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Reaching for the Sun?

Observing Gravitropism

Introduction

Which way is up? Ever been under water and lost your sense of up and down? What helped you figure it out and let you come to the surface? How does a plant know which way is up? What helps a plant keep its bearing? What happens if you turn a plant upside down?

Concepts

- Gravitropism
- Differential growth rates

Materials

Water, tap	Masking tape
Bunsen burner	Modeling clay
Dandelion scapes	Permanent marker
Glass tubing, 6–7 mm o.d., 15-cm lengths	Razor blade
Graduated cylinder, 100-mL	Ruler or protractor
Graph paper	

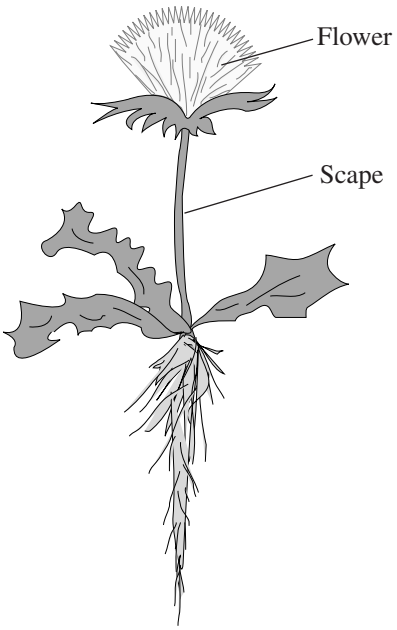


Figure 1. Dandelion Plant

Safety Precautions

Inspect dandelion collection sites for safety hazards. Students should not collect scapes from areas that have been sprayed recently with insecticides or herbicides. Have students wash their hands after handling plants collected in the wild. Be sure to note any students with allergies or other potential health problems during outdoor field trips.

When cutting and fire-polishing glass tubing:

- *Wear protective eyewear.*
- *Protect your hands when breaking the tubing by wrapping a cloth around the glass tubing and by breaking the glass away from you.*
- *Rotate the tubing evenly in the burner flame.*
- *Remember—glass may look cool but still be hot.*

Background

The dandelion, *Taraxacum officinale,* is a common weed found almost everywhere in North America. In the spring, each plant produces large numbers of bright yellow flowers supported by long, straight, hollow stalks called *scapes* (see Figure 1). Dandelion scapes are very interesting and convenient to use in studying reactions to some environmental influences. Plant growth reactions to stimuli or environmental influences are called *tropisms*. Reactions to gravity or position are called *gravitropisms*.

Pre-Lab

Scape holders can be made by cutting 15-cm lengths of glass tubing (6–7 mm outer diameter) and sealing one end by melting the end shut over a Bunsen burner.

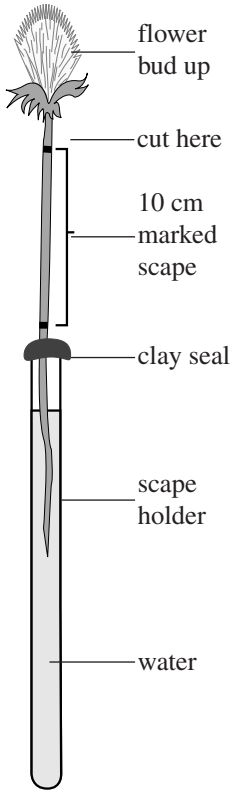
Part I. Observing Gravitropism

Procedure

1. If scapes have already been collected, go on to step 2.

   Collect scapes as follows: Find dandelion plants with long straight upright scapes where the flower has not yet opened. Choose scapes at least 15 cm in length and cut them at their base with a razor blade. Handle the scapes as little as possible. Place them immediately into a graduated cylinder that is partially filled with water. Put the cut end into the water. Keep the scapes upright (flower end straight up) at all times until you are ready to do the experiment.

2. Fill a scape holder with water. While still holding the scape upright, slide it into the water with at least 10 cm of scape sticking out of the glass tube (see Figure 2).
3. Soften a small, thin layer of clay (or Flinn Slide Gel) and place a ring of it around the open end of the scape holder to seal the scape into the holder. Do this carefully so as not to harm the scape.
4. Use a permanent marker to mark two rings around the scape 10 cm apart (see Figure 2).
5. Cut the flower off of the scape just before you are ready to start the experiment. Cut it at the base of the flower.
6. Your instructor will set up a table or other horizontal surface where the scape can lie and not be disturbed for a day. Place your scape in a horizontal position and tape it down to a horizontal surface. The scape should be over the edge (see Figure 3). Make sure the water does not leak out of the scape holder.
7. Record the time when each scape is placed in the horizontal position. Observe the scapes and look for movements away from the horizontal position. Movement may not be detected immediately but will start to occur after an adjustment period to the new horizontal position.
8. Measure the distance the tip moves from the horizontal position either as a linear distance (use a ruler) or as an angle (use a protractor). Make measurements every 15 minutes for the first hour and each hour (as possible) for the next three hours. Record your observations and measurements.
9. Consider these questions before doing Part II of the experiment:
   a. What could be causing the bending of the scape?
   b. Is the scape reaching for the sun?
   c. Discuss alternative explanations for what you have observed.



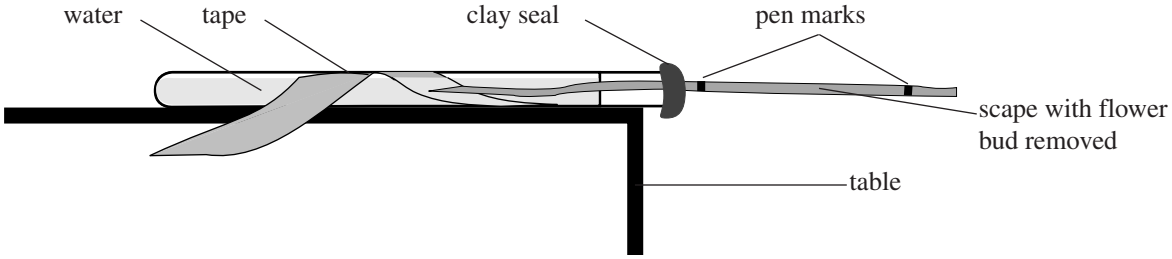


Figure 3. Scape in horizontal position

Part II. Growth and Gravitropism

Procedure

1. Carefully cut the marked scape portion from the scape holder.
2. Use a razor blade to split the scape in half longitudinally to separate the upper and lower surfaces (see Figure 4).

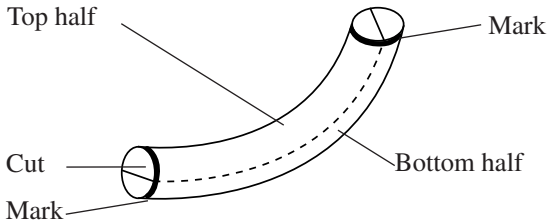


Figure 4. Cut Scape

3. Lay each half on a smooth surface. Straighten the bend in each half with gentle pressure and measure its length along the midline on the outside surface between the marks placed around the scape in Part I. Measure the length between the marks for the upper and lower surface to the nearest mm. Record your measurements.
4. Now consider these questions:
   a. Is the scape still alive after being removed from the dandelion?
   b. What can explain the difference in lengths between the top and the bottom of the scape?
   c. Describe the next experiment you would like to do to determine if your ideas are correct.

Going Further

Scapes are useful for other student-designed experiments.

1. Does a scape grow when held up straight? What affects the growth rate? Can it be increased or decreased?
2. How will a scape react if it is held in a horizontal position for a brief time and then turned vertical again?
3. What happens if you turn a scape upside down?
4. What might the scape top and bottom look like under a microscope—can differences be seen?
5. Test scapes with dilute treatments of dandelion killer. Can you determine how they work?

Discussion

A tropic response is, by definition, a growth response. Bending of the dandelion scape is brought about by the difference in growth rate between upper and lower sides of the scape. Upward bending occurs because the lower side grows faster than the upper side. Data from Part II of the experiment supports this idea. Gravistimulation can produce differential elongation in one of three ways:

1. The elongation of both sides can be stimulated with growth on the lower side to a greater degree.
2. Both sides grow more slowly with the retarding effect being greater on the upper surface.
3. Growth could be retarded on the upper surface while being accelerated on the lower side. (In the case of dandelion scapes this one seems to be the case.)

Gravistimulation of scapes is followed by a lag time when the scape does not seem to bend. It will vary from scape to scape, but will average between 20 and 30 minutes. After a lag phase, the scapes will start to bend in a rather dramatic fashion and some will reach a vertical stage in as little as $2^1/_2$ hours. Once a 90° bend has been achieved, the cut tip of the scape will be vertical and the 10 cm length of free scape will form a nearly perfect quarter circle. Once vertical position is achieved it will stay vertical. Growth of the scape does not stop, however, and regions below the tip start to straighten out. Eventually the scape will be almost entirely vertical with a tightly bent section where it is inserted in the glass holder.

Scapes that are exposed to 1–20 minutes of horizontal stimulation and then replaced vertically will bend in the direction that was the top when in the vertical position. After bending slightly to the left or right it will again straighten back to vertical.

Plant organs are believed to perceive gravity by means of the sedimentation of amyloplasts within specialized cells called statocytes. Dandelion scapes have particularly large amyloplasts and statocytes. The statocytes are located in the endodermis, near vascular bundles, and can be seen in transverse sections stained with iodine. Once stained, they can actually be viewed falling down the length of statocytes when turned upside down. (Since the microscope must be turned on its side to change the gravitational field, this is not recommended for most classrooms.) Much is known about the mechanism of gravitropism; however, the link between graviperception (by means of the sedimenting amyloplasts) and the resulting growth responses that bring about the differential growth is not totally understood.

Tips

- Students enjoy picking their own scapes. Do the collection the day before the lab. (See the safety precautions about collecting in unsafe areas.) Watch the dandelion bloom in your area in the spring or in the fall. When they flower, they will typically stay low to the ground and then elongate rapidly and go to seed in one day. When scapes are in this explosive phase they can demonstrate gravitropisms within the time limits of one class period. The longer the scapes the more dramatic the result. Store the harvested scapes vertically in graduated cylinders with their cut bottoms submerged in water.
- The more time available for observation after the scapes are placed in the horizontal position the more successful the lab. Try staggering the setup of this lab so that students can observe scape setups from previous class periods. Also encourage students to check on their scape activity throughout the lab day.
- In part II, the measurements should be made along the midline of the top and bottom halves of the scape. The difference in length should be easily measured if the marking in Part I is clear and the cut is made carefully along the full length of the scape.
- This simple and inexpensive experimental setup can be used for many student-designed experiments. By springtime your students should be experienced in designing experiments and should be encouraged to experiment further with dandelions.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Form and function

Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard C: Life Science, structure and function in living systems, regulation and behavior, diversity and adaptations of organisms

Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard C: Life Science, behavior of organisms

Reference

Moore, R. *Best Labs That Work; The Best of How-To-Do-Its;* NABT: Reston, VA, 1994; pp 90–97.

Materials for *Reaching for the Sun?* from Flinn Scientific, Inc.

Catalog No.	Description
AP8136	Graduated Cylinder Polypropylene, 100-mL
AB1043	Razor Blades, Single-edged
GP9015	Tubing, Glass, Pyrex,™ 7 mm
AP1734	Masking Tape, ¾″
FB0600	Clay, Modeling
AP1872	Ruler, Transparent
AP9286	Protractor, 180°
AP1813	Graph Paper

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

