Which Way to Grow?

Principle of Plant Biology #11

Plant growth and development are under the control of hormones and can be affected by external signals such as light, gravity, touch or environmental stresses.

Have you ever wondered how bananas get to your local grocery store? Like all plants, the growth and development of bananas is controlled by genes, the environment, and hormones. Knowledge of all three is needed to get bananas all the way to your kitchen.

Genes determine the basic characteristics of plants. The genes of most bananas in grocery stores have been selected to grow large fruits with no seeds. Most of them are genetically identical (just like identical twins), explaining why the size, shape, and flavor of bananas is usually very consistent.

The environment also influences plant growth and development. Environmental factors that influence bananas and other plants include water and nutrient availability, the presence of viruses and fungi, and the amount, color and direction of light. Banana plants will not bear fruit unless they are grown in a tropical environment. As a result, many countries must import bananas from tropical regions such as Central America. Banana fruits are cut from the plants, packed into crates, driven to a port, and shipped all around the world.

Just before bananas arrive at a grocery store, they are often exposed to ethylene gas so that they will ripen just in time to be eaten. Ethylene is a hormone, a chemical messenger that influences growth and development. Hormones in plants include ethylene, auxins, cytokinins, gibberellins, and abscisic acid.

In this activity, you will examine how different amounts of light affect plant growth and development. Imagine all the experiments that could be done using the same basic design – just change some aspect of a plant's genes, environment, or hormones and then measure some aspect of their growth and/or development.

Real-world Connection:
Understanding plant growth and development allows us to dramatically increase crop yields, improve product consistency, and time ripening so that food is ready to be eaten when it arrives at the grocery store.

Activity: Effects of Light on Plant Growth

Procedure:

1. Put potting soil into two pots. Plant five seeds into one of the pots and five seeds into the other (seeds that work well include pea, corn, bean and radish). Add enough water to ensure that the soil is thoroughly moist.
2. Label each pot with the date, type of seed, and your initials. On one cup, write "Light" and on the other cup write "Dark."
3. Place one of the pots into a location that gets light, such as a windowsill or under plant grow-lights. Place the other pot into a very dark location, such as a cabinet or closet.
4. Make a specific hypothesis below. What do you think will happen? Try to include something that you can actually measure such as height, mass, number of leaves, etc.

Observations:

After a week or two, compare the plants that grew in the light and dark. Sketch what you see below or on a separate sheet of paper.

Perform the measurements needed to address your hypothesis, and record them on the next page. Was your hypothesis rejected or accepted? How did the light affect growth?

Identify some other plant characteristics that you can measure. Record this information on the next page. For each characteristic determine the **average** and the **range** for the dark-grown plants and the light-grown plants. Which characteristics were affected by light and which (if any) were not affected?

Student-Designed Experiments

Using the methods you learned in the activity above and the "Guide for Student Experimentation" below, design and carry out your own experiment. Questions you might consider include how an intermediate amount of light would affect plant growth, whether the color of light affected the plants' growth (remember that white light such as that from the sun or a grow-light includes all colors of light), or how other variables affect growth (temperature, humidity, gravity, soil, etc.). You can also set up a box with holes that permit light to enter solely from the top, the bottom or one of the sides to investigate how the direction of the light affects the plants' growth.

Data Sheet for Plant Growth Experiment **Name**____________________________

Plant type (pea, corn, other) ___________________

Independent variable (Light, dark, other) ________________

Plant number	Characteristic 1:	Characteristic 2:	Characteristic 3:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			
Range			

Plant type (pea, corn, other) ___________________

Independent variable (Light, dark, other) ________________

Plant number	Characteristic 1:	Characteristic 2:	Characteristic 3:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			
Range			

Guide for Student Experimentation

Guidelines for Achieving Great Experiments

1. Ask a very specific, testable question.
2. Test a control for comparison (a group that does not receive the experimental treatment).
3. Use a sample size large enough to allow firm conclusions.
4. To understand a whole population, obtain a random sample of that population to avoid bias.
5. Replicate each part of the experiment (at least 3 times).
6. Hold all variables constant between trials except the variable being tested.
7. Collect quantitative data whenever possible.
8. Measure using metric units.
9. Gather data carefully and accurately.
10. Be objective and honest.

Introduction

Question:

Hypothesis:

Materials and Methods

Independent variable:

Dependent variable:

Experimental constants:

Control:

Protocol:

Results

Data collected:

Other observations:

Graph(s):

Discussion

Interpretation of data:

Conclusions:

Teacher's Guide to "Which Way to Grow?"

Links to National Science Education Standards

Grades 5-8:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Regulation and behavior
- Diversity and adaptations of organisms
- Science and technology in society

Grades 9-12:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Behavior of organisms
- Science and technology in local, national, and global challenges

Materials (per group)

- Two pots (4-inch plastic pots work well, but any will do); using small cups will work if the students poke small holes in the bottom
- Seeds (at least 10 of each seed type; available from garden stores as well as science supply companies; follow instructions on seed packages)
- Potting soil (one 2 cubic foot bag will fill over 100 4-inch pots)
- Grow-lights or other source of illumination, and a dark location such as a cupboard or closet
- Rulers, protractors, and/or scales for quantitative measurements
- For the student-designed experiments, additional materials will be needed.

Teaching hints

1. Sample size: To minimize the effects of plant-to-plant variation, each student or team should measure several plants from each condition and compare averages between conditions. This experiment works best if the number of seeds planted per pot is at least five. Often some seeds won't germinate and one may have been damaged so it will be stunted or abnormal in some way. Fresh seeds generally have a higher rate of germination – if using older seeds have the students plant a few more seeds per pot.

2. Set-up: The day before, soak seeds in a container of water – this treatment helps promote germination. Corn seeds are sometimes coated in a red fungicide which should be washed off with soap before giving the seeds to the students. Place kernels in a pint jar and fill with water and 4 or 5 drops of detergent. Cover and shake periodically for 3 minutes, drain, and rinse 3 times. Before class, moisten the potting soil with water in a large bucket or tub. Cover the tables with newspaper or other absorbent material to make clean-up easier.

3. Keep soil moist: The students should fill each pot to an equal level with soil, and then thoroughly water the soil to ensure that the seeds don't dry out. Seeds should be poked into the soil about ¼ inch below the surface (or according to the directions on the seed package). Plants grown on a sunny windowsill may need extra water during the experiment.

4. Successful student-designed experiments:

- Emphasize the "Guidelines for Achieving Great Experiments."
- Before students design experiments, tell them how much time they will have.

- Allow students to present their experiments and lead a short discussion about each one. Encourage other students to ask questions.

Web Resources

Roger Hangarter's "Plants in Motion" project contains time-lapse movies of plant growth (including light-dark experiments). http://plantsinmotion.bio.indiana.edu/plantmotion/.

Paul William's Wisconsin Fast Plants® are a popular tool for doing plant growth experiments in the classroom. http://www.fastplants.org/activities.physiology.php.

Acknowledgements

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