Phototropism:

How Little Light Will Bend a Seedling?

Introduction

On Earth gravity is present in the quantity of 1 g (unit gravity). The quantity of light on the other hand can vary enormously from very large quantities of irradiance in the order of 8000 $\mu Em^{-2}s^{-1}$ in sunlight at noon to vanishingly small amounts. With the film can phototropism chambers, that you and your students will construct in this activity, it is easy to investigate the effects of light quantity on bending of seedlings.

Question: How much light is needed to bend a seedling?

Hypothesis: You provide an amount. Then find out!

Design

- Groups of students will use a set of film can phototropism chambers to vary the quantity (intensity and duration) of unidirectional light reaching seedlings and measure the responses over time. This experiment can be run at home to facilitate observation and data collection.
- Students will record observations and measurements on the Phototropism Data Sheet.

Time Frame

Construction of the phototropism chamber will require approximately half of one 50 minute class period. The experiment will run 96 hours from the time seeds are placed in the chamber, with observations and measurements made at specific intervals. The time required for the measurements will be approximately 15 minutes at each interval.

Learning Objectives

In participating in this activity students will:

- learn to construct their own experimental equipment from low-cost materials;
- apply simple geometry to the determination of the experimental variables of light quantity impacting a seedling; and
- learn to interpret complex interactions involving three variables, including three-dimensional graphing of data representing two independent variables (time and quantity of light) and one independent variable (angle of plant bending).

Materials *(per group of four students)*

- four 35 mm black film cans with lids
- four grid strips, 0.5 cm x 4 cm
- four wick strips, 1 cm x 4.5 cm, made of soft paper toweling
- four Fast Plant seeds
- water bottle
- forceps to handle seed
- 2 cm wide clear adhesive tape
- 2 cm wide black vinyl electrical tape
- scissors
- four 1.5 cm squares of aluminum foil
- fine needles or pencil point for making holes in aluminum
- dissection strips (see WFPID *Dissection Strips*)
- hand lens
- hand-held hole punch
- small plastic protractor or Tropism Response Measuring Card

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Procedure

1. On each of four black film cans, use a hand-held hole punch to make a single hole of 6 mm diameter 1.5 cm from the rim and cover it with a clear strip of tape to make a window.

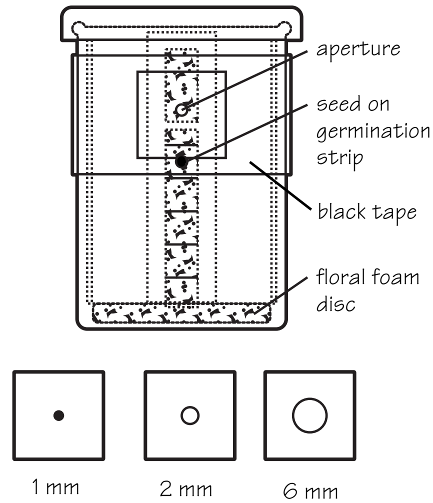
2. Taking a 1.5 cm square of aluminum foil, puncture the center of the foil with a very fine needle to make a circular hole (aperture of 1 mm diameter).

3. On a second square of foil, use the needle to puncture an aperture of about 2 mm diameter. On a third square puncture an aperture of 6 mm (Figure 5).

4. On a fourth foil square, make no aperture.

5. Measure the actual diameter of each aperture with the aid of a hand lens and ruler, estimating to a fraction of a millimeter, enter the diameter on the Phototropism Data Sheet. Calculate the area of each window and enter it on the data sheet.

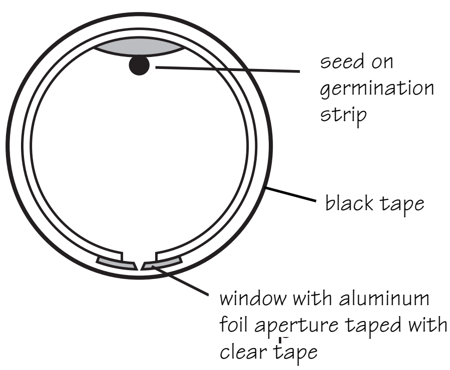
Figure 5: Side view of tropism chamber, and aluminum foil squares with varying apertures.



6. With clear tape, mount each foil square over the window on a different film can phototropism chamber, so that now there are four chambers each with a window of differing aperture diameter (0 aperture, 1 mm, 2 mm and 6 mm).

7. Cover each of the windows with a 3 cm strip of black vinyl tape that has a 5 mm length folded back on itself to produce a tab so the tape can be easily removed.

Figure 6: Film can phototropism chamber, view from above.



8. Set up each chamber by adding just enough water to cover the bottom of the film can (about 2-3 ml). Wet a single germination strip and place one seed located 2 cm down the strip.

9. Place the germination strip and seed opposite the window (Figure 6).

10. Set the chambers under the light bank with the windows in a position to receive light when the black tape window covers are removed.

11. **Let germination proceed in the dark for 36 to 48 hours**, then remove the window covers.

12. After removing the window covers, open the lid of each chamber and observe the orientation of the seedlings.

    - Remove each germ strip with its seedling. Lay each down on a Tropism Response Measuring Card as shown in Figure 7. Draw a line indicating the angle of bending from the vertical, θ.

    - Work quickly so that your delicate seedlings do not dry out.

    - Carefully return the germination strip and the seedling to the original position in the chamber and replace the cap.

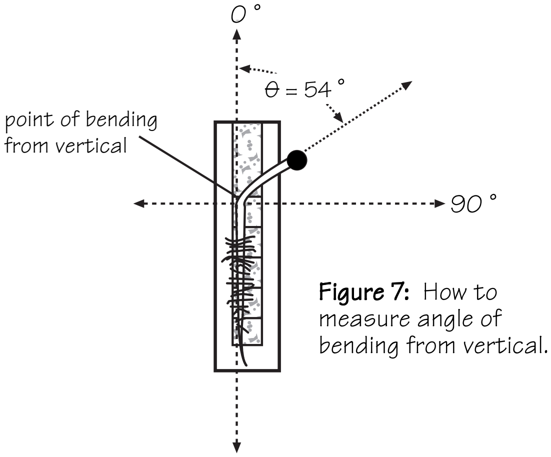


Figure 7: How to measure angle of bending from vertical.

13. With a protractor on the Tropism Response Measuring Card, estimate the angle of bending for each seedling and enter the data on the Phototropism Data Sheet under T_1. Note the number of hours that have passed between the time the seeds were placed and the time of measurement.

14. Repeat steps 12 and 13 at each of three additional time intervals: **6, 24 and 48 hours after removing the window covers**. Record the high, low and average ambient temperatures during each time period.

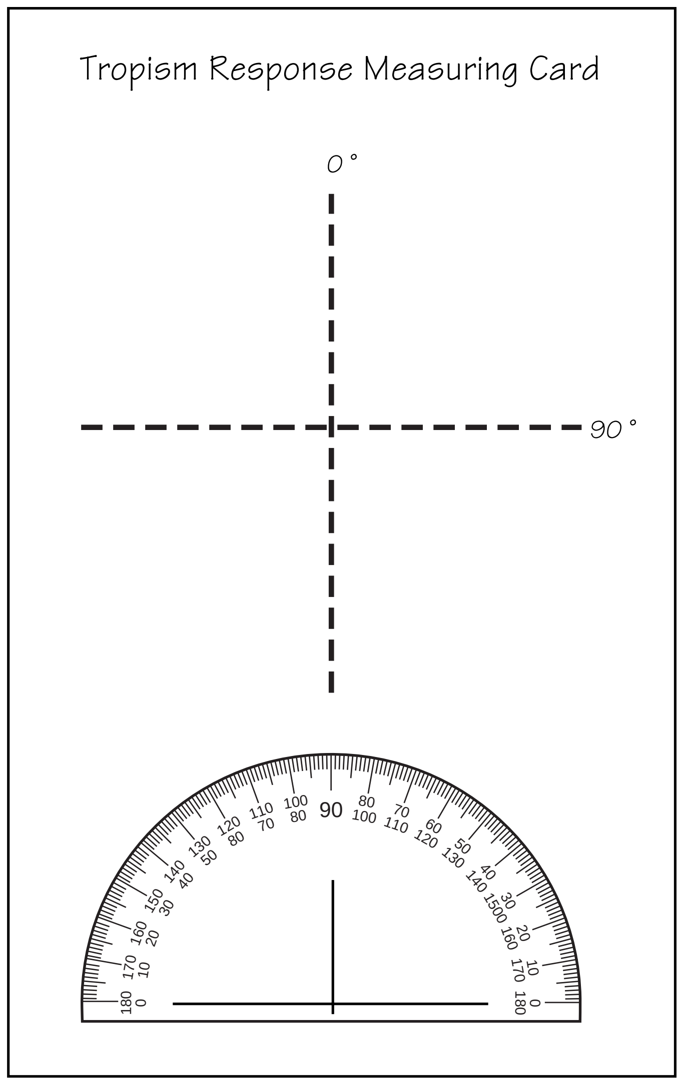
Concluding Activities and Questions

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

- From the Phototropism Data Sheet, plot a line graph with aperture diameter on the x-axis and degrees of plant response from the vertical (θ) on the y-axis, with each line representing a different time of exposure to light. On another graph, plot a second set of four lines with time of light exposure on the x-axis and the degrees of response from the vertical (θ) on the y-axis, with each line representing a different quantity of light. How do the two line graphs compare?

- This experiment represents two independent variables (time and quantity of light) and one dependent variable (angle of plant bending). These could be displayed graphically in a three-dimensional graph with axes x, y and z. Try plotting this graph; some computer software programs have this capability.

- Discuss the observed phototropic responses from the standpoint of the interaction of light direction and quantity (as aperture) as an opposing horizontal force at an angle of 90˚ to the constant vertical force of gravity.



Additional Activities

- Try covering the window apertures with transparent colored foils of Rosolux® (see WFPID *Phototropism: Do Fast Plants Prefer the Blues*) to test the effects of light wavelength, light quality, light quantity, and time on the amount and rate of bending.

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