Geotropism in Germinating Bean Seeds

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Topic

Geotropic response in plants

Time

½ hour preparation; 4 to 5 days to completion

Safety

Please click on the safety icon to view the safety precautions. Adult supervision is necessary when burning holes in the plastic petri dish. Make sure you use a hot glove and tongs to hold the nail. Be sure to work in a well-ventilated area. Be extremely careful using bleach. Do not spill it or drink it. Do not eat the bean seeds before or after soaking. Rinse any leftover been seeds in clear water, and dispose of them properly with other wet garbage. Pour the leftover soaking solution down a drain, and rinse away all traces of the bleach with clear water.

Materials

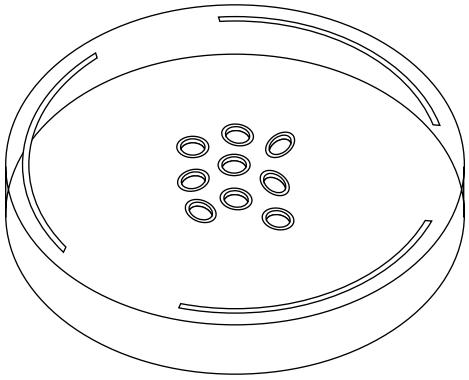
bleach
water
six to eight viable lima or bush bean seeds
marking pen or grease pencil
vermiculite
masking tape
modeling clay
nail
eyedropper
hot glove
saucer or paper plate
hot tongs
small bowl
candle
plastic petri dish

Procedure

1. Soak the bean seeds in water in the small bowl overnight.
2. The next day prepare a 2% solution of bleach by adding 20 drops of bleach (about 1 mL) to 50 mL water. Soak the bean seeds in this for ½ hr before starting, to inhibit the growth of mold on the seeds over the course of the experiment.
3. While working in a well-ventilated area, make air holes in the bottom of the petri dish as follows: Place the dish upside down on a nonflammable surface (the top of a stove is ideal). While wearing the hot glove and holding the nail in the tongs, heat the nail in the flame of a candle. When the nail is hot, force it

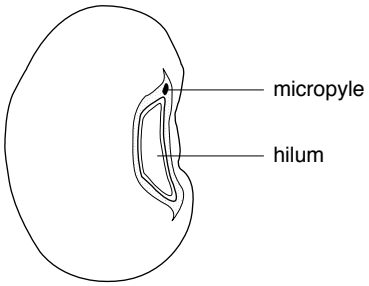
through the bottom of the dish. Make 9 or 10 holes, starting in the center of the dish, as shown in figure 1.

Figure 1

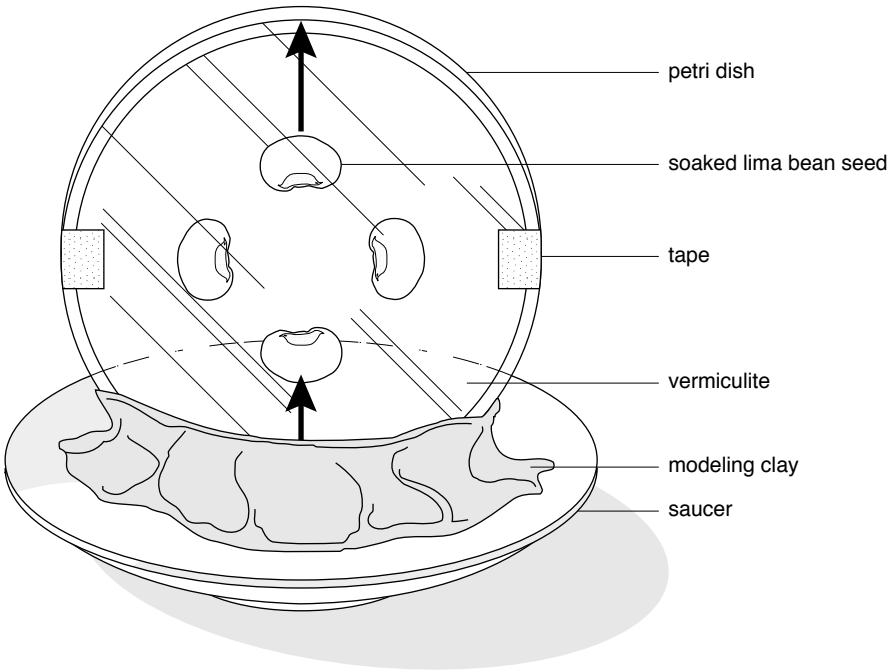


4. Place a uniform layer of vermiculite in the bottom of the petri dish on top of the punched holes.
5. Remove the seeds from the soaking solution and examine them. Identify the hilum (the point at which the seed was attached to the pod it grew in) and the micropyle (the pore through which water entered the seed when soaking; see figure 2.)

Figure 2



6. Choose four plump, well-formed seeds, and place them in the dish on top of the vermiculite in the positions indicated in figure 3: at 12 o'clock, 9 o'clock, 6 o'clock, and 3 o'clock. Make sure that each seed is positioned differently with reference to its hilum and micropyle.
7. Add additional water to the setup, and place the cover on the dish. Make sure that the seeds are held in place by the cover when the dish is placed on end. If they are not held in place, add more vermiculite to the dish. Tape the cover on the dish.
8. Draw arrows on the dish with the marker, to indicate the orientation of the dish to be maintained throughout the experiment (see figure 3).
9. Place a small mound of modeling clay in the bottom of a saucer or paper plate and set the petri dish on end, as shown in figure 3.



10. Place the dish in an undisturbed area that provides reduced light and moderate temperature.
11. Make daily observations for 5 days, noting the orientation of roots relative to the placement of each seed's hilum and micropyle. Each day, draw on the data table the roots you observe.

DATA TABLE

Day	Seed position			
	12	9	6	3
1				
2				
3				
4				
5				

What's Going On

The initial direction of the root when it first emerges from the seed is determined by the seed's position. However, all roots soon start to grow in a downward direction. The roots of the seed in the 6 o'clock position have to arch over the seed itself in order to grow in their normal (downward) direction. The roots of the seeds in the 3 and 9 o'clock positions have to bend downward in order to grow correctly. The roots of the seed in the 12 o'clock position grew directly downward, with no need for bending. In general, plant roots grow downward for two reasons: First, they are positively *geotropic*. They are also positively *hydrotropic*, meaning that they tend to grow toward water. This is almost always a downward growth pattern because most water remains in the ground. In this experiment, the roots are responding only geotropically. We know this because the water in the petri dish is evenly distributed throughout and the roots still consistently grow downward. Plant roots are positively geotropic. This means they grow toward the center of the earth. The fact that the stems grow upward, opposite to the pull of gravity and away from the earth's center, means that they are negatively geotropic.

Connections

Plant seeds contain tiny structures that have the potential to grow into roots, stems, and leaves. For the plant to thrive, these must grow in the proper direction, no matter how the seed is positioned when planted. This type of directional growth is called a *tropism*, which occurs in response to an external stimulus. Maybe you have noticed that the leaves of a plant tend to grow toward light; this is an example of *phototropism* ("photo" is a prefix meaning "light"). In this experiment you saw how a plant's response to the earth's gravitational pull, called *geotropism* ("geo" is a prefix meaning "earth"), determines the direction in which the leaf and root structures grow.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES