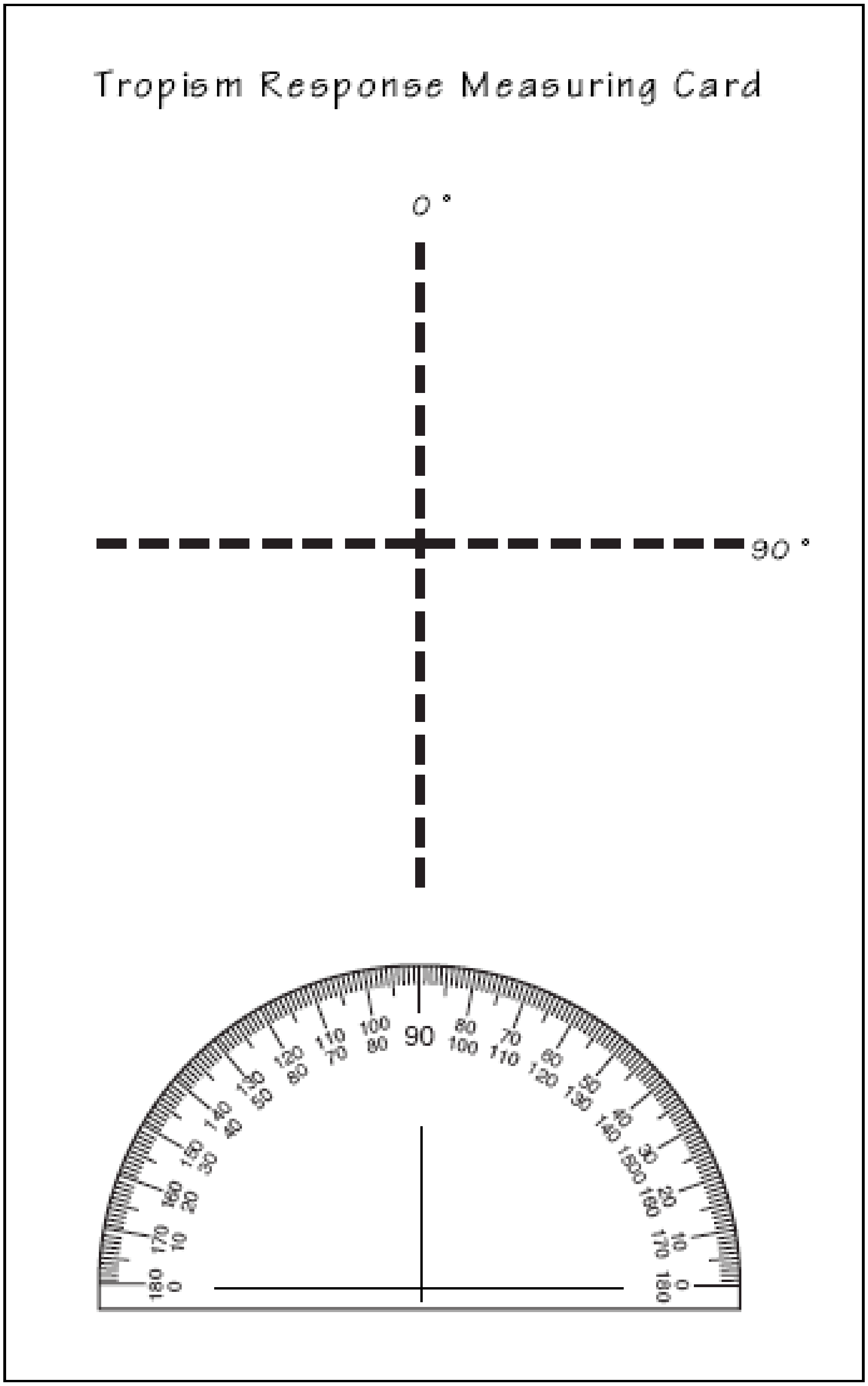
Temperature Range: __________ ˚C

Average Daily Temperature of Growing Environment: __________ ˚C

Date	Time (24 hr clock)	Total Hours	Hours from Last Rotation	Rotation Angle	Germination Strip Position Number 1		2		3		4	
					predicted	observed	predicted	observed	predicted	observed	predicted	observed
			0	0	X							
				90								
				180								
				270								
				360								
length of hypocotyl after ________ hours:					______ mm		______ mm		______ mm		______ mm	

Williams, 2007

Appendix C



Williams, 2007

Phototropism Data Sheet

Student Name 1 ______________________________
Student Name 2 ______________________________
Student Name 3 ______________________________
Student Name 4 ______________________________

Environment
Temperature Range: __________ ˚C
Average Daily Temperature of Growing Environment: __________ ˚C

			Angle (θ) at Hour of Light Exposure											
Chamber Aperture #	Aperture Diameter (mm)	Area of Aperture (mm^2)	T_1 ______ hr			T_2 ______ hr			T_3 ______ hr			T_4 ______ hr		
1	0	0												
2														
3														
4														
ambient temperature during time period (°C):			hi	lo	avg	hi	lo	avg	hi	lo	avg	hi	lo	avg

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.

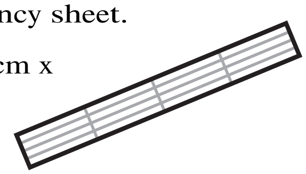
Learning Objectives
In participating in the activity students will:
- learn to construct their own experimental equipment from low-cost materials;
- learn to set up a simple experiment, make a prediction and observe results; and
- understand that blue wavelengths of visible light affect the bending of 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
  (Floral foam is available from most florist supply stores cut to deminsions noted)
- three germination strips (See preparation of germination strips)
- three Fast Plant seeds
- 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

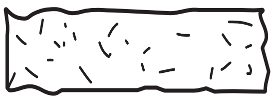
Department of Plant Pathology, 1630 Linden Drive, Madison, WI 53706 1-800-462-7417 wfp@fastplants.cals.wisc.edu

Preparation of Germination Strip

- *Making grid strips:*
  - Photocopy millimeter square graph paper onto an overhead transparency sheet.
  - Cut the sheet along the lines to make strips with the dimensions 0.5 cm x 4 cm.
  - Grid strips can be reused after rinsing, soaking for 20 minutes in a 20% bleach solution, then rinsing again and drying on paper toweling.

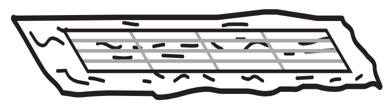


- *Making wick strips:*



  - Fold a square sheet of kitchen paper toweling to form an eight layered rectangle.
  - With scissors, trim end and folds to make a rectangle with the dimensions 4.5 cm x 10 to 12 cm.
  - Cut wick strips from the rectangle by cutting 1 cm strips.

- *Making germination strips:*
  - Hold a wick strip with a grid strip aligned on top of it. Moisten the wick strip.
  - As the wick strip becomes moist through capillary action, the grid strip will adhere to it through the adhesive forces of the water. Together the wick and grid strip make a germination strip.
  - The wet germination strip will adhere to the inner wall of the film can gravitropism chamber.



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 1). 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.

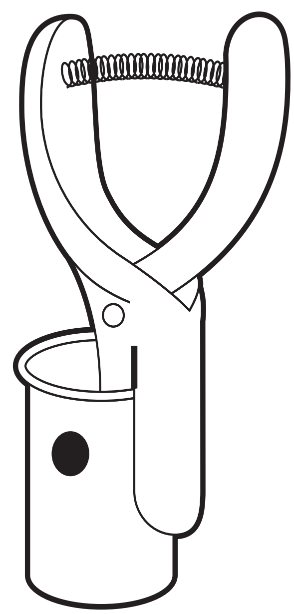
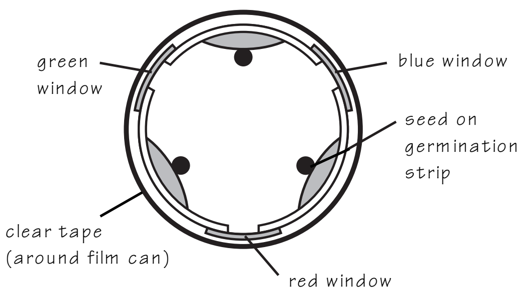


Figure 1: Film can phototropism chamber, view from above.



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

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* or *cryptochrome* that absorbs blue light and is active in the signal transduction pathway that transmits energy from the blue light to the bending response.

PRE-ASSESSMENT/POST ASSESSMENT

Question 1

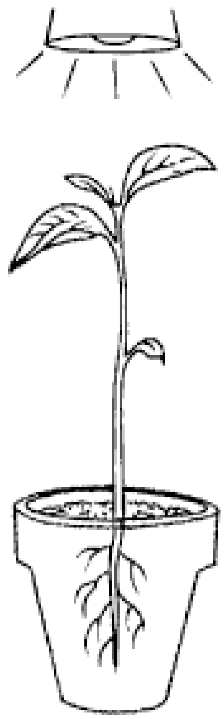


figure 1

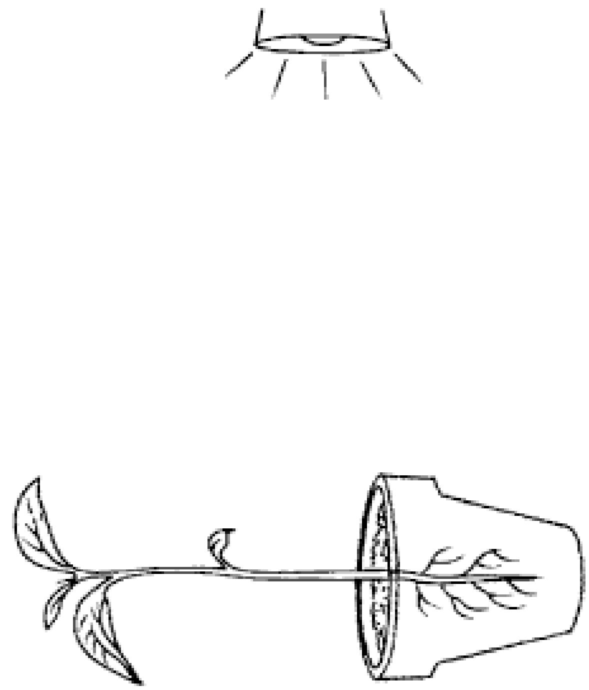


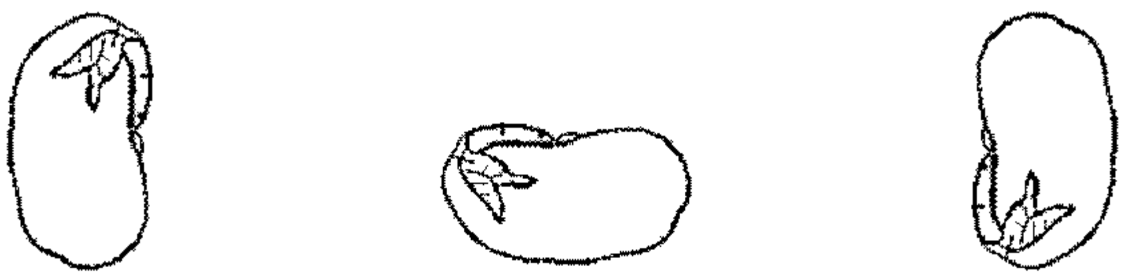
figure 2

http://www.tea.state.tx.us/student.assessment/resources/online/2006/grade8/science/8science.htm

Figure 1 above shows a normally growing house plant. Figure 2 shows the same plant lying on its side. If plant 2 is left in this position for several weeks, explain in detail what changes, if any, the plant will show in growth. In your description, be sure to describe the affects of both the roots as well as the stem/leaves. Finally, draw what you believe the plant will look like at the end of this several week period.

Question 2

Below are three identical bean seeds growing in soil. Each of them is oriented in a different direction in the soil as can be judged by the emerging cotyledon shown. Draw the root structure and stem system for each seed as it will appear in several weeks time. Explain in detail what caused the roots and stems to develop in the way you have shown.



http://io.uwinnipeg.ca/~simmons/images/seed.gif