National Aeronautics and
Space Administration

Langley Research Center
Hampton, VA 23681-2199

Educational Product	
Educators	Grades 3-5

EG-2004-03-06-LARC

The NASA SCI Files™ The Case of the Prize-Winning Plants

A Lesson Guide with Activities in Mathematics, Science, and Technology

Please Note: Our name has changed! The NASA "Why" Files™ is now the NASA SCIence Files™ and is also known as the NASA SCI Files™.

http://scifiles.larc.nasa.gov

The Case of the Prize-Winning Plants lesson guide is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**

A PDF version of the lesson guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site: **http://scifiles.larc.nasa.gov**

The NASA Science Files™ is produced by the NASA Center for Distance Learning, a component of the Office of Education at NASA's Langley Research Center, Hampton, VA. The NASA Center for Distance Learning is operated under cooperative agreement NCC-1-02039 with Christopher Newport University, Newport News, VA. Use of trade names does not imply endorsement by NASA.

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The NASA SCI Files™
The Case of the
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For additional information about the NASA SCI Files™, contact Shannon Ricles at (757) 864-5044 or **s.s.ricles@larc.nasa.gov**.

Production of the NASA SCI Files™ is made possible by the generous support provided by the Society of Women Engineers (SWE); Busch Gardens, Williamsburg; Hampton City Public Schools; and the NASA Langley Research Center's Aerospace Vehicle Systems Technology Program Office.

Writer and Teacher Advisor: Shannon Ricles.

Graphic Designer: René Peniza

Editor: Susan Hurd

Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail **kimlien.vu@swe.org**

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Program Overview

In *The Case of the Prize-Winning Plants*, Tony, the financial wizard of the tree house detectives is interested in investing in a fertilizer company. He agrees that he had better check out the fertilizer before investing and decides that the best way to do that is to grow a plant and actually use the fertilizer. To prove beyond a shadow of a doubt that his fertilizer is the best, Tony also decides to enter his plant in the Virginia State Fair's plant competition, sure that it will win.

Kali suggests that Tony grow a pineapple plant. Even though a pineapple plant is a bit unusual and not native to the Virginia area, Tony agrees. He soon realizes that they must learn a lot more about plants if they are going to successfully grow a pineapple plant in the Virginia climate. Kali promises to help but explains that she will be gone for a couple of weeks attending an ecology tour in Hawaii.

When Kali arrives in Hawaii, her first stop is the rain forest on the island of Hawaii to visit Ms. Rhonda Loh, a park ranger at Hawaii Volcanoes National Park. Ms. Loh explains how plants are classified and discusses the importance of rain forests throughout the world. Meanwhile, back in Virginia, the tree house detectives visit Dr. D to learn about plants' basic needs and the parts of plants.

The tree house detectives decide that they need to learn more about the basic needs of plants, and Bianca visits Ms. Lori Jones at NASA Kennedy Space Center. Ms. Jones explains how plants need and use carbon dioxide (CO_2) and shows Bianca the CO_2 lab. From there, Bianca visits Dr. Gregory Goins, who explains how plants use the energy from light for photosynthesis. Back in the tree house, Jacob is trying out his own CO_2 experiment. After realizing that he might need some "professional" help, the tree house detectives contact Ms. Leeper's class at Pearl Harbor Kai Elementary School in Honolulu, Hawaii. The class is conducting experiments with plants, light, and CO_2—just what the detectives need.

The detectives read that volcanic soil is best for growing pineapples, so they ask Kali to visit Dr. Don Swanson at the Hawaiian Volcano Observatory on the island of Hawaii. Kali not only learns about shield volcanoes and hot spots, but Dr. Swanson also explains that soil is formed from the weathering of rock and that basalt rock is rich in the minerals that plants need to grow well. Unable to locate volcanic soil, the detectives decide to dial up Dr. Susan Steinberg at NASA Johnson Space Center to learn about potting soil and how to grow a plant in a small pot. The next stop is Dr. D's for an explanation of how plants reproduce.

The tree house detectives finally think they have all the pieces put together when they discover that pineapples don't have seeds. They are confused and decide it is time for Kali to visit a pineapple expert. She heads for the Dole Pineapple Plantation on the island of Oahu to speak with Mr. Mark Takemoto. Now the tree house detectives are truly ready to grow a pineapple, and they head to Dr. D for a wrap-up.

National Science Standards (Grades K – 4)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
Systems, orders, and organization	✖	✖		
Evidence, models, and explanations	✖	✖	✖	✖
Change, constancy, and measurement	✖	✖	✖	✖
Form and Function		✖		
Science as Inquiry (A)				
Abilities necessary to do scientific inquiry	✖	✖	✖	✖
Understanding scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
Light, heat, electricity, and magnetism		✖		
Life Science (C)				
Characteristics of Organisms	✖	✖	✖	✖
Life cycles of organisms	✖	✖	✖	✖
Organisms and their environments	✖	✖	✖	✖
Earth and Space Science (D)				
Properties of Earth materials			✖	
Changes in Earth and sky			✖	
Science in Personal and Social Perspective (F)				
Abilities of technological design	✖	✖	✖	✖
Understanding science and technology	✖	✖	✖	✖
Abilities to distinguish between natural objects and objects made by humans	✖	✖	✖	✖
History and Nature of Science (G)				
Science as a human endeavor	✖	✖	✖	✖

National Science Standards (Grades 5 – 8)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Unifying Concepts and Processes				
Systems, order, and organization	✖	✖		
Evidence, models, and explanations	✖	✖	✖	✖
Change, constancy, and measurement	✖	✖	✖	✖
Form and function		✖		
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	✖	✖	✖	✖
Understanding scientific inquiry	✖	✖	✖	✖
Physical Science (B)				
Transfer of energy	✖	✖	✖	✖
Life Science (C)				
Structure and function in living systems	✖			
Reproduction and heredity			✖	
Regulation and behavior	✖	✖	✖	✖
Populations and ecosystems	✖			✖
Diversity and adaptations of organisms	✖	✖	✖	✖
Earth and Space Science (D)				
Structure of the Earth system			✖	
Earth's history			✖	
Science and Technology (Content Standard E)				
Abilities of technological design	✖	✖	✖	✖
Understanding science and technology	✖	✖	✖	✖
Science in Personal and Social Perspectives (Content Standard F)				
Science and technology in society	✖	✖	✖	✖
History and Nature of Science (Content Standard G)				
Science as a human endeavor	✖	✖	✖	✖
Nature of science	✖	✖	✖	✖

National Mathematics Standards (Grades 3 – 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Number and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.	✖			✖
Geometry				
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.	✖			
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	✖	✖	✖	✖
Apply appropriate techniques, tools, and formulas to determine measurements.	✖	✖	✖	✖
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.		✖		
Select and use appropriate statistical methods to analyze data.		✖		
Develop and evaluate inferences and predictions that are based on data.		✖		
Problem Solving				
Build new mathematical knowledge through problem solving.	✖	✖		✖
Solve problems that arise in mathematics and in other contexts.	✖	✖		
Apply and adapt a variety of appropriate strategies to solve problems.	✖	✖		
Monitor and reflect on the process of mathematical problem solving.		✖		
Communication				
Organize and consolidate students' mathematical thinking through communication.		✖		
Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.		✖		
Analyze and evaluate the mathematical thinking and strategies of others.		✖		
Connections				
Recognize and apply mathematics in contexts outside of mathematics.		✖		
Representation				
Create and use representations to organize, record, and communicate mathematical ideas.		✖		
Use representations to model and interpret physical, social, and mathematical phenomena.		✖		

International Technology Education Association Standards (ITEA Standards for Technology Literacy, Grades 3 - 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	✖	✖	✖	✖
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	✖	✖	✖	✖
The Designed World				
Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.	✖	✖	✖	✖

National Geography Standards, Grades 3 - 5

Standard	Segment 1	Segment 2	Segment 3	Segment 4
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire process and report information from a spatial perspective	✖		✖	
How to use mental maps to organize information about people, places, and environments in a spatial context	✖			
How to analyze the spatial organizations of people, places, and environments on Earth's surface	✖			
Physical Systems				
The physical process that shapes the patterns of Earth's surface	✖		✖	
The characteristics and spatial distribution of ecosystems on Earth's surface	✖			
Environment and Society				
How human actions modify the physical environment	✖	✖		
How physical systems affect human systems	✖	✖		

National Technology Standards (ISTE National Educational Technology Standards, Grades 3 – 5)

Standard	Segment 1	Segment 2	Segment 3	Segment 4
Basic Operations and Concepts				
Use keyboards and other common input and output devices efficiently and effectively.	✖	✖	✖	✖
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	✖	✖	✖	✖
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.	✖	✖	✖	✖
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	✖	✖	✖	✖
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	✖	✖	✖	✖
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	✖	✖	✖	✖
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	✖
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	✖	✖	✖	✖
Use technology resources for problem solving, self-directed learning, and extended learning activities.	✖	✖	✖	✖
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	✖	✖	✖	✖
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	✖	✖	✖	✖
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	✖	✖	✖	✖

The NASA SCI Files™
The Case of the
Prize-Winning Plants

Segment 1

Tony is eager to win the plant competition at the state fair to prove that his fertilizer is "top of the line." After some debate, the tree house detectives and Tony decide to grow a pineapple plant, hoping that such an unusual plant will guarantee a win. However, the pineapple is not indigenous to Virginia, and they soon learn that it isn't as easy as they thought. Kali has to leave to go on an eco tour in Hawaii but promises to help. Her first stop is Hawaii Volcanoes National Park to visit with Ms. Loh in the rain forest on the Big Island of Hawaii. Ms. Loh helps the tree house detectives learn how plants are classified and why rain forests are important to our global climate. Back home, the detectives visit Dr. D in his lab to learn more about the basic parts of a plant.

Objectives

The student will

- understand how plants are classified.
- compare vascular and nonvascular plants.
- recognize the importance of rain forests.
- identify the basic parts of a plant.
- identify the basic needs of plants.

Vocabulary

basic needs—the essential needs of a plant or animal, such as food, air, water, and shelter

binomial—a biological species name consisting of two terms according to the system of binomial nomenclature

bromeliad—a tropical American plant with fleshy, funnel shaped leaves that hold water

chloroplasts—a membranous sac (plastid) that contains chlorophyll and is the site of photosynthesis and starch formation in the cells of plants and algae

epidermis—a thin surface layer of protecting cells in seed plants and ferns

kingdom—one of the three primary divisions into which natural objects are classified – Animal Kingdom, Mineral Kingdom, and Plant Kingdom; a major category in the scientific classification of living things that ranks above the phylum and is the highest and broadest group

nonvascular—not having a tube or channel for carrying fluid (as the sap of a plant)

phloem—one of the two main types of tissues in the more highly developed plants. Phloem conducts dissolved food materials to all parts of the plant.

rain forest—an often tropical woodland with a high annual rainfall and very tall trees

temperate—having or associated with a climate that is usually mild

tropical—having a very hot climate that is often combined with a high degree of humidity

vascular—of or relating to a tube or channel for carrying fluid (as the sap of a plant) or to a system of such channels or tubes

xylem—plant tissue that carries water and dissolved minerals from the roots through the stem and leaves; functions also in support and storage, lies deeper inside the plant than the phloem, and usually makes up the woody parts (as of a plant stem)

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Before viewing Segment 1 of *The Case of the Prize-Winning Plants*, read the program overview to the students. List and discuss questions and preconceptions that students may have about plants and how they grow. Make a list of things that the tree house detectives might need to learn so they can grow a healthy plant.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them better understand the problem. To locate the following tools on the NASA SCI Files™ web site, select Educators from the menu bar, click on Tools, and then select Instructional Tools. You will find them listed under the Problem-Based Learning tab.

Problem Board—Printable form to create student or class K-W-L chart

Guiding Questions for Problem Solving—Questions for students to use while conducting research

Problem Log and Rubric—Students' printable log with the stages of the problem-solving process

Brainstorming Map—Graphic representation of key concepts and their relationships

The Scientific Method and Flowchart—Chart that describes the scientific method process

3. **Focus Questions**—These questions at the beginning of each segment help students focus on a reason for viewing. They can be printed ahead of time from the Educators area of the web site in the Activities/Worksheet section under Worksheets for the current episode. Students should copy these questions into their science journals prior to viewing the program. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
4. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigative process and how the information learned will affect the case. They can be printed by selecting Educators on the web site in the Activities/Worksheet section under Worksheets for the current episode.

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Prize-Winning Plants* in 15-minute segments and not in its entirety. If you are watching a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about plants, how plants are classified, and the basic parts of a plant. Have the students conduct research on the basic needs of plants. Brainstorm for ideas of what plants need to grow and be healthy. As a class, reach a consensus on what additional information is needed. Have the students conduct independent research or provide them with the information needed.
4. Have the students complete Action Plans, which can be printed from the Educators area or the tree house Problem Board area in the Problem-Solving Tools section of the web site for the current online investigation. Students should then conduct independent or group research by using books and Internet sites noted in the Research Rack section of the Problem Board in the Tree House. Educators can also search for resources by topic, episode, and media type under the Educators main menu option Resources.
5. Choose activities from this Educator Guide and the web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students "solve" the problem along with the tree house detectives.
6. Have the students work individually, in pairs, or in small groups on the problem-based learning (PBL) activity on the NASA SCI Files™ web site. To locate the PBL activity, click on Tree House and then the Problem Board. Choose the 2003–2004 Season and click on "Runaway Runoff."
   - To begin the PBL activity, read the scenario (Here's the Situation) to the students.
   - Read and discuss the various roles involved in the investigation.
   - Print the criteria for the investigation and distribute.
   - Have students begin their investigation by using the Research Rack and the Problem-Solving Tools located on the bottom menu bar for the PBL activity. The Research Rack is also located in the Tree House.
7. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess student progress. In the beginning, students may have difficulty reflecting. To help them, ask specific questions that are related to the concepts.

Careers

botanist
conservationist
ecologist
forester
park ranger
plant taxonomist

8. Have students complete a Reflection Journal, which can be found in the Problem-Solving Tools section of the online PBL investigation or in the Instructional Tools section under Educators.

9. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Resources (additional resources located on web site)

Books

Berger, Melvin: *Does It Always Rain in the Rain Forest?* Scholastic, Inc., 2002, ISBN: 0439193834.

Blevins, Wiley: *Parts of a Plant*. Compass Point Books, 2003, ISBN: 0756505186.

Cherry, Lynn: *The Great Kapok Tree*. Bt Bound, 2001, ISBN: 0613285077.

Cole, Joanna: *The Magic School Bus Plants Seeds: A Book About How Living Things Grow*. Scholastic, 1995, ISBN: 0590222961.

Dunphy, Madeline: *Here is the Tropical Rainforest*. Hyperion Press, 1997, ISBN: 0786812125.

Olien, Rebecca: *Exploring Plants*. Scholastic, 1997, ASIN: 0590963724.

Osborne, Will and Ma: R*ain Forest (Magic Tree House Research Guide)*. Random House Books for Young Readers, 2001, ISBN: 0375813551.

Worth, Bonnie: *If I Ran the Rain Forest: All About Tropical Rain Forests*. Random House Books for Young Readers, 2003, ISBN: 0375810978.

Video

Jacobs, Larry and Bastien, Charles: *The Magic School Bus—In the Rainforest*. A Vision, 2003, ASIN: 1568328613.

Web Sites

The Great Plant Escape
Help Detective Leplant and his partners, Bud and Spout, unlock the amazing mysteries of plant life. This site offers six different "cases" students can solve as they learn all about plants in the process. The site is also offered in Spanish.
http://www.urbanext.uiuc.edu/gpe/index.html

Texas A&M University: "Kinder Garden"
An introduction to the many ways children can interact with plants and the outdoors.
http://aggie-horticulture.tamu.edu/kindergarden/kinder.htm

Fullerton Arboretum
Visit this site to learn more about the parts of a plant. There are games for students as well as word searches and crossword puzzles.
http://www.arboretum.fullerton.edu/educ/chld.asp

4-H Children's Garden at Michigan State
Magnificent site with views of 56 theme gardens for children. Theme gardens include the Crayon Color Garden, Perfume Garden, Pizza Garden, African American garden, Dinosaur Garden, Pond & Water Garden, and the Cereal Bowl Garden.
http://4hgarden.msu.edu/main.html

Missouri Botanical Garden: Tropical Rain Forests
Explore this site to learn about all the unusual plants of the various rain forests around the world and plan your own tropical feast!
http://mbgnet.mobot.org/sets/rforest/index.htm

Hawaii Volcanoes National Park
Visit this site to learn more about the park and the volcanoes that created the islands.
http://www.nps.gov/havo

Activities and Worksheets

Classic Classifying

Purpose

To understand how things are classified

Materials

index cards
sand samples *(may be obtained from sandboxes, rivers, beaches, hardware stores)*
wide, clear packing tape
hand lens or microscope
wire tea strainers or pieces of screen wire
empty plastic soda or water bottles
science journal

Background

You classify things every day. When you sort objects and put them in a specific place, that's classification. Think about your bedroom. Do you have a sock drawer, a drawer for pants and shirts, or a drawer for toys? What about the kitchen? Are the glasses all together or are they mixed in with the pots and pans? We classify things to organize them and better understand them.

Procedure

1. Place the box of assorted buttons on the table. Carefully examine the buttons and begin to group the buttons according to any characteristics you choose; for example, size, color, number of holes, or texture.
2. In your science journal, illustrate your groupings and explain why you grouped items in such a way.
3. Now look at the peanuts and group them according to external structure and characteristics.
4. Illustrate your groupings and explain.
5. Break open the shells and observe the internal characteristics of the peanut and regroup them.
6. Illustrate and explain the groupings.
7. Observe the plant leaves and group them according to structure and characteristics.
8. Try regrouping them according to alternate characteristics.
9. Illustrate and explain the groupings

.

Conclusion

1. Which group was the easiest to arrange? Why?
2. What are the common characteristics of peanuts? Do these characteristics make it easier or more difficult to classify them?

Extension

1. Brainstorm for ideas to classify other groups of living things such as pets, animals in the zoo, animals in the jungle, and so on.
2. Use a copy-paper box lid and cardboard strips to make a classification box with individual compartments of various sizes. Collect items from nature such as leaves, seeds, flowers, and so on and group them together in the individual compartments.

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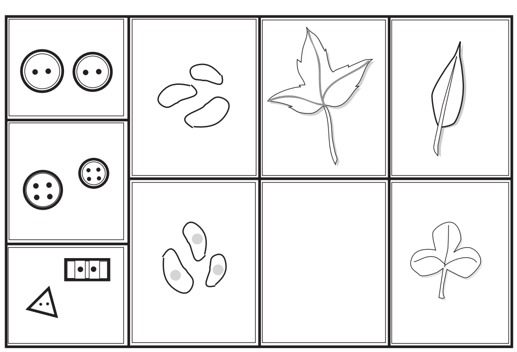
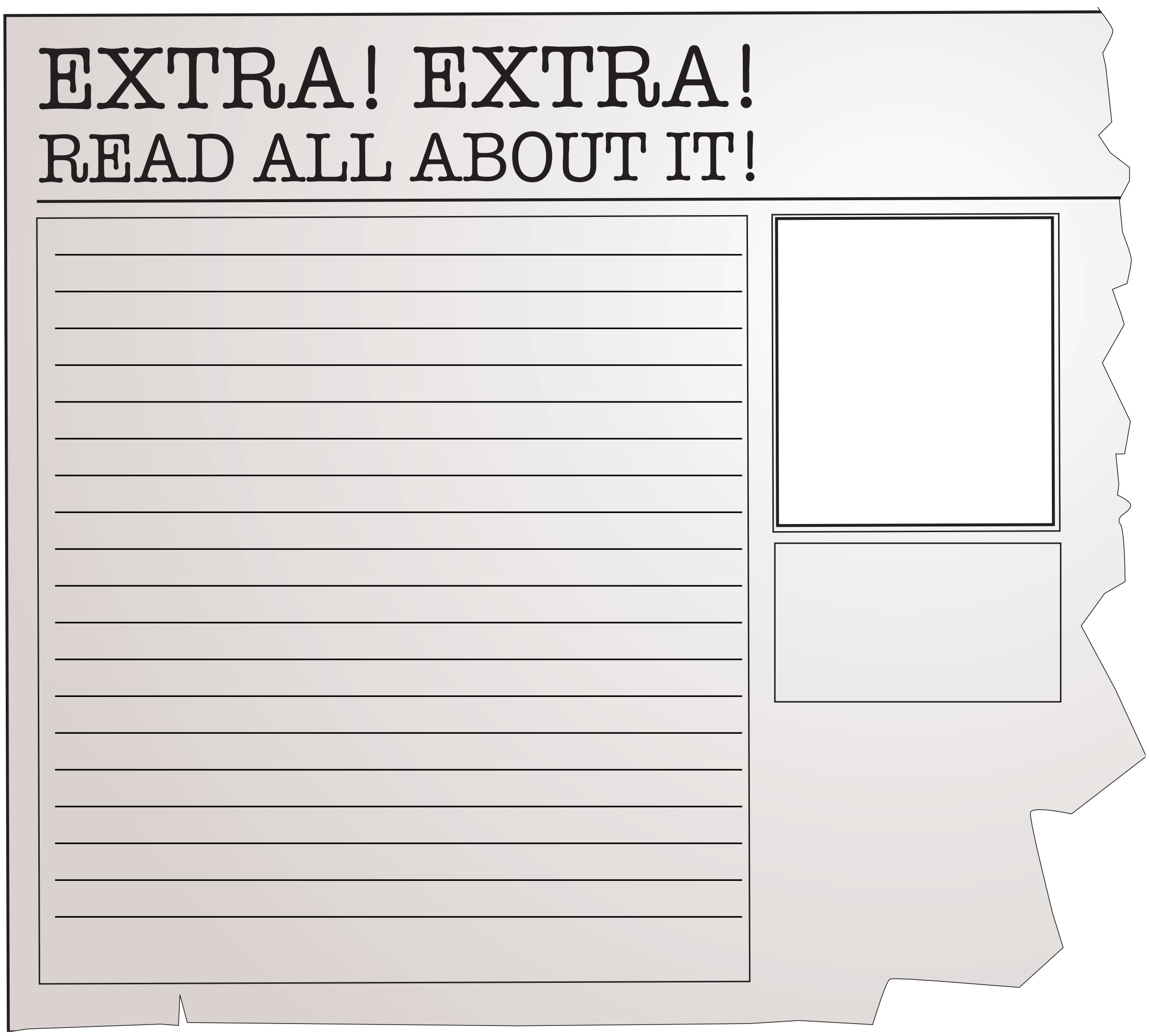


EXTRA! EXTRA! READ ALL ABOUT IT!

Using a newspaper writing style, write a story about the day you discovered a new species of plant.

Background

Newspaper stories are usually written in an inverted pyramid style. This style arranges the lead, the basic facts, and the conclusion first. As you move through the story, more and more detail and background are provided. This type of writing is best in newspapers for many reasons. First, in the days of the telegraph, it took a long time to transmit the entire news story, and starting with the main information ("The battle was lost; 940 killed") was more important than the details ("Our soldiers crossed the bridge at dawn with fresh supplies . . ."). Secondly, giving the important facts first made it easier for the layout people to fit the story into the available space because they could just cut off the end if necessary. Finally, the pyramid style also presented the important information first for readers who had less time to read. Newspaper readers should know at first glance what the story is about and what its emphasis is. When writing newspaper articles, be sure to answer the five Ws and an H: Who, What, Where, When, Why, and How.



Classy Plants

Purpose

To become familiar with how plants are classified

Background

The plant kingdom is classified into major groups called divisions. A division is the same as a phylum in other kingdoms. Another way to group plants is as vascular or nonvascular plants. Vascular plants have tube-like structures that carry water, nutrients, and other substances throughout the plant. Nonvascular plants do not have these tube-like structures and use other ways to move water and substances.

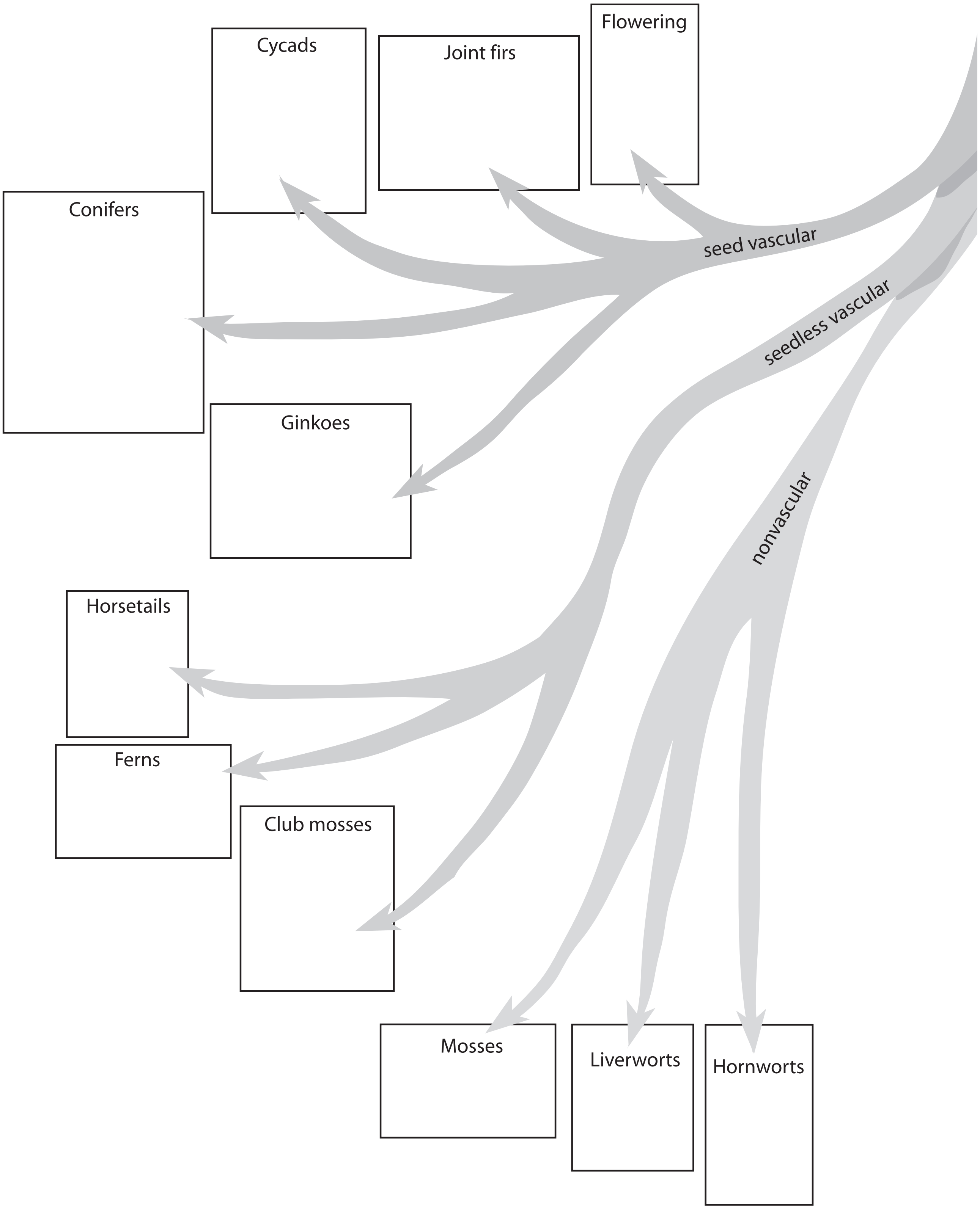
Materials

glue
Internet (optional)
magazines to cut apart
plant books
scissors

Procedure

1. Use reference books to find examples of each plant in the diagram below.
2. Use garden magazines or the Internet to find pictures of each plant.
3. Cut out or print a picture of each plant.
4. Glue the pictures in the boxes.

Classy Plants



Tubes for the Move

Purpose

To observe the movement of water through the vascular tubes of a plant

Materials

glue
Internet (optional)
magazines to cut apart
plant books
scissors

Background

The plant kingdom is classified into major groups called divisions. A division is the same as a phylum in other kingdoms. Another way to group plants is as vascular or nonvascular plants. Vascular plants have tube-like structures that carry water, nutrients, and other substances throughout the plant. Nonvascular plants do not have these tube-like structures and use other ways to move water and substances.

Procedure

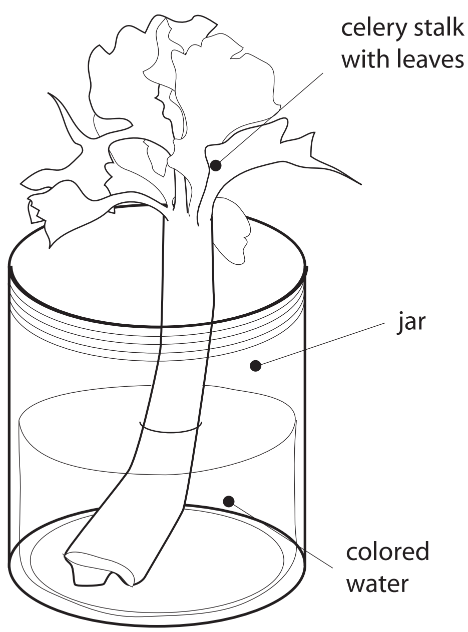
1. Fill the jar almost to the top with water.
2. Add 5–10 drops of food coloring to the water and gently stir.
3. Cut the stem of the celery stalk diagonally so that it measures 20 cm.
4. Place the celery stalk into the jar with the stem inside the water.
5. Observe and record your observations in your science journal.
6. Each hour observe and record your observations until you notice a change in the leaves of the celery stalk.
7. Carefully take the celery stalk out of the water and dry the stalk so as to not drip colored water. Observe the stalk, paying close attention to the end where the stem was cut. Record your observations.

Conclusion

1. What happened to the leaves of the celery stalk? Why?
2. What can you conclude by observing the cut part of the stem?

Extension

1. Use flowers such as carnations and see if the results are the same as with the celery.
2. Conduct the experiment again, but with three stalks. Place one in a dark room, one in the sunlight, and one in fluorescent light. Observe and record your observations each hour. Do they all react the same?
3. Observe a cross section of a tree and compare it to the cross section of the celery stalk or flower stem. Count the number of light and dark rings. Hypothesize why the rings are different colors and sizes.



The Leafy Debate

Purpose

To demonstrate how the loss of forests may change the climate

Materials

medium-sized plant with several branches
2 plastic bags
science journal
scissors
sunny area
2 twist ties

Background

Tropical rain forests are in great danger because they are being cut or burned down at an alarmingly fast rate. This deforestation causes many animals and plants to disappear because their habitats are destroyed. In addition, the loss of the rain forests may change the climate of the tropics, which may affect other areas on Earth.

Procedure

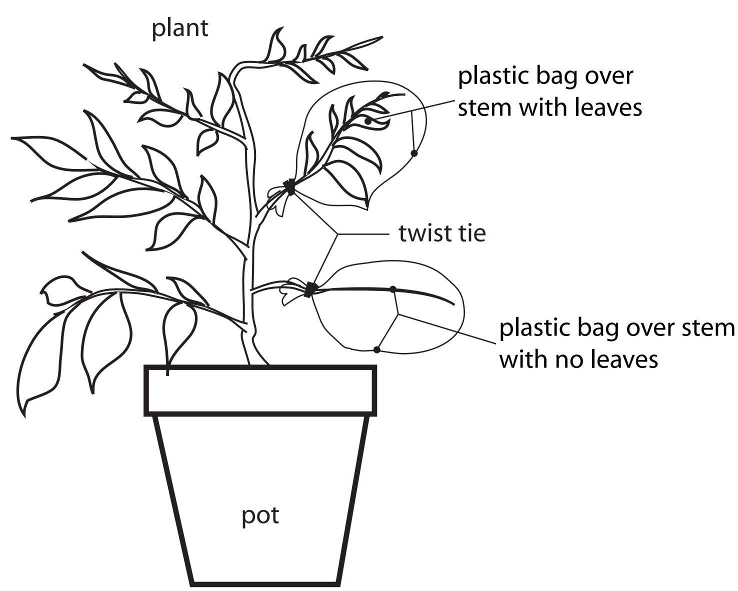
1. Select two branches that are similar in size and number of leaves.
2. Carefully cover one of the branches with a plastic bag, being sure not to break off any of the leaves.
3. Using a twist tie, carefully secure the bag to the branch. This branch represents an intact tropical rain forest.
4. Using scissors, cut the leaves off the other branch.
5. Repeat steps 2 and 3. This branch represents an area of the tropical rain forest that has been cut down.
6. Put the plant in a sunny spot and let it stand for about 24 hours.
7. Observe the plant the next day and record your observations in your science journal.
8. Illustrate your observations.

Conclusion

1. Where did the water come from?
2. What can you infer about the amounts of water created by forests? By deforested areas?
3. What role do plants play in the water cycle?
4. Why should people be concerned about the destruction of tropical rain forests?

Extension

1. Keep observing the plant daily for two weeks and record your observations.
2. Try this experiment with other plants.



Danger! Deforestation

Purpose

To understand the results of deforestation

Materials

2 funnels
2 large jars
mixture of leaves, moss, grass, etc.
science journal
soil
stopwatch (optional)
water
watering can

Procedure

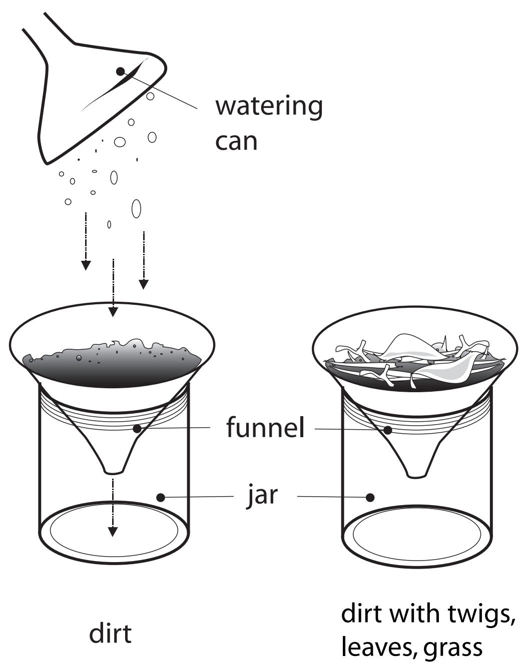
1. Fill one funnel with soil and place the funnel inside the mouth of the jar.
2. Fill the other funnel with a mixture of soil, leaves, grass, pine needles, and so on. Place the funnel inside the mouth of the second jar. See diagram 1.
3. Use the watering can to simulate "rain." Be sure to hold the watering can over each funnel for the same amount of time.
4. Observe each jar and record your observations in your science journal.

Conclusion

1. Which jar contained the most sediment? Why?
2. In which jar did the water filter through the quickest? Why?
3. Explain how this experiment simulates what happens when the rain forests are deforested.
4. Predict what effect the destruction of the rain forest might have on global climate, new medicines, and the people who live in rain forests.

Extension

1. Write a story about a young child who lives in the rain forest and encounters his/her home being burned and destroyed to make room for cropland.



It's Raining in My Classroom

Purpose

To create a facsimile of a tropical rain forest to become more familiar with a rain forest environment

Materials

butcher paper
construction paper
glue
miscellaneous items
scissors

Teacher Note

Before beginning this activity, it might be helpful to complete two activities, Layers of the Rainforest and Around the World. Both are located in Dr. D's Lab (2003–2004 season: Runaway Runoff) on the NASA SCI Files™ web site **http://scifiles.larc.nasa.gov/kids/D_Lab/d_lab.html**

Procedure

1. Brainstorm and list in your science journal what you know about a tropical rain forest.
2. Research the various layers of a rain forest and determine the types of plants in each layer.
3. Using butcher paper (blue or white), cover one wall or area from floor-to-ceiling.
4. Build the rain forest one layer at a time, starting with the top (emergent) layer.
5. Use construction paper, butcher paper, and newspapers to create trees. Trees in the emergent layer often rise from 50–60 m. Discuss what scale might be appropriate to use for these trees. The trees also host glorious blooms so be sure to include lots of flowers and any animals that might live there.
6. Continue until each layer of the rain forest is complete.

Extension

1. Invite other classes to visit the "rain forest."
2. Give guided tours or "eco" tours to students, parents, and other adults.
3. Investigate the people that live in the rain forests around the world. Create and give a presentation about your findings.

Plant Nomenclature

Purpose

To learn the nomenclature and parts of a plant

Note: *Be sure to put these cards in a safe place so as to use them with the other nomenclature cards you will be creating later.*

Materials

books about plants
copy of plant sheet *(page 25)*
red pencil
scissors

Procedure

1. Cut along the dotted lines of the plant sheet (page 25) to form individual plant cards.
2. Using reference books and a red pencil, shade in the root part of the plant on one plant card.
3. Write the word "roots" at the bottom of the page. See diagram 1.
4. Repeat steps 2 and 3 for each part of the plant: stem, root, root hairs, leaves, anther, pistil, petals, and stamen.
5. Using books, the Internet, or other reference sources, write a brief description of each part of the plant on the top back portion of each plant card.
6. Cut along the line at the bottom of each plant card to detach the word from the picture and create a label. See diagram 2.
7. Shuffle the cards and labels. Practice matching the labels to the correct picture for each part of the plant.

Extension

1. Compare the parts of a flowering plant to the parts of other plants such as trees, shrubs, vegetable plants, and so on.
2. Obtain a real plant and use the labels to identify the parts of the plant.
3. Observe different roots, stems, and leaves of various plants and compare and contrast them.
4. Try to pull a dandelion from the ground. With the help of an adult, dig the dandelion up and observe its roots. Research the two main types of roots found in plants, taproots, and fibrous roots. Give examples of each.

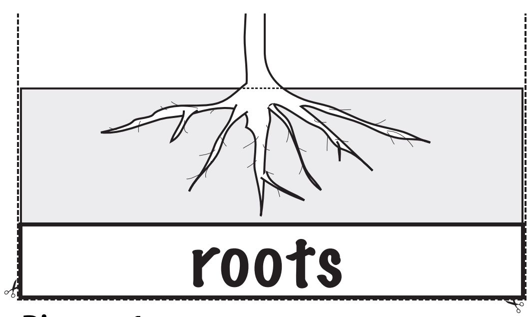


Diagram 1

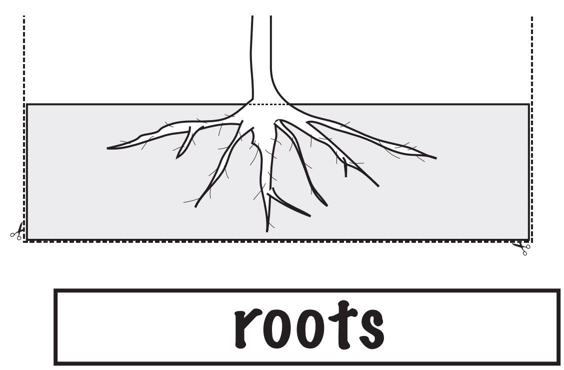
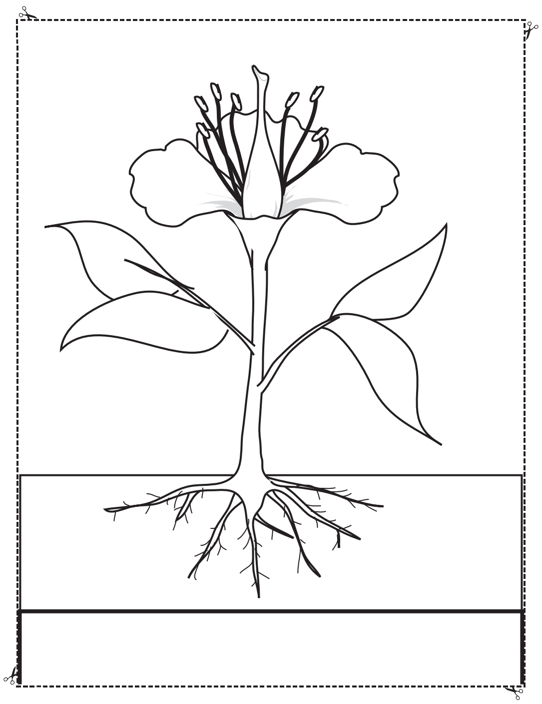


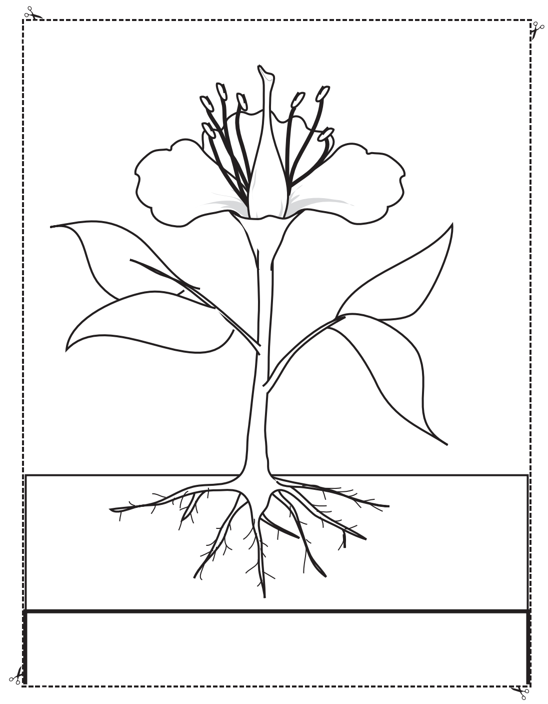
Diagram 2

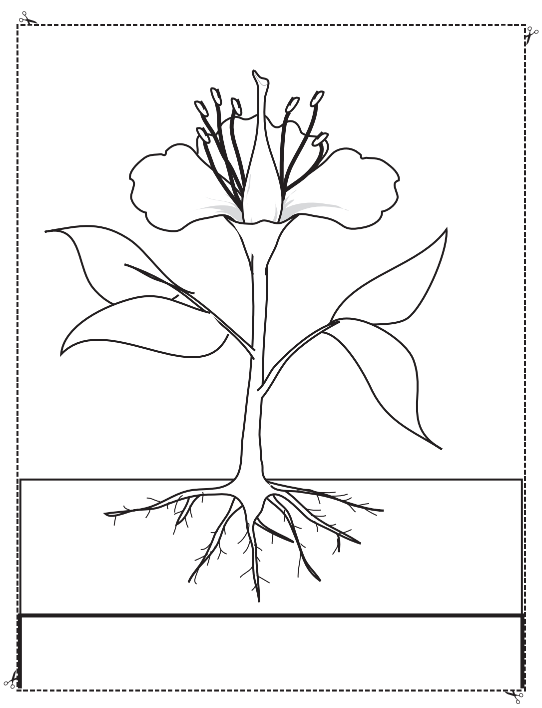
Plant Nomenclature - Plant Sheet

1



2





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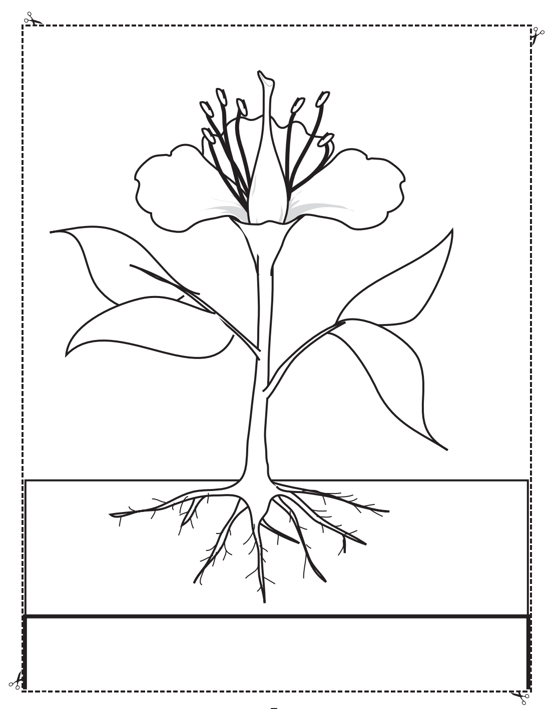


4

It's Basically Basic

Purpose

To understand that plants have basic needs for survival (light, air, water, and minerals)

Plant 1: Control plant
Plant 2: Light
Plant 3: Water
Plant 4: No light
Plant 5: No water

Materials

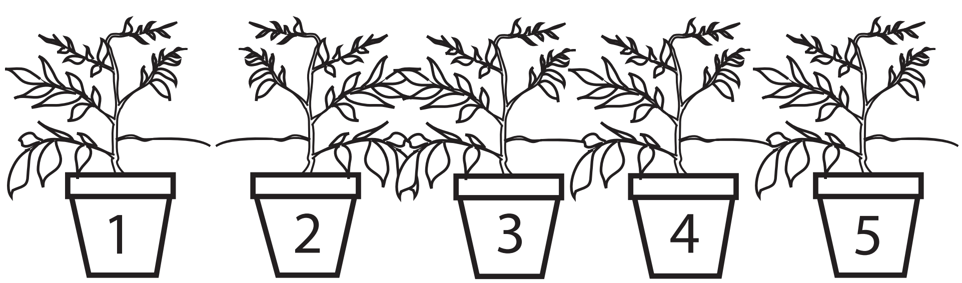
colored pencils
dark area
labels
marker
5 small plants in pots
science journal
sunny area
water

Procedure

1. Observe each of the five plants and record your observations in your science journal.
2. Using colored pencils, draw a picture of each plant, paying careful attention to the number of leaves, color of the leaves and stem, and any other feature determined to be important.
3. Using a label and marker, label each plant 1, 2, 3, 4, or 5.
4. Carefully water plants 1–4. Be sure that you give each plant the same amount of water.
5. Place plants 1, 2, 3, and 5 in a sunny area.
6. Place plant 4 in a dark area that never receives sunlight. Note: All areas should be inside in a controlled temperature environment so that only one variable is being manipulated.
7. Observe your plants over the next couple of weeks and record your observations in your science journal. Water plants 1–4 as needed, but be sure to always give each one the same amount of water. Don't water 1 unless you also water plants 2, 3, and 4. DO NOT water plant 5.
8. Discuss your observations and draw conclusions.

Conclusion

1. What happened to plant 5? Why?
2. What happened to plant 4? Why?
3. From conducting this experiment, what did you determine are two of the basic needs of plants?
4. What are the other basic needs of plants?
5. How are plants' basic needs similar to animals' basic needs. How are they different?



Answer Key

Classic Classifying

1. The buttons should have been the easiest group to sort. Even though the buttons were different from each other, they may have been sorted by only one characteristic such as size, color, or number of holes, and so on.
2. The common characteristics of the peanuts might include color, shape, size, texture, and so on. These characteristics make it more difficult to classify the peanuts because there is not enough that is "different" about each one.

Tubes for the Move

1. The leaves in the celery stalk turned the color of the food coloring. The colored water was carried through the tubes in the celery stalk to the leaves.
2. There are small tubes in the stalk that carry water and nutrients to the other parts of the celery plant.

The Leafy Debate

1. The water came from the leaves of the plant. What is happening is called "transpiration," the process whereby the leaves on green plants give off water that they do not need. As water moves into root cells, it goes up through the plant to be used. Any unused water vapor exits through the leaf.
2. You can infer that very large forests such as tropical rain forests transpire a great amount of water into the atmosphere. Without trees and other plants, deforested areas are not able to put moisture back into the air. Without the moisture going back into the air, rainfall would decrease.
3. The roots of plants take in water from the soil, and the leaves of the plants transpire any unused water as water vapor back into the air. Moisture in the air can rise and condense to form clouds and eventually rain.
4. Answers will vary but might include that rain forests offer homes to millions of different species of life, some unknown to scientists. Many of the plants are used for medicines. Rain forests also play a vital role in weather patterns around the world.

Danger! Deforestation

1. The jar under the funnel without leaves contained the most sediment because without leaves and other debris, the dripping water easily washed away the soil.
2. The jar without the leaves and debris filtered the water the quickest because there was nothing to hold the water back.
3. When rain forests are slashed and burned, it leaves the land barren just like the funnel that had no leaves or debris. When it rains (dripping water), the rain easily washes away the soil and causes erosion.
4. Answers will vary.

It's Basically Basic

1. Answers will vary, but if the plant goes without water for a long time, the leaves will turn yellow and brown and eventually drop off or shrivel and dry up. Plants need water to survive. Water is necessary for sugar production, which provides food for the plant.
2. Answers will vary, but if the plant is placed in the dark for a long time, it will begin to turn yellow and brown and eventually begin to die. Without sunlight, a plant cannot make sugar, which is food to the plant. Without food, a plant cannot survive.
3. This experiment proves that plants have two basic needs: light and water. Answers will vary but should include that plants also need air (carbon dioxide) and minerals (food) to survive. Another need could be that plants need space because if plants become overcrowded, some will die.
4. Animals and plants also need air, water, and food to survive; however, animals breathe oxygen instead of carbon dioxide, and they eat plants and other animals for food. Animals also need shelter.

On the Web

Around the World

1. Rain forests are in temperate and tropical regions, with the most well-known ones occurring in a belt around the equator between the Tropic of Cancer and the Tropic of Capricorn.
2. The amount of solar energy received at a particular location on Earth depends on the angle at which the sunlight strikes Earth. Areas in the tropics receive the most direct rays. Year-round temperatures in these areas are always hot, except at high elevations. As the Sun's rays heat the Earth's surface (water and land), hot air rises. As the hot air rises, it cools and condenses, forming clouds. Eventually the clouds become saturated and it rains. The tropical area near the equator is more water than land. Heating this great amount of water creates a lot of moisture in the air and causes bountiful rainfall.

The NASA SCI Files™
The Case of the
Prize-Winning Plants

Segment 2

The tree house detectives are eager to learn more about the basic needs of plants. While accompanying her mom on a trip to NASA Kennedy Space Center in Florida, Bianca visits Ms. Lori Jones at the CO_2 lab. Ms. Jones explains how plants need oxygen for respiration and how they use CO_2 from the air to make sugars and other chemical compounds. Next, Bianca visits Dr. Gregory Goins to learn about the light spectrum and why light is important to plants. Meanwhile, back at the tree house, Jacob is busy with his own CO_2 experiment, which leaves him a little "breathless." The other detectives decide that they should learn more about photosynthesis and contact students at Pearl Harbor Kai Elementary School in Honolulu, Hawaii, who share the results of their experiments on light. However, the tree house detectives are still concerned that a pineapple plant won't adapt to the Virginia climate, so they decide to visit Dr. D to learn about plant adaptations.

Objectives

Students will

- understand the importance of carbon dioxide for plant growth.
- learn the function of stomata.
- understand that light is an energy source that powers the food-making process of photosynthesis.
- learn how plants adapt to their environment.

Vocabulary

adaptations—characteristics that enable a living thing to survive in its environment

air—the invisible mixture of odorless, tasteless gases that surrounds the Earth

carbon dioxide ***(CO_2)***—a heavy, colorless gas that does not support burning, dissolves in water to form carbonic acid, is formed especially by the burning and breaking down of organic substances, is absorbed from the air by plants in photosynthesis, and has many industrial uses

chlorophyll—a pigment that causes a plant to appear green. Chlorophyll absorbs visible light from the Sun to provide the energy for photosynthesis.

epiphyte—a plant that gets moisture and the materials needed to make its food from the air and rain and that usually grows on another plant

fluorescent light—light created by an electric lamp in the form of a tube in which light is produced on the inside fluorescent coating by the action of ultraviolet light

light—an electromagnetic radiation in the wavelength range, including infrared, visible, ultraviolet, and X-rays, which travel in a vacuum about 300,000 km per second

photosynthesis—the process by which plants that contain chlorophyll use carbon dioxide and water with light energy to produce food and oxygen

respiration—the physical and chemical processes by which a living thing obtains the gases that it needs to produce energy and eliminate waste gases

stomata—small openings surrounded by two guard cells through which moisture and gases pass in and out of a leaf's epidermis

visible spectrum—the only part of the electromagnetic spectrum we can see that includes the colors of the rainbow: red, orange, yellow, green, blue, and violet

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Prize-Winning Plants*, discuss the previous segment to review the problem and reaffirm what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site, select Educators, and click on the Tools section. The Problem Board can also be found in the Problem-Solving Tools section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.

View Segment 2 on the Video

For optimal educational benefit, view *The Case of the Prize-Winning Plants* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about plants, how plants are classified, the parts of plants, plants' basic needs, and plant adaptations.
4. Organize the information and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information is needed for the tree house detectives to grow a healthy, prize-winning pineapple plant. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the Educator Guide for *The Case of the Mysterious Red Light* and *The Case of the Inhabitable Habitat*, select Educators, and click on Activities/Worksheets in the menu bar at the top. Scroll down to the 2001–2002 season and click on either *The Case of the Mysterious Red Light* or *The Case of the Inhabitable Habitat*.

a. In the Educator Guide for *The Case of the Mysterious Red Light*, you will find

a. Segment 1—*Natural or Artificial, Photons, Traveling the Straight and Narrow, Roping a Wave,* and *Roll Out the Frequency*

b. Segment 2—*The Zig-Zag Race of Reflectors, The Bendable Light*, and *Refraction Action*

c. Segment 3—*Over the Rainbow, Primary Colors of Light*, and *Rainbow of Knowledge*

b. In the Educator Guide for *The Case of the Inhabitable Habitat*, you will find

a. Segment 1—*Biomes, Welcome to My Habitat*, and *How Does Your Garden Grow?*

b. Segment 2—*Sprouts to Grow*

c. Segment 3—*Leaf the Wax On* and *Have Seed, Will Travel*

c. On the web site in the Activities/Worksheet section for *The Case of the Mysterious Red Light*, you will find

a. *The Edible Spectrum*

b. *The Incredible Edible Wave*

c. *Pouring a Little Light on the Subject*

d. *What is the Color White?*

d. On the web site in the Activities/Worksheet section for *The Case of the Inhabitable Habitat,* you will find

a. *Animal Adaptations*

b. *The Creature from the Adapting Lagoon*

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under After Viewing on page 13 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

Research Rack—books, Internet sites, and research tools

Problem-Solving Tools—tools and strategies to help guide the problem-solving process

Dr. D's Lab—interactive activities and simulations

Media Zone—interviews with experts from this segment

Expert's Corner—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

Careers

ethnobotanist

9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the PBL Facilitator Prompting Questions instructional tool found by selecting Educators on the web site.

10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools found on the web site. For more assessment ideas and tools, go to Educators and click on Instructional Tools in the menu bar.

Resources

Books

Batten, Mary: Hungry Plants (Road to Reading Series: Mile 4). Golden Books, 2000, ISBN: 0307264017.

Charman, Andrew: I Wonder Why Trees Have Leaves and Other Questions About Plants. Houghton Mifflin Company, 2003, ISBN: 075345663X.

Moore, Jo Ellen: Learning About Plants. Evan-Moor Educational Publishers, 2000, ISBN: 155799772.

Silverstein, Alvin: Photosynthesis. Millbrook Press, 1998, ISBN: 0761330003.

VanCleave, Janice: Janice VanCleave's Play and Find Out About Nature: Easy Experiments for Young Children. John Wiley & Sons, 1997, ISBN: 0471129399.

Web Sites

NASA-Fundamental Space Biology
Visit their site to learn how NASA is studying biological processes through space flight and ground-based research.
http://fundamentalbiology.arc.nasa.gov

Composition of the Atmosphere
Take a short trip through history to learn how atmospheric gases were discovered and how they affect us today.
http://www.msnucleus.org/membership/html/jh/earth/atmosphere/lesson1/atmosphere1a.html

National Gardening Association/Kids & Classrooms
This site provides information about the Grow Lab Indoor Garden—Basic Science Program and includes an online newsletter with articles on herbs, seed saving, nutrition, and more. *http://www.kidsgardening.com/*

Arizona State University—Photosynthesis
This wonderful resource helps teachers find out everything they ever wanted to know about photosynthesis.
http://photoscience.la.asu.edu/photosyn/education/learn.html

BBC—ReviseWise Science
Visit this web site to learn about the basic needs of a plant and the photosynthesis process. Play an interactive game to learn what makes a plant grow.
http://www.bbc.co.uk/schools/revisewise/science/living/06_act.shtml

BBC—Gardening with Children
Learn all about photosynthesis and other interesting facts about plants.
http://www.bbc.co.uk/gardening/children/didyouknow/didyouknow_photosynthesis.shtml

USDA—Agricultural Research Service—Sci4Kids
This USDA web site illustrates some of the ways that plants defend themselves against hungry animals and how important plants are to people.
http://www.ars.usda.gov/is/kids/plants/plantsintro.htm

Environmental Protection Agency (EPA)—Global Warming
This site is a great resource for educators to learn the latest on how increasing carbon dioxide in the atmosphere affects our Earth.
http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html

Classroom of the Future—Biomes
This web site is a great introduction to the various biomes of the world. Within each biome, students can further explore the plants of the biome and learn how they adapt to their environment. Great teacher resources too!
http://www.cotf.edu/ete/modules/msese/earthsysflr/biomes.html

Activities and Worksheets

In the Guide

On the Web

Guards at the Door

Purpose

To understand how stomata function in a plant

Materials

houseplant
petroleum jelly
2 plastic bags
2 twist ties

Background

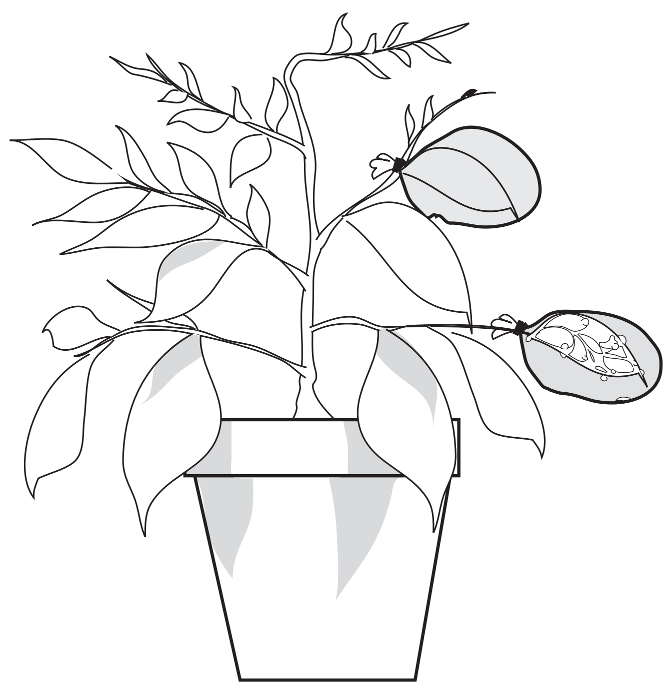
Plants contain openings that permit air to enter and water vapor to leave. These openings are called stomata. The word stoma comes from the Greek word meaning "mouth." Stomata open into the air spaces inside the leaf, and two cells called guard cells surround each stoma. Leaves usually have more stomata on the lower surface layer (epidermis) of a leaf than on the upper layer. Green stems can also have stomata.

Procedure

1. Place a plastic bag over one leaf of the plant.
2. Use a twist tie to close the bag's opening firmly around the leaf's stem.
3. Rub petroleum jelly on both sides of a second leaf.
4. Repeat steps 1 and 2 for the second leaf.
5. Observe and record your observations in your science journal.
6. Observe the two leaves every 24 hours for three days and record your observations.

Conclusion

1. What happened to the two different leaves? Why?



Stomata, Up Close and Personal

Purpose

To observe stomata open and close

Teacher Note

An adult may need to prepare slides ahead of time.

Materials

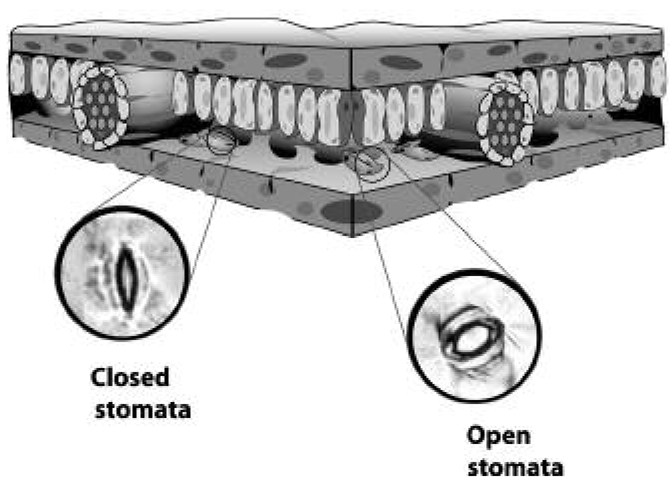
clock
cover slip
distilled water
dropper
forceps or tweezers
hand lens
lettuce leaf
metric ruler
microscope
microscope slide
paper towel
saltwater
science journal

Procedure

1. Use a hand lens to observe the upper and lower surfaces of the lettuce leaf.
2. Tear a small 5-cm square from the lettuce leaf.
3. Bend this square in half.
4. Use the forceps to remove a thin layer of epidermis from the leaf.
5. Place one drop of distilled water onto the microscope slide.
6. Place the thin layer of epidermis removed from the lettuce leaf onto the drop of water and place a cover slip over it.
7. Place the prepared slide on the microscope and observe the epidermis layer by using low power.
8. Locate a pair of kidney-bean-shaped guard cells and a stoma. Illustrate your observations in your science journal.
9. Use the dropper to place a drop of saltwater next to the edge of the cover slip.
10. Use a small piece of the paper towel to draw the saltwater under the cover slip by touching the paper towel to the side of the cover slip opposite the drop of saltwater.
11. Wait about 5–10 minutes and observe using low power on the microscope.
12. Illustrate your observations in your science journal.
13. Compare and contrast the two illustrations. Describe how guard cells are different from the other cells of the epidermis.

Conclusion

1. How are the stomata affected by the guard cells when they come in contact with the saltwater?
2. What causes the stomata in a plant to open and close?
3. Why is it important for a plant to have stomata?



The Green, Green Grass of Home

Problem

To understand that plants need light

Background

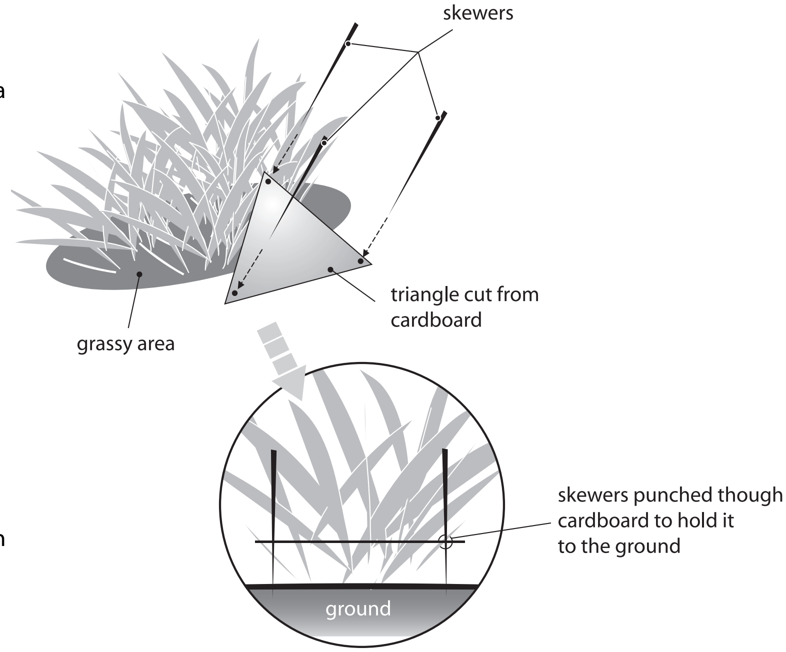
Rocks that have hardened from liquids are called igneous {IG nee us} rocks. The word "igneous" comes from the Greek word for fire. All igneous rocks begin below the Earth's surface in a liquid state of hot melted matter called magma. When magma forces its way to the surface through volcanic eruptions, it is called lava. As magma and lava cool, they form different types of igneous rocks. When magma cools underground, it cools very slowly, forms large crystals, and is called an intrusive igneous rock. When lava cools above ground, it cools more quickly, forms very small or no crystals, and is called extrusive igneous rock.

Materials

- cardboard (cereal box)
- large, green, grassy area
- pencil
- scissors
- science journal
- wooden skewers

Procedure

1. Cut out one side of an empty cereal box.
2. On the cardboard, draw a shape such as a crescent moon, a triangle, or even the first letter of your name.
3. Use scissors to cut out the shape.
4. Go outside to a large, grassy area and place your shape on the ground, covering a section of the grass.
5. Punch a hole through the cardboard with the sharp end of the wooden skewer and insert the skewer into the ground to hold the cardboard shape in place.
6. Wait one week and return to the grassy area and remove your cardboard.
7. Observe the grassy area where the cardboard had been and record your observations. (***Safety tip:*** *Use caution when handling pointed, wooden skewers.)*



Conclusion

1. What happened to the grass under the cardboard? Why?
2. Which one of a plant's basic needs does this experiment demonstrate?

Extension

1. Cut out small shapes and paper clip them to the leaves of a large plant. After several days to a week, take the shapes off and observe.
2. Place a small drop of iodine on the green part of the leaf and observe what happens. Place a small drop of iodine on the part of the leaf that was covered by the shapes and observe. Why did the iodine change color on only one part of the leaf? Hint: Iodine is an indicator for starch.

Oh Colors, Where Art Thou? Chromatography

Problem

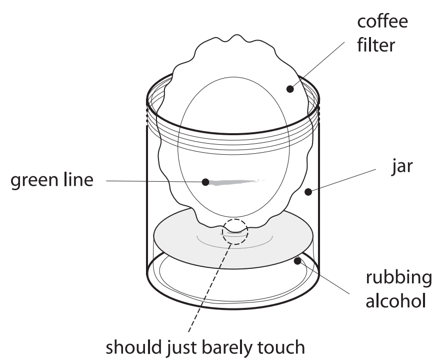
To separate the colors hidden within a leaf

Materials

clock
coffee filter
coin
jar
leaf from outdoor plant
metric ruler
pencil
permanent marker
rubbing alcohol
science journal
tape

Procedure

1. Lay the coffee filter flat and place the green leaf on top of it about 2 to 5 cm from the bottom of the filter.
2. Roll a quarter back and forth several times over the leaf to make a line of pigment on the filter paper.
3. Have an adult pour a small amount of rubbing alcohol into a jar or beaker until the liquid level is approximately 5 mm deep.
4. Place the bottom edge of the filter into the liquid so that the filter is just barely touching the liquid and hold it steady. Optional: Tape the filter to the side of the jar.
5. Allow enough time for the filter to absorb the liquid. You will notice that the liquid creeps upward toward the line of pigment that you made on the filter. Once it reaches the line, continue to wait and observe what happens as more of the alcohol reaches the line of pigment.



Conclusion

1. What happened to the green line after you placed the coffee filter paper in the rubbing alcohol?
2. What colors did you observe on the paper after it was in the rubbing alcohol for 10 minutes?
3. Where did these colors come from?

Bubbles To Go

Problem

To demonstrate that different wavelengths of light affect the process of photosynthesis

Teachers Note

Elodea is an inexpensive aquatic plant that can be obtained from most pet stores. It is also sometimes referred to as *Anacharis* or *Elodea canadensis*. An overhead projector works well for the light source, but a fluorescent lamp can also be used. For several groups, position a test tube rack(s) so that the overhead projector or lamp shines directly on it from a distance of about 15-20 cm. As the students finish their test tubes, have them place the test tubes in the rack for observation. If you have a large class, a second light source might be needed.

Background

Photosynthesis is the metabolic process within the green parts of the plant. During this process, molecules of carbon dioxide and water are restructured into sugar. Light provides the energy needed for photosynthesis to occur. However, many factors such as the wavelength of the light, the intensity of the light, the amount of carbon dioxide, and even the temperature can affect the process. During the process of photosynthesis, oxygen is created as a "waste product."

Materials

(per group)

large test tube
de-chlorinated water
12-14 cm of *Elodea*
metric ruler
scissors
stopwatch or clock with second hand
red, blue, and green filter sheets
baking soda
grease pencil or marker

(per class)

light source
test tube rack(s)

Procedure

1. Using a grease pencil or marker, label your test tube with your group's name or number.
2. Place one-eighth of a teaspoon of baking soda in the bottom of the test tube.
3. Fill the test tube halfway with water.
4. Gently shake the test tube to mix the water and baking soda.
5. Measuring from the top of the plant cut a 12-14 cm section. **Note:** Be careful as you cut the plant not to smash the tubes in the stem. If you do, try to roll them between your fingers to open the tubes up or make a new cut.
6. Remove a few of the bottom leaves from the cut end.
7. Place the *Elodea* plant into the test tube lengthwise with about 2 cm of space from the plant to the top of the test tube. Cut end of plant should be facing up. If the plant is too long, cut it to fit. See diagram 1.
8. Fill the remainder of the test tube with water.
9. Place the test tube 15-20 cm from the light source.
10. Let the test tube stand in front of the light source for about 10-15 minutes and then check for bubbles. Once bubbles are forming and floating to the top from the end of the stem, you are ready to collect your data.
11. Data Collection:
    a. Place a red filter sheet in front of your test tube.
    b. Wait for a bubble to float to the surface and start the stopwatch.
    c. Count the bubbles after that first one until you reach 10 bubbles and stop the stopwatch.
    d. Record the time in the data chart.
    e. Repeat for 3 more trials.
    f. Find the average time for all 3 trials.
    g. Place the blue filter sheet in front of your test tube and repeat steps a-f.
    h. Place the green filter sheet in front of your test tube and repeat steps a-f.
12. Using the average time for each filter, create a graph of your data. Be sure to label the x and y axis, create a key, and title the graph.
13. Share your data with your class and create a class chart and graph.

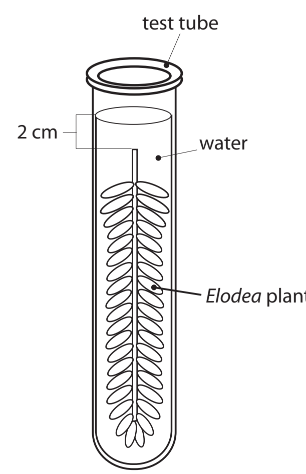


Diagram 1

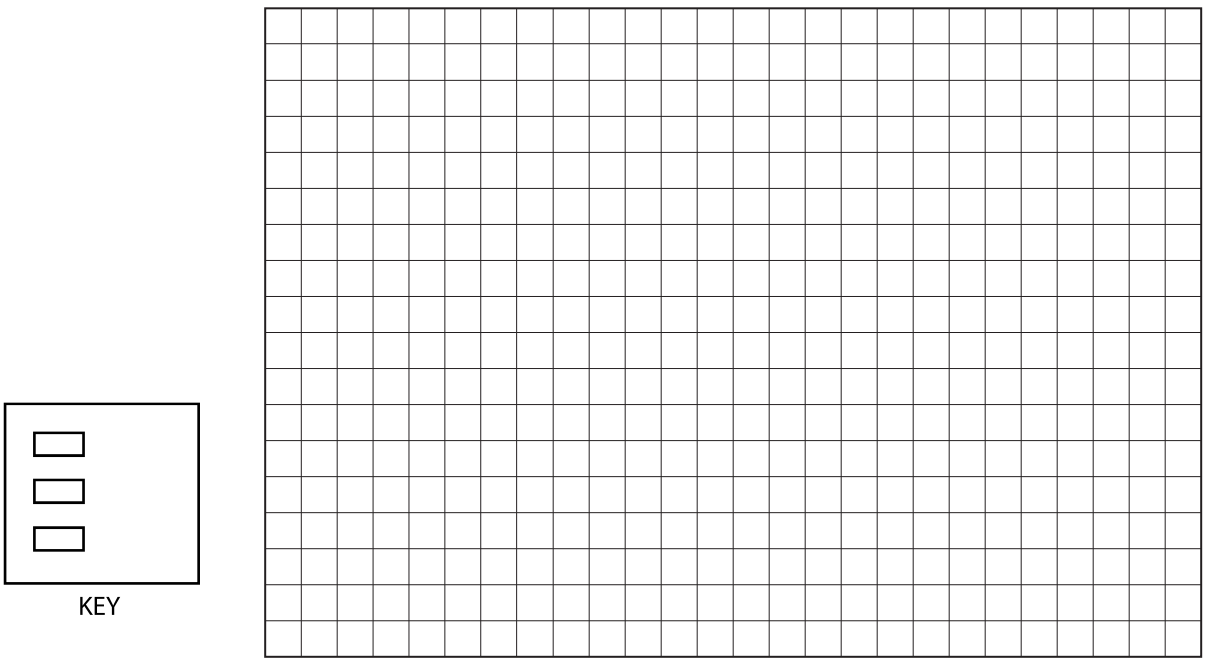
Bubbles To Go (concluded)

Data Chart

Filter	Trial 1	Trial 2	Trial 3	Average Time
Red Filter				
Blue Filter				
Green Filter				

Graph: ____________________

Title



Conclusion

1. Where are the bubbles coming from?
2. Which filter made the bubbles form the fastest? Why?
3. Which filter made the bubbles form the slowest? Why?
4. Why is it important to do three trials?
5. How did your class chart and graph compare to your data?
6. Explain why more data are better?

Extension

To understand the effect that the intensity of light has on photosynthesis, place the test tube at different distances from the light (10 cm, 15 cm, 20 cm, and so on). Record the amount of time it takes for 10 bubbles to form, create a chart and graph of your data.

Waxing a Plant

Materials

science journal
scissors
2 small pans
2 sponges
water
zippered plastic bag

Purpose

To learn how some plants adapt to a dry environment

Procedure

1. Soak each sponge in water.
2. Use scissors to make five small cuts in the plastic bag.
3. Place one sponge in the bag and "zip" the bag closed.
4. Place the plastic bag with the sponge in a pan.
5. Place the other sponge in the other pan. See diagram 1.
6. Leave both pans in a warm, sunny place.
7. Observe the two sponges and record your observations in your science journal.
8. Predict what will happen to the two sponges and record your prediction in your science journal.
9. Observe the sponges again the next day and record your observations.

Conclusion

1. Which sponge lost the least amount of water? Why?
2. How might leaves with a wax covering help plants adapt to a dry environment?
3. Where might you find plants with wax coverings?

Extension

Instead of using a plastic bag, cover one sponge with petroleum jelly.

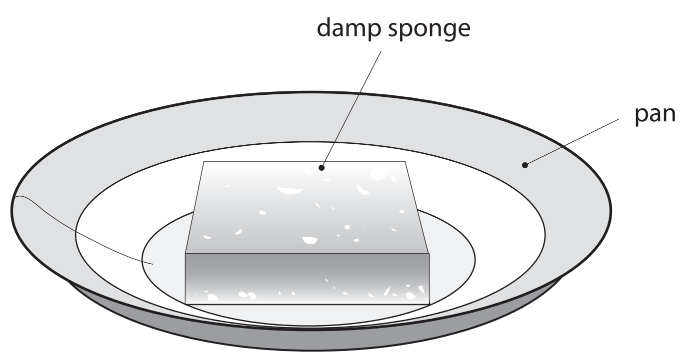
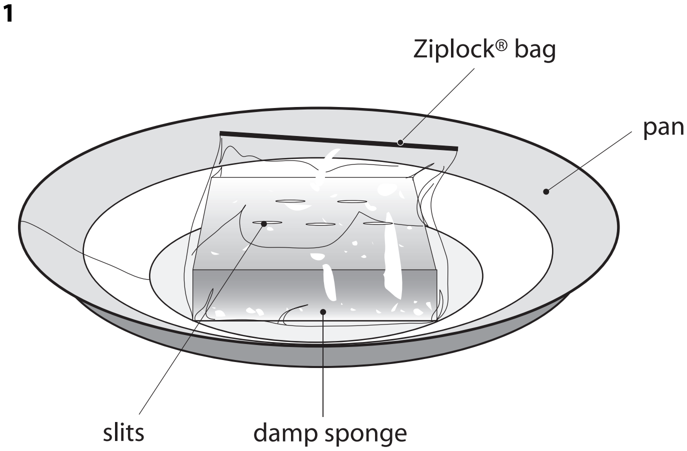


Diagram 1



Adapting for the Future

Purpose To understand how plants must adapt to survive changes in their environment

Procedure

1. Choose one of the following scenarios:
   a. Meteorologists have noted a slow change over time in the weather patterns for your local area. Currently, the area's average rainfall is only 40 inches per year. However, the meteorologists predict that in the next 100 years, the area will receive an extraordinary amount of rainfall with a possible 100 or more inches of rain each year. What will happen to the plant life in the area? How will plants adapt to such a drastic change in the environment?
   b. Meteorologists have noted a slow change over time in the weather patterns for your local area. Currently, the area's average rainfall is only 60–80 inches per year. However, the meteorologists predict that in the next 100 years, the area will experience a drought and will receive about 10–15 inches of rain each year. What will happen to the plant life in the area? How will plants adapt to the change in the environment?
   c. You have just been hired as a marine biologist to study plants in the Pacific Ocean. You will be spending the next year in an underwater habitat to learn how plants adapt to the ocean's ever-changing environment. Scientists are worried that if global warming is possible and the sea levels rise, then the oceans will become less salty with the increase of freshwater. Will an increase in sea level affect aquatic plants? How will they adapt to the changing environment?
2. As a botanist, research the scenario you chose and design a garden that could survive in the new environment.
3. Your garden may be real (in a planter) or may be presented in the form of a poster, PowerPoint presentation, or other creative way.
   a. Draw and label the parts of at least four of the plants in your garden.
   b. Identify the type of environment (biome) to which it has adapted.
   c. Describe the area's new climate.
   d. Describe how each plant reproduces and mention any adaptations that might aid in the reproduction process.
   e. Describe any other adaptations that help plants survive in the new environment.
4. Share your garden and research with the class.

Answer Key

Guards at the Door

1. The bag surrounding the leaf without the petroleum jelly had moisture on its surface while the other one remained dry. Rubbing petroleum jelly on the surface of one leaf prevented the escape of moisture through the stomata and the bag remained dry. The normal exchange of air and water occurred in the bag with the untreated leaf, and the moisture condensed on the inside surface of the bag.

Stomata, Up Close and Personal

1. When the guard cells came in contact with the saltwater, they shrank in size and the stomata closed.
2. When guard cells absorb water by osmosis, they swell and the stomata open. When stomata are open, carbon dioxide gas can diffuse into leaves and any waste gases such as oxygen can move out. When guard cells lose water by osmosis, they shrink, causing the stomata to close; therefore, gases cannot move either in or out of the leaves.
3. Stomata are important to plants because they help protect the plant from the changing environment. When the stomata on a leaf are open, carbon dioxide gas can diffuse into the leaf, and water can diffuse out of the leaf by the process of transpiration. Transpiration decreases the amount of water in the leaf, and the plant then needs to absorb more water from the soil through its roots to make up for the water lost by transpiration. Also, plants must make their own food by photosynthesis. Photosynthesis can occur only when chlorophyll absorbs the light in a leaf, when the stomata are open and allow carbon dioxide gas into the leaf, and when water is available in the cells of the leaf. Photosynthesis cannot occur at night because there is no light; therefore, the stomata on a leaf will close to keep the water from transpiring from the leaf and being wasted.

The Green, Green Grass of Home

1. The grass under the cardboard turned a yellowish color. The green coloring in plant leaves is called chlorophyll. It traps the Sun's energy to produce food, which makes the plant grow. Plants need light to be able to make chlorophyll. When there is no light, the plant stops producing this green pigment and its leaves yellow. As soon as the plant has light again, it is stimulated to make chlorophyll, turning the leaves green and putting its food-making processes back into production.
2. This experiment demonstrates a plant's basic need for light.

Oh Colors, Where Art Thou? Chromatography

1. The green line began to separate into different colors.
2. Orange, yellow, light green, and dark green.
3. The colors are in the leaf, but you are unable to see them because the chlorophyll (green) is dominant during photosynthesis. Have you ever noticed that leaves change colors in the fall? Have you wondered why they change? During the autumn, fewer hours of daylight and less sunlight cause changes in plant hormones (chemical messengers). These changing plant hormones can cause chlorophyll to break down. When chlorophyll breaks down, the plant will no longer appear green. Without chlorophyll, photosynthesis cannot occur. As the chlorophyll begins to fade away, the other colors in the leaf can finally show their true intensity. The fall colors were always there; they were just hidden by the abundant amount of green color produced by the chlorophyll. For more information, visit NASA Kids' Science News Network™ (KSNN™) at *http://ksnn.larc.nasa.gov/webtext.cfm?unit=leaves*

Answer Key (concluded)

Bubbles to Go

1. Photosynthesis is the metabolic process within the green parts of the plant. During this process, molecules of carbon dioxide and water are restructured into sugar. Light provides the energy needed for photosynthesis to occur. The "waste product" of photosynthesis is oxygen. The bubbles are the oxygen that was created during photosynthesis.
2. The bubbles formed the fastest and about equally with the red and blue filters. In the visible spectrum of light there are many colors (red, orange, yellow, green, blue, and violet). Plants absorb light energy as photons, which are packets of energy. To grow well, plants require (absorb) mostly red and blue light while reflecting most of the green light. By receiving red and blue light, photosynthesis occurred more quickly and the bubbles were created faster.
3. The green filter. Plants mostly reflect the green part of the spectrum; therefore, with the green filter the plant was receiving less energy and photosynthesis slowed.
4. At least three trials are necessary to make sure that your data are accurate. If your times were very different from each other, then several more trials would be required.
5. Answers will vary.
6. The more data you collect, the more reliable your results and conclusions will be. There are too many factors that can "skew" data and by performing many trials and collecting data from other groups, you are less likely to have "skewed" data.

Waxing a Plant

1. The sponge with the plastic bag lost the least amount of water. The plastic bag helped keep most of the moisture from evaporating.
2. Just as the plastic bag helped keep the sponge wet, the wax covering on a leaf helps keep the water in a plant from escaping. Not allowing water to escape helps the plant retain more water so it can survive during droughts.
3. Plants with wax coverings exist in many places, but answers should include the desert and alpine environments.

The NASA SCI Files™
The Case of the
Prize-Winning Plants

Segment 3

The tree house detectives continue to research the basic needs of plants and decide to investigate soils. They suggest that Kali visit Dr. Donald Swanson, of the United States Geological Survey (USGS), on the big island of Hawaii at the Hawaiian Volcano Observatory in Hawaii Volcanoes National Park. Standing on Crater Rim, Dr. Swanson explains how volcanoes formed and continue to form the islands of Hawaii. He also tells Kali how soil develops and why volcanic soil is often rich in nutrients. Back at the tree house, the detectives decide that growing a potted pineapple plant is a lot different from growing one in the ground, so they contact Dr. Susan Steinberg at NASA Johnson Space Center in Houston, Texas. Dr. Steinberg describes how to grow small, potted plants and emphasizes the importance of proper drainage in plant containers. Finally, it's time to meet Dr. D at the Virginia Marine Science Museum in Virginia Beach, Virginia to learn about "the birds and the bees!"

Objectives

The students will

- learn how soil is formed.
- understand that soil provides important nutrients to plants.
- understand that all plants require different amounts of water.
- learn the life cycle of a plant.

Vocabulary

anther—the part of the flower that produces and contains pollen and is usually borne on a stalk

capillary action— the movement of water within the spaces of a porous material caused by the forces of adhesion, cohesion, and surface tension

carpel—one of the structures deep inside the flower of a seed plant that makes up the ovary

hot spot—the hotter areas in Earth's mantle that form magma that rises toward the crust

ovary—the enlarged, rounded lower part of a flower's pistil, in which seeds are formed

pistil—the seed-producing part of a flower, which usually consists of the stigma, style, and ovary

pollen—a mass of tiny particles in the anthers of a flower that fertilizes the seeds and usually appears as fine yellow dust

pollination—the movement of pollen grains—by wind, water, or animals—from a flower anther to a flower stigma

potting soil—a mixture of soil specially made for growing plants in containers, which are often made of pet moss and perlite or vermiculite

reproduction—the process by which plants and animals produce offspring

rhizoids—long, single cells that attach liverworts and mosses to the ground

seed—the plant embryo, stored food, and seed coat

soil—the loose, surface material of the earth in which plants grow

stamen—the flower's organ (consisting of an anther and a filament) that produces pollen

vegetative reproduction—process by which new plant "individuals" arise or are obtained without production of seeds or spores

volcano—a vent in the Earth's crust from which melted or hot rock and steam emerge

waterlogged—a soggy root condition that occurs when roots sit in water for a prolonged period of time due to poor drainage; saturated

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Prize-Winning Plants*, discuss the previous segment to review the problem and assess what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site, select Educators, and click on Tools. The Problem Board can also be found in the Problem-Solving Tools section of the latest online investigation. Have students use this section of the web site to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.

3. Revise and correct any misconceptions that may have occurred during previous segments. Use tools located on the Web, as was previously mentioned in Segment 1.

4. Review the list of ideas and additional questions that were created after viewing Segment 2.

5. Read the overview for Segment 3 and have students add any questions to their list that will help them better understand the problem.

6. Focus Questions—Print the questions from the Educators area of the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program so they will be able to answer the questions. An icon will appear when the answer is near.

7. "What's Up?" Questions—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the Educators area of the web site ahead of time for students to copy into their science journals.

View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Prize-Winning Plants* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.

2. Discuss the Focus Questions.

3. Have students work in small groups or as a class to discuss and list what new information they have learned about plants, how plants are classified, the parts of a plant, plants' basic needs, plant adaptations, soil, and plant reproduction. Organize the information, place it on the Problem Board, and determine whether any of the students' questions from the previous segments were answered.

4. Decide what additional information is needed for the tree house detectives to determine how to grow a healthy prize-winning plant. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.

5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.

6. For related activities from previous programs, on the home page, click on the fence post that says Guides to download the Educator Guide for *The Case of the Mysterious Red Light* (2001–2002 Season), *The Case of the Shaky Quake* (2002–2003 Season), and *The Case of the Disappearing Dirt* (2003–2004 Season). For additional activities on the web site, select Educators, and click on Activities/Worksheets in the menu bar at the top. Scroll down to the appropriate "Season" and click on the correct program.

A. In the Educator Guides

1. *The Case of the Mysterious Red Light* (2001–2002 Season)
   a. Segment 3—*You've Got the Whole Egg in Your Hand, The Three Little Volcanoes*, and *The Ring of Fire*

2. *The Case of the Shaky Quake*
   a. Segment 1—*Layering of the Earth* and *Plates on the Move*

3. *The Case of the Disappearing Dirt*
   a. Segment 2—*The Incredible, Edible Igneous Rock, It's "Sedimentary," My Dear Watson!, "Metamorphically" Speaking, Rocking Around the Cycle, "Splitting" on the Ritz,* and *"Weathering" Heights*

B. On the web site in the Activities/Worksheet section

1. *The Case of the Mysterious Red Light*
   a. *Magnificent Magma*

2. *The Case of the Shaky Quake*
   a. *Just How Do These Plates Move, Plates on a Globe*, and *Modeled to a Fault*

3. *The Case of the Disappearing Dirt*
   a. *Edible Rock Families, Frosty Effects*, and *The Rock Cycle*

7. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under After Viewing on page 13 and begin the PBL activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:

Research Rack—books, Internet sites, and research tools

Problem-Solving Tools—tools and strategies to help guide the problem-solving process

Dr. D's Lab—interactive activities and simulations

Media Zone—interviews with experts from this segment

Expert's Corner—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

Careers

geodynamacist
geoscientist
paleoecologist
paleontologist
plant pathologist
sedimentologist
soil scientist
volcanologist

8. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon, as suggested on the PBL Facilitator Prompting Questions instructional tool found by selecting Educators on the web site.

9. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the Research Rack in the Tree House and find the online PBL investigation main menu section, Problem-Solving Tools, and the Tools section of the Educators area for more assessment ideas and tools.

Resources

Books

Bial, Raymond: *A Handful of Dirt*. Walker & Co., 2000, ISBN: 0802786987.

Bourgeois, Paulette: *The Amazing Dirt Book*. Addison-Wesley, 1996, ASIN: 0201550962.

Clifford, Nick: *Incredible Earth-Insider DK Guides*. Dorling Kindersley Publishing Inc., 1996, ASIN: 1552090442.

Rosinsky, Natalie: *Dirt: The Scoop on Soil*. Picture Window Books, 2002, ISBN: 1404800123.

Schwartz, David: *Plant Stems and Roots*. Creative Teaching Press, Inc., 1998, ISBN: 1574713272.

Silverstein, Alvin: *Life in a Bucket of Soil*. Dover Pub., 2000, ISBN: 0486410579.

Tomecek, Steve: *Dirt: Jump Into Science*. National Geographic, 2002, ISBN: 0792282043.

Carle, Eric: *The Tiny Seed*. Simon & Schuster Children's Publisher, 1991, ISBN: 088708155X.

Gibbons, Gail: *From Seed to Plant*. Holiday House, Inc., 1993, ISBN: 0823410250.

Jordan, Helene, J.: *How a Seed Grows*. HarperCollins Children's Books, 1992, ISBN: 0064451070.

Wyatt, Valerie: *Wacky Plant Cycles*. Mondo Publishing, 2000, ISBN: 1572557958.

Worth, Bonnie: *Oh Say Can You Seed?*: All About Flowering Plants. Random House, Inc., 2001, ISBN: 0375810951.

Web Sites

NASA—Space Agriculture in the Classroom
Visit this site to learn what's new in the world of agriculture at NASA. Find great links to learn more about careers, plants in space, and much more.
http://www.spaceag.org/

NASA—Soil Science Education
Visit this great web site to learn all you ever wanted to know about soil and more. Resources, activities, news articles, and much more.
http://ltpwww.gsfc.nasa.gov/globe/

NASA Quest—Farming in Space
Visit this site to view archived web casts with various experts talking about farming in space.
http://quest.arc.nasa.gov/ltc/farming/farming.html

U.S. Department of Agriculture—USDA for Kids
This web site is packed full of fun and interesting "kid" things. Learn about gardening, view a U.S. agricultural time line, play games, and much more. Everything is only a few clicks away.
http://www.usda.gov/news/usdakids/

USDA National Agricultural Library—Kids' Science Page
At this site you can read scientists' biographies, learn more about careers in science, explore some 4-H projects, and learn more about plants.
http://www.nal.usda.gov/Kids/

Texas A&M—Monocot Vs. Dicot
An easy-to-read student diagram is displayed that depicts the differences between a monocot and a dicot.
http://www.csdl.tamu.edu/FLORA/201Manhart/mono.vs.di/monosvsdi.html

Backyard Nature
This web site offers a good resource that helps teachers understand the difference between monocot and dicot.
http://www.backyardnature.net/monodico.htm

Activities and Worksheets

In the Guide

On the Web

Eating Dirt
Make an edible "dirt" for dessert.

The Cycle of Plant Life
Use the diagrams to create the plant cycle.

A Few Good Soils

Materials

beaker or large jar
clay
graduated cylinder
hand lens
humus soil
metric measuring cup
5 16-oz plastic cups
paper towels
permanent marker
sand
science journal
shallow pan
silt
stopwatch
water

Problem

To determine which material allows water to pass through the easiest

Teacher Note

To avoid contaminants, purchase materials from a local garden store. If you collect your own materials, bake them in an oven at 350° for 20 minutes to sterilize them.

Background

The ability of soil to hold water is an important characteristic. For a plant to grow properly, the soil around a plant's roots must be able to hold some water while being able to drain and not become soggy or waterlogged. Too much water or not enough water will cause the plant to die. Combine sand, silt, clay, and humus to create a soil that drains properly and retains enough moisture for healthy plant growth.

Teacher Prep

Carefully punch 5 holes in the bottom of 4 cups per group. The fifth cup is used for pouring the water.

Procedure

1. With a permanent marker, label one cup "sand" and fill it 3/4 full of sand.
2. Repeat with silt, clay, and humus, being careful to fill the cups to the same level.
3. Use a hand lens to observe each material and record your observations in your science journal.
4. Predict which material will drain the most amount of water. Predict which material will drain the least amount of water.
5. In the remaining cup (without holes), measure 240 mL of water.
6. Hold the sand-filled cup over the beaker and pour the water into the cup. See diagram 1.
7. Have a partner use a stopwatch and begin timing as soon as the water is poured into the cup.
8. After 3 minutes, remove the cup from the beaker and place it in the shallow pan.
9. Measure the amount of water that drained through the sand by pouring the water from the beaker into the graduated cylinder.
10. Record your measurement in the Data Chart on page 51.
11. Repeat steps 4–9 with the silt, clay, and humus.
12. Create a class chart for each material.
13. Using the class data, calculate the average amount of water that drained from each material.

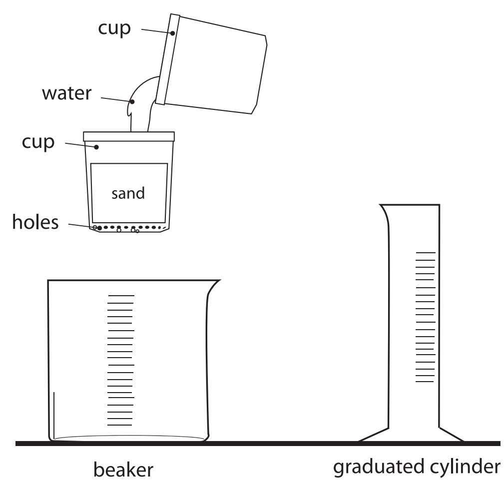


Diagram 1

A Few Good Soils (concluded)

14. Rank the materials from most to least in their ability to allow water to pass through them.
15. Rank the materials from most to least in their ability to hold water.
16. In your group or with a partner, use the results to determine the best combination of materials to make a "good" soil. Be sure to decide upon proportions. Remember that the soil should drain well but also hold some water. The soil should drain about half the water (120 mL).
17. Using dry materials and the fifth cup, combine the materials in the proportions decided upon and repeat steps 4–9.
18. Analyze your results and draw a conclusion.
19. Discuss your results with the class.

DATA CHART

	Sand	Silt	Clay	Humus
Amount of Water Drained				

Conclusion

1. Did your new soil perform as expected? Why or Why not?
2. What would you do differently next time?
3. Were your predictions correct? How did your observations of each material help you make your predictions?

Only the Best of the Best for My Plant!

Problem To compare how plants grow in different kinds of soil

Procedure

1. Discuss the importance of soil to plants. List a soil's important features, such as the ability to drain water, provide nutrients, and so on.
2. In your group, reach a consensus about which soil will be the best for growing the seeds you plant. Write your prediction in your science journal.
3. Place a layer of small pebbles on the bottom of each milk carton. The pebbles will help the soil drain properly.
4. Fill one milk carton 3/4 full with potting soil. See diagram 1.
5. Label the carton "potting soil."
6. Repeat steps 2 and 3 with clay, peat moss, sand, and vermiculite.
7. Plant three or four seeds in each pot. Follow the instructions on the seed packet or plant the seed about 2 cm below the surface of the soil.
8. Water each plant with 80 mL of water. Remember that each plant must receive the same amount of water so that only one variable is being manipulated.
9. Observe and record your observations in your science journal.
10. Place the cartons in a sunny area and cover each one with an index card. See diagram 2.
11. Water every third day using 80 mL of water for each plant.
12. Remove the index card covers when the plants begin to sprout.
13. When the plants finally grow real leaves, snip back all the plants except two.
14. Continue to observe your plants every 3–4 days for several weeks. Record your observations in your science journal and be sure to note the size and color of each plant, the number and condition of the leaves and flowers (if any), and the strength of the stems.
15. After 4 weeks, draw some conclusions about which soil is the best for growing the seeds.

Conclusion

1. Which soil was best for growing your seeds? Why?
2. Why was it important to give each plant the same amount of water each time?

Materials

- clay soil
- 5 index cards
- 5 small, clean milk cartons
- labels
- large spoon
- marker
- measuring cups
- peat moss
- pebbles
- potting soil
- sand
- science journal
- seeds *(radish, beans, marigolds, or sweet peas)*
- vermiculite
- water

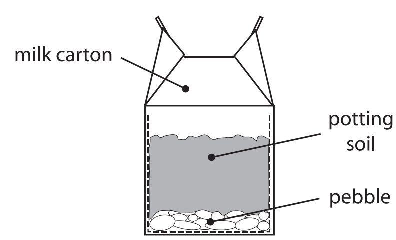


Diagram 1

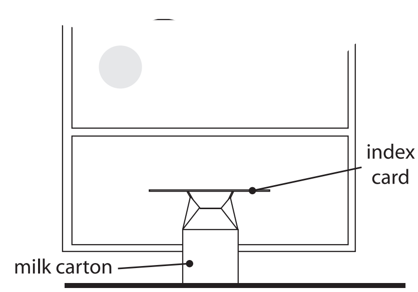


Diagram 2

The Origin of Soil

Purpose To create a concept map depicting the formation of soil

Soil can be found in many places: the yard, on your shoes, and even sometimes behind your ears! But where does soil come from? Did you know that soil comes from rocks? The weathering process gradually breaks down rocks into smaller and smaller fragments. When plants and animals live in these fragments, organic matter is added (leaves, twigs, dead insects). Soil that evolves as organic matter is gradually added to the weathered rock. Most soil is about 50 percent rock and mineral fragments and 50 percent air, water, and organic matter. Soil can take hundreds of years to form and can range in thickness from 60 meters to only a few centimeters. Once soil begins to form, plants begin to grow, and other living things, such as worms, insects, fungi, and bacteria, begin to live among the plants. When plants and animals eventually die, they decay and form a dark-colored organic matter called humus. As worms and insects burrow throughout the soil, they mix the humus with the rock fragments.

Create a concept map (events chain) to illustrate how soil evolves. Use the following terms and phrases: worms and insects are added, humus mixes with weathered rock, soil is formed, rock is weathered, humus develops, and plants grow.

If you're not sure how to create a concept map, visit this web site to learn more: *http://www.graphic.org/concept.html*

Soil Formation
Concept Map

Flower Power

Purpose

To identify the parts of a flower
**Suggested flowers: lily, geranium, petunia, and gladiolus*

Materials

Per Group
8 coverslips
4 different flowers* with stems and leaves
eyedropper
8 glass slides
microscope
plastic cup
water

Procedure

1. Fill the plastic cup with a small amount of water.
2. In your group, examine each flower with its stems and leaves.
3. Record in the Data Chart the name of each flower, along with its color and number of petals. Identify the sepal, petals, stem, and leaves.
4. Have each member in your group choose one flower to work with. Do not remove the steam or leaves from the flower.
5. Find and observe the reproductive structures of the flower.
6. Locate the stamen with the yellow pollen grains on top.
7. Gently shake or rub a few pollen grains from the stamen onto a glass slide.
8. Add a drop of water and carefully place a coverslip on top. See diagram 1.
9. Observe the grains under low power on a microscope.
10. Draw and record your observations in the Data Chart, on this page.
11. Observe the pollen grains from each of the other flowers and repeat step 9.
12. Locate the pistil with the sticky substance on top.
13. Shake a few pollen grains from the stamen to the pistil and observe.
14. Have an adult open the pistil and observe.
15. Remove the contents from the pistil and place one of the ovules on a clean glass slide.
16. Add a drop of water and a coverslip.
17. Observe under low power.
18. Draw and record your observations in the Data Chart.
19. Repeat with each of the other flowers.

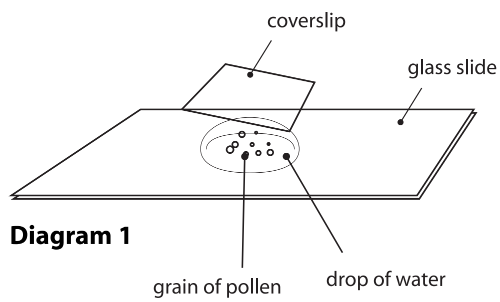


Diagram 1

DATA CHART

Observations	Flower 1:	Flower 2:	Flower 3:	Flower 4:
Color and number of petals				
Pollen Grain: Draw and describe				
Ovule: Draw and describe				

Conclusion

1. A flower has multiple stamens with many pollen grains on each stamen. Why do you think having multiple parts is important to a plant?
2. Why do some flowers have multiple pistils?
3. Did the pollen grains from all the flowers in your group look the same under the microscope? Describe how they were similar and different.
4. Did the ovules from the pistils from all the flowers in your group look the same under the microscope? Describe how they were similar and different.
5. How might pollen be transferred from the stamen to the pistil?
6. Do all flowers have both stamens and pistils? Why or why not?

On the Seedy Side of Life

Purpose

To observe the differences between monocot and dicot seeds

Materials

5 corn seeds
hand lens
4 lima beans
paper towels
permanent marker
science journal
small jar or clear cup
water

Background

Angiosperms make up the largest division in the plant kingdom. Angiosperms are plants that flower and have seeds protected by a fruit. A seed has three main parts. The first part is the embryo, which is a young, growing plant. The second part is the cotyledon where food (nutrients) is stored as starch. The third part is the seed coat. The seed coat encases the whole seed in a tough, protective covering. Angiosperms are divided into two groups called monocotyledons *(monocot for short)* and dicotyledons (dicot for short). Monocot seeds contain one cotyledon (mono means one). In monocot seeds, stored nutrients for the growing embryo are located in the endosperm. The endosperm in a corn seed is the kernel, the part that you eat. Dicot seed embryos contain two cotyledons (di means two). In dicot seeds, nutrients are stored in the cotyledons, which are the main part of the bean seed that you eat. When a seed begins to grow or germinate, the young plant needs the stored nutrients in the endosperm or cotyledon to grow into a mature plant.

Teacher Prep

Soak the seeds to be dissected in a container of water for about 3 hours prior to this activity. Soak enough seeds for each student to have 1 lima bean and 2 corn seeds. One of the corn seeds should be cut open so students can see the inside. The remaining "dry" seeds will be used for planting.

Procedure

1. Use a hand lens to observe the unopened corn seed.
2. In the Observation Chart, draw and describe what you see.
3. Use a hand lens to observe the cut corn seed.
4. Locate the shoot section and the root section of the embryo.
5. In the Observation Chart (page 56), draw and describe what you see.
6. Repeat steps 1 and 2 with the lima bean.
7. Remove the seed coat (outer skin) of the lima bean.
8. Find the opening between the lima bean's two cotyledons and pull them apart.
9. Repeat steps 3–5 with the lima bean.
10. Compare and contrast the corn seed and the lima bean.
11. Label the diagrams the monocot and dicot seeds.
12. Moisten paper towels with water.
13. Fold and place the moistened paper towels so that they fit inside the jar.
14. Crumple and place additional paper towels inside the jar so that the folded paper towels stay against the inside of the jar.
15. Place 3 corn seeds and 3 lima bean seeds between the folded paper towels and the jar. See diagram 1.
16. Use a permanent marker to label each seed on the outside of the jar.
17. Keep the paper towels moist but not too wet.
18. Observe the seeds each day for 2 weeks.
19. In your science journal, create a chart and record your daily observations. Be sure to include a drawing of each seed every day.

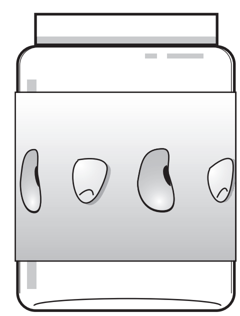
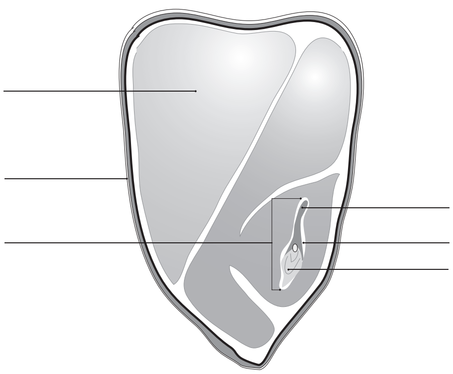


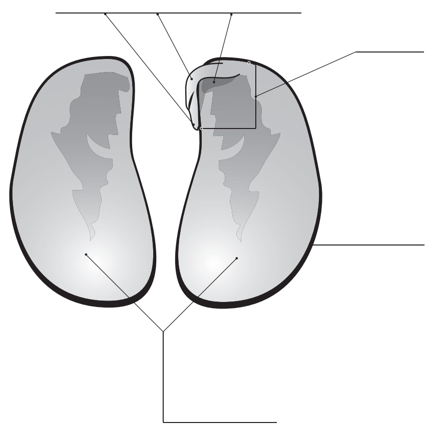
Diagram 1

On the Seedy Side of Life (concluded)

OBSERVATION CHART

Corn Seed	Lima Bean
Unopened	Unopened
Opened	Opened





Conclusion

1. What differences did you notice when the seeds germinated?
2. Do all plants produce seeds? If not, how do they reproduce?

Extension

1. Collect and observe various other seeds and determine whether they are monocot or dicot.
2. Plant a variety of monocot and dicot seeds and determine whether there are any differences in the plant and flower structures. For example: Does a flower produced from a dicot seed have a different number of petals than a flower that comes from a monocot seed? Are their leaves different? How does the vascular system of each compare?
3. Research gymnosperms and explain how they differ from angiosperms.

Flowers in Bloom

Purpose

To compare and contrast monocot and dicot flowers

Materials

clay
Flower Parts (page 58)
markers
tape
scissors
toothpicks

Procedure

1. To make the monocot flower, use modeling clay to form a pistil with three lobes. See diagram 1.
2. Use toothpicks topped with small balls of clay to make the six stamens.
3. Stick the ends of the toothpicks into the clay below the pistil.
4. Color the monocot petals (page 58) and cut them out.
5. Tape a toothpick to the back of each petal. See diagram 2.
6. Arrange the petals around the pistil and stamens by pushing the toothpicks into the clay.
7. Repeat steps 4–6 for the monocot sepals and color them the same color as the petals. The sepals are directly below the petals and cover the flower bud before it opens. See diagram 3.
8. To make the dicot flower, use modeling clay to form a pistil with five lobes.
9. Use toothpicks topped with small balls of clay to make five stamens.
10. Stick the ends of the toothpicks into the clay below the pistil.
11. Repeat steps 4–6 for the dicot petals and sepals, but this time color the sepals green.

Conclusion

1. How are monocot and dicot flowers similar?
2. How are they different?

Extension

1. Go on a nature walk with an adult to observe or collect various leaves and flowers. Identify them as monocot or dicot.

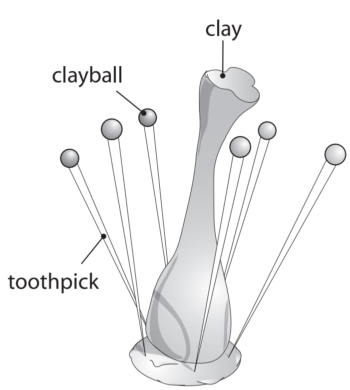


Diagram 1

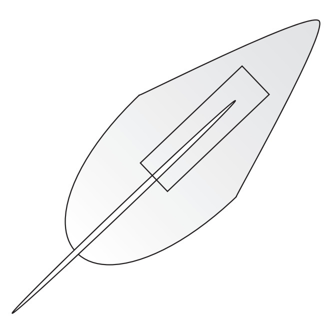


Diagram 2

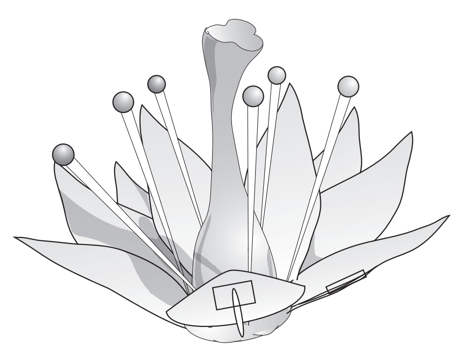
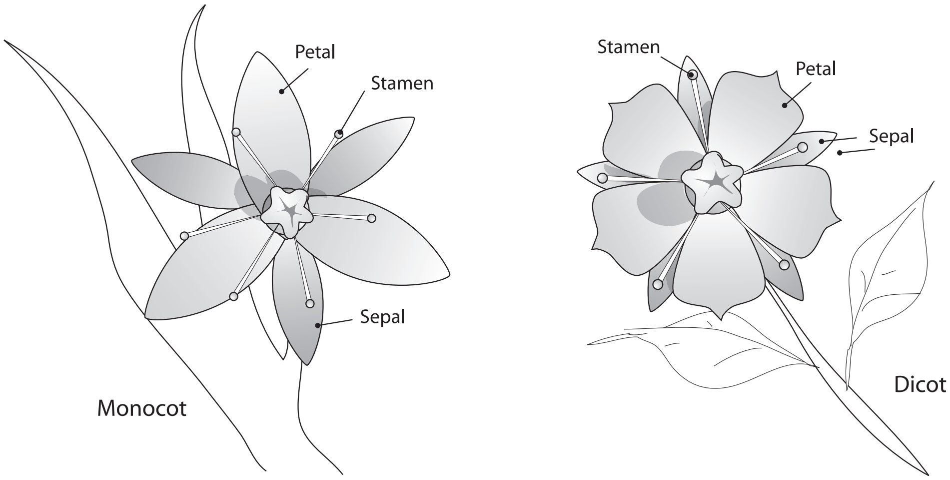
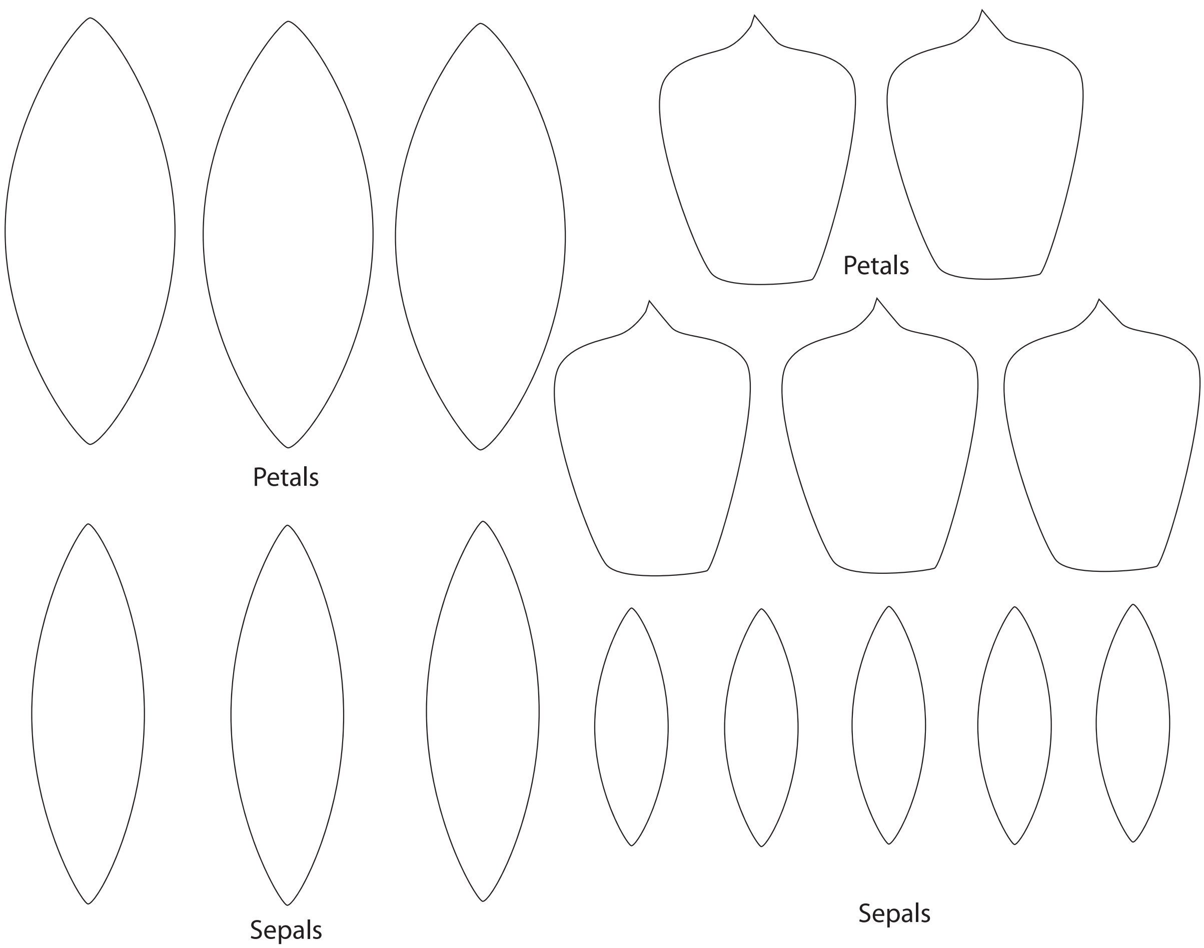


Diagram 3

Flowers in Bloom: Flower Parts (concluded)





Gone With the Wind

Purpose

To learn how seeds are dispersed

Materials

cocklebur
dandelion seed head
game board (page 61)
maple seed
milkweed
nuts
pea pod
strawberry
1 zippered bag

Background

Once a seed forms, it needs to find a place to grow. It has a better chance of survival if it grows away from its parent plant. If the parent plant and other plants like it are too close, the larger plants block sunlight from reaching the seedling, and they use up the water and nutrients needed for the seedling to grow. The best chance for a plant to grow is for the seed to be carried away (dispersed) from the parent. Seeds are dispersed in different ways. Some plants scatter their own seeds when the protective fleshy fruits explode to shoot the seeds away (mechanical propulsion). Other seeds are carried by wind or water. Animals also help disperse seeds. When animals eat the fruit of a plant, the seeds may fall to the ground. If they eat the seeds, the seeds may pass through them and be deposited in the animal's droppings. Some seeds even hitchhike on an animal's fur or feathers to far off places.

Teacher Note

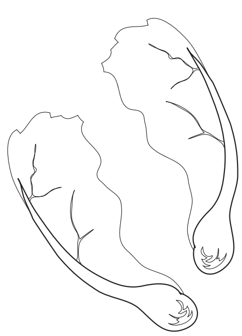
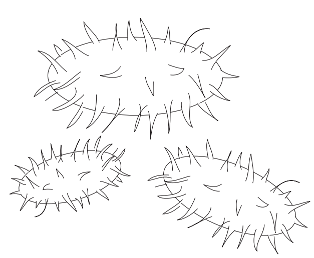
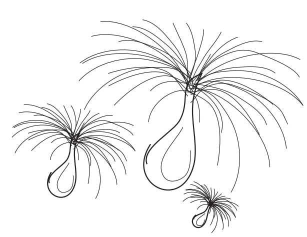
The list of seeds is only a suggested list. You may wish to substitute these seeds with local seeds and fruits that depict the various methods of dispersal.

Procedure

1. Observe the various seeds and classify them by the way they might be dispersed (wind, water, animal, or mechanical propulsion).
2. Explain why you classified each one the way you did.
3. Describe any adaptation the seed may have that benefits its dispersal.
4. Conduct research to find at least two other seeds that are dispersed by wind, water, animals, and mechanical propulsion.
5. In your science journal, draw or paste a picture of each.

Game

This game is called seed bingo. Each team will have a zippered bag for the seeds and a game board. In an area designated by the teacher, each team will find seeds that are dispersed by one of the dispersal methods. The first team that finds five different seeds that can be dispersed by one of the dispersal methods or that finds one seed for each of the five dispersal methods wins the game. As you find the seed, be sure to put an "X" in the correct box on the game board and place it in your zippered bag. When you return to the classroom, glue or tape your seed to the game board in the correct spot and share your seeds with the class.

Gone With the Wind (concluded)

Conclusion

1. What is the advantage of having animals eat the seeds of a fruit? Any disadvantages?
2. Do all dispersed seeds grow into plants? Why or why not?
3. What are some advantages and disadvantages of wind dispersal?
4. The coconut is a seed. Explain how it might be dispersed.

Extensions

1. Collect "hitchhiker" seeds by wearing large old socks turned inside out over your shoes and walking through a tall, grassy area designated by an adult. This collection method works best in the late summer and fall. Be careful to avoid poison ivy or other dangerous plants. Categorize the seeds by the type of adaptation that makes the seed or fruits stick (fuzz, hooks, or sharp points).
2. Observe a piece of Velcro® and describe its similarities to a cocklebur. Research how the inventor George deMestral came up with the idea of a "hook-and-loop fastening" tape.
3. Make a seed bracelet by placing two-sided tape or masking tape with the sticky side out on your wrist. Use the seed bracelet to collect seeds as you go on a nature walk. As you find seeds, just stick them to the tape! Sort the seeds into categories either by shape, type, or dispersal method.
4. Bring in a variety of fruits and cut them open to observe the seeds. Discuss what type of animal would eat each fruit and why. What characteristics do fruits have that attract animals?

Gone With the Wind (Game Board)

Dispersal Method	1	2	3	4	5
Wind					
Water					
Mechanical Propulsion			Free Space		
Hitchhiker					
Eaten by Animals					

Taking Root

Purpose

To demonstrate ways (other than by seeds and spores) that plants reproduce

Materials

ivy leaves
1 large, clear cup or jar
1 narrow-necked jar
permanent marker
sweet potato
science journal
toothpicks
water

Background

Plants can grow from seeds, but sometimes they grow from leaves, stems, roots, and bulbs. This type of reproduction is called vegetative reproduction. Nutrients are stored in seeds, roots, and bulbs. A new plant uses these nutrients to help it sprout and grow. Leaves and stems also store some nutrients as well.

Procedure

1. Observe the sweet potato and locate the narrow, pointed end where the sweet potato was attached to the mother plant. This part is the "proximal" end. The other end is larger and is called the "distal" end.
2. Push toothpicks into the sweet potato to support it in the large jar. The distal end should be inside the jar with the proximal end pointing out of the jar. See diagram 1.
3. Add water (2 cm) to just below the rim of the jar.
4. Mark the water line on the outside of the jar with a permanent marker.
5. Set in a warm, sunny place.
6. Fill the narrow-necked jar with water and place several leaves cut from an ivy plant in the jar.
7. Over the next 3 weeks, continue to add water to both jars so that the water line for each remains constant.
8. For 3 weeks, make daily observations of each jar and record your observations in your science journal.

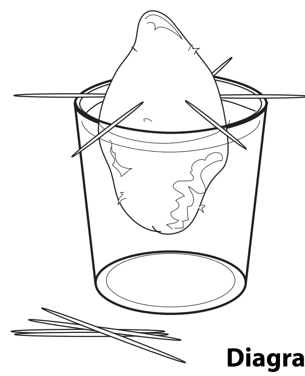


Diagram 1

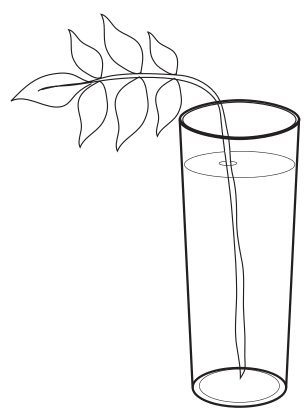


Diagram 2

Conclusion

1. Describe what happened to the sweet potato.
2. Describe what happened to the ivy leaves.
3. Where did the plants get the necessary food to reproduce?

Extension

1. When the sprouts are about 15 cm to 20 cm long, cut them just above the surface of the sweet potato, leaving green stubs. Place the shoots in another jar and add water. Continue to "harvest" sprouts until the weather turns warm. Plant the sprouts in warm soil, 1 m apart in rows spaced 3 m apart. Sandy or clay soils in full sun are best. The vines will grow until the weather turns cold, at which time the sweet potatoes can be harvested.
2. Plant the ivy in a pot that has good drainage and use potting soil. Observe how the ivy grows new leaves.

Answer Key

A Few Good Soils

1. Answers will vary.
2. Answers will vary.
3. Answers will vary. By observing the materials, students should have seen that some materials were more porous than others and/or more loosely consolidated. They should have predicted that porous materials would drain more water.

Only the Best of the Best for My Plants!

1. Answers will vary, but the "best" soil should have been the potting soil because it contained the necessary nutrients needed for growth, drained properly, and also allowed moisture to be retained.
2. In an experiment, only one variable should be manipulated. If you gave the plants different amounts of water, you could not determine whether it was the soil or the water that caused the differences in plant growth.

Flower Power

1. Answers will vary but should include that wind, animals, and insects usually disperse pollen. These ways are not always reliable; therefore, the more pollen grains produced, the greater the chance they will land on or be transferred to another plant for fertilization.
2. Multiple pistils help increase the chances that fertilization will occur.
3. Answers will vary.
4. Answers will vary.
5. Answers might include that wind, animals, and insects transfer pollen from the stamen to the pistil.
6. Not all flowers have both a stamen and a pistil. A perfect flower has both. An imperfect flower has one or the other.

On the Seedy Side of Life

1. Answers will vary. Students should notice that as dicot seeds sprout, the root section grows downward, while the shoot section (cotyledons) grows upward and forms a loop as it unfurls. The seed coat falls away and leaves develop from the cotyledons. With the monocot seed, the root section grew downward, while the shoot section grew straight up and formed leaves. The cotyledon (endosperm) remained underground.
2. No, not all plants produce seeds. Answers will vary but should include that plants can reproduce by spores and vegetative reproduction.

Flowers in Bloom

1. Monocots and dicots are similar because they both have petals, sepals, stamens, and a pistil.
2. If you count the number of petals, stamens, or other floral parts, you will find that monocot flowers tend to have a number of parts divisible by three—usually three or six. Dicot flowers on the other hand, tend to have parts in multiples of four or five (four, five, ten, and so on).

Gone With the Wind

1. Answers will vary, but should include that if an animal eats the fruit, the seed will be dispersed away from the parent plant because animals travel around and do not stay in one spot. Disadvantages may include that the animal may "drop" the seed in an area that is not conducive for the plant to survive (i.e., on a rocky surface).
2. No, all dispersed seeds do not grow into plants. Some seeds may land in areas that do not support their growth.
3. One advantage with wind dispersal is that plants can disperse over large areas. However, one disadvantage is that lots of seeds land in unsuitable spots. Plants compensate for this disadvantage by producing large numbers of seeds, so the odds are that some will land in good areas.
4. The main way that a coconut seed is dispersed is by water. The coconut can float in the ocean for thousands of miles to populate new areas. It also falls from the tree, can roll in a heavy wind, or be carried off by animals.

Taking Root

1. Answers will vary depending on the conditions and growth that occurred. The sweet potato should begin to grow roots and leaves.
2. The ivy should have begun to grow roots.
3. The food that was used was stored in the root (sweet potato) and in the stem and leaves of the ivy.

The NASA SCI Files™
The Case of the
Prize-Winning Plants

Segment 4

After learning all about their plant's basic needs, the tree house detectives are still not sure that they can successfully grow a prize-winning pineapple plant. Kali sets off to visit Mr. Mark Takemoto at the Dole Pineapple Plantation on the island of Oahu to learn more about the pineapple plant. Back at the tree house, Jacob's plants are not doing so well. He is frustrated because he has been giving his plants extra "attention" and just doesn't know what went wrong. Bianca thinks she can help when she comes across research being conducted at NASA Kennedy Space Center on genetic markers. She contacts Dr. Anna-Lisa Paul to learn more about smart plants and how they might help scientists grow plants on Mars someday. After a wrap-up with Dr. D, the tree house detectives are ready to begin growing their prize-winning plant, but soon discover that the "prize" is not exactly what Tony had thought it was!

Objectives

The students will

- learn how pineapple plants are planted and grown.
- understand how genes are bioengineered.
- learn to use a Punnett square to calculate probability of genotypes.

Vocabulary

allele—an alternate form that a gene may have for a single trait; it can be dominant or recessive

bioengineering—the use of engineering principles and techniques to solve problems in medicine and biology

crown—the top portion of the pineapple fruit used for propagation

genotype—an organism's genetic makeup

heterozygous—an organism with two different alleles for a trait

homozygous—an organism with two alleles that are the same for a trait

Punnett square—a tool that predicts the probability of certain traits in offspring and shows the different ways alleles can combine

reporter genes—bioengineered genes that are part plant and part glowing jellyfish. These genes might help scientists someday grow plants on Mars and other planets.

Video Component

Implementation Stratey

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Prize-Winning Plants*, discuss the previous segment to review the problem and discover what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site, select Educators, and click on the Tools section. The Problem Board can also be found in the Problem-Solving Tools section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 3.
5. Read the overview for Segment 4 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to help them answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of Prize-Winning Plants* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. At the end of Segment 4, lead students in a discussion of the Focus Questions for Segment 4.
2. Have students discuss and reflect upon the process that the tree house detectives used to determine how to grow a prize-winning pineapple plant. The following instructional tools located in the Educators area of the web site may aid in the discussion: Experimental Inquiry Process Flowchart and/or Scientific Method Flowchart.
3. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
4. Wrap up the featured online PBL investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Sample evaluation tools can be found in the Educators area of the web site under the main menu topic Tools by clicking on Instructional Tools.
5. Have students write in their journals what they have learned about the basic needs of plants and how to grow healthy plants so that they can share their entry with a partner or the class.

Careers

floriculturist
geneticist
bioengineer

Resources

Books

Balkwill, Frances R. and Mic Rolph: *Gene Machines.* Cold Spring Harbor Laboratory Press, 2002, ISBN: 0879696117.

Balkwill, Frances R. and Mic Rolph: *Have a Nice DNA.* Cold Spring Harbor Laboratory Press, 2002, ISBN: 0879696109.

Hershey, Rebecca: *Ready, Set, Grow!: A Kid's Guide to Gardening*. Goodyear Publishing Company, 1995, ISBN: 067336139X.

Dorling-Kindersley: *Hawaii (Eyewitness Travel Guides)*. DK Publishing, 2003, ISBN: 0789497328.

Osborne, Mary Pope: *High Tide in Hawaii.* Random House Books for Young Readers, 2003, ISBN: 0375806164.

Web Sites

Dole Pineapple Plantation
Visit this web site to take a virtual tour of the gardens and be sure to check out the "Fun Facts" section to learn about the pineapple's history, how to select a pineapple, and even how to cut one!
http://www.dole-plantation.com/

NASA Thursday's Classroom—Jelly Plants on Mars
Read an article on how scientists are creating a new breed of glowing plants—part mustard and part jellyfish—to help humans explore Mars. There is also an accompanying lesson guide, discussion questions, and other web links.
http://science.nasa.gov/headlines/y2001/ast01jun_1.htm

University of Florida—Genetically Modified Earth Plants Will Grow From Mars
Read how NASA and scientists from the University of Florida hope to send genetically modified tiny plants (smart plants) into space to send reports back from Mars in a most unworldly way: by emitting an eerie, fluorescent glow.
http://news.ifas.ufl.edu/print/2001/01_0426.html

GlaxoSmithKline-Kids' Genetics
Professor U. Gene (animated character) helps students use interactive games and activities to learn about DNA, RNA, dominant and recessive genes, traits, interesting facts, and much more.
http://www.genetics.gsk.com/kids/index_kids.htm

Activities and Worksheets

In the Guide

On the Web

An Ode to a Plant

Learn to write a cinquain with plants as the topic.

Planting Pineapples

Purpose

To grow a pineapple in a pot from a pineapple crown

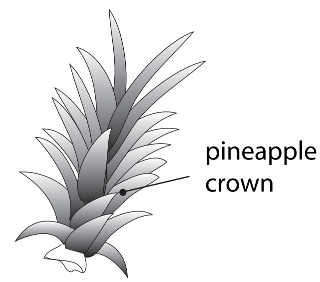
Materials

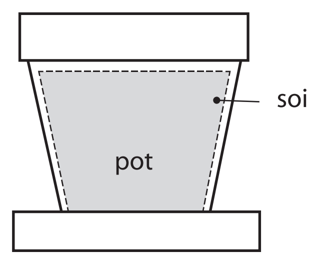
fresh pineapple
6-in. to 8- in. pot
potting soil with good drainage
science journal
water

Procedure

1. With the help of an adult, hold a pineapple in one hand, grab hold of the entire top set of leaves (crown) with the other hand, and twist hard.
2. To dry the crown, place it in a warm, dry area for about 5 days. Drying the crown helps seal off any excess openings for disease and decay.
3. Remove about 15–20 of the lower leaves by pulling them downward. They will come off in a spiral fashion. If there are any roots growing next to the stalk, do not damage them.
4. Plant the stem end of the crown into the potting soil about 5 cm deep.
5. Place the pot in a warm area that receives good indirect light.
6. Water thoroughly and keep moist but not "wet" for 3–4 weeks.
7. Once the roots begin to grow, water the plant just once or twice a week, letting the soil dry a little between watering.
8. In about 3 months, repot the plant into a larger container (1-gal nursery pot) and move it to a warm area that receives at least 6 hours or more of direct sunlight.
9. Continue to water, making sure that the soil is never dry but also not soggy.
10. Be sure to keep the plant in a warm area and bring it indoors during the winter months if the temperature gets cold.
11. After a year of growth, repot the plant into a final 5-gal container.

NOTE: The following year, the plant should develop a large stalk above the foliage, and the stalk will take on a red tinge. The top will swell with many small sections and a light blue flower will emerge from each. The flowers will only last for 1 day, so enjoy them! After the flowers have opened and closed, it will take about 3–4 months for the fruit to mature and ripen. Keep the plant well watered.





A Glowing Report

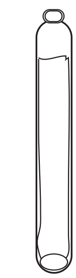
Problem

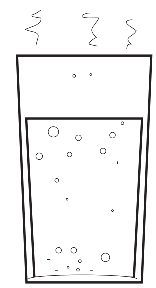
To demonstrate how bioengineered reporter genes help plants report stressful conditions

Materials

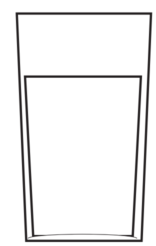
freezer
3 clear glasses
ice cubes
3 light sticks
water
hot water
science journal

light stick

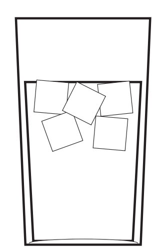




hot water



temperate water



ice water

Background

Learning how to grow plants on Mars will be an important precursor to humans living there. Future explorers will need oxygen, food, and purified water. Plants can help provide these essentials inexpensively; therefore, scientists are creating a new breed of glowing plants by adding reporter genes that are part plant and part glowing jellyfish. Just like humans, plants must learn how to adapt to any new environment. On Mars, plants will encounter conditions such as extreme temperatures, low air pressure, exposure to harsh ultraviolet light, and inadequate soil that will make it difficult for plants to grow. Plants that have reporter genes can send messages back to Earth about how they are faring. The plants will be genetically wired to glow a soft green aura when they encounter problems such as low water or low oxygen levels. The plants' designer genes consist of two parts: a sensor side to detect stress and a reporter side to trigger the glow. Thriving plants won't glow at all; they will look like normal plants, but plants struggling to survive will emit a soft, green light that gives researchers a signal that something is amiss.
To read more about jellyplants on Mars visit
http://science.nasa.gov/headlines/y2001/ast01jun_1.htm

Procedure

1. Follow the directions on the light stick package to start them glowing.
2. Observe how brightly they glow and record your observations in your science journal.
3. Place all three light sticks in the freezer.
4. Keep the light sticks in the freezer until they freeze (about 30 minutes).
5. Fill one glass about 3/4 full with cold water and add ice cubes. Stir until the water is very cold.
6. Fill the second glass with room temperature water.
7. With the help of an adult, fill the third glass with hot water.
8. Take one of the frozen light sticks out of the freezer and observe it. Record your observations in your science journal. Is the light stick "glowing?"
9. Place the frozen light stick in the glass of hot water.
10. Observe and record your observations.
11. Take a second light stick out of the freezer. Observe and record.
12. Place it in the glass with room temperature water.
13. Observe and record your observations.
14. Take the final light stick out of the freezer. Observe and record.
15. Place it in the glass with ice water. Observe and record.

Conclusion

1. Describe what happened to each light stick and why.
2. How will reporter genes help scientists grow plants on Mars?
3. Would reporter genes benefit plants grown on Earth?

The Teenage Mutant–Corn?

Problem

To demonstrate dominant and recessive traits by using peach-albino corn seeds

Materials

freezer
3 clear glasses
ice cubes
3 light sticks
water
hot water

Teacher Note

Before conducting this experiment, it may be helpful to use the "Predicting with a Punnett Square" activity found on the NASA SCI Files™ web site http://scifiles.larc.nasa.gov to help students better understand traits and how they occur.

Teacher Prep

Peach-albino seeds can be obtained free of charge from the Maize Genetics Cooperation Stock Center. Use the link in the right green bar labeled "Order this stock" and fill out the form generated when you click the blue "submit this order to the stock center" link on the page that pops up.
http://www.maizegdb.org/cgi-bin/displaystockrecord.cgi?id=498225

Background

Just like all living organisms, corn plants have genes that control their form and function. One type of gene in corn plants controls plant color. The "green gene" (dominant) makes the plant green and the "white gene" (recessive) makes the plant white. Because plants need to be green for photosynthesis to occur, the white gene is considered a mutation. A mutation is any change in a gene or chromosome of a cell that can be beneficial, harmful, or even have little effect on an organism. Mutations are mistakes made when the DNA is not copied exactly or is damaged by environmental factors such as chemicals or radiation.

Procedure

1. Place 20 green beads and 20 white beads in a small bag. The beads represent the green and white genes of corn plants.
2. Using what you have learned about genes, predict how many green plants will occur and how many white plants will occur. Record your prediction below.
3. Without looking and one at a time, take two beads out of the bag and record the color combination in the Data Chart (page 72). Use "G" for green bead and "W" for white bead.
4. Place the beads in the second bag.
5. Repeat step 3, continuing to take out two beads at a time until all beads are gone from the first bag.
6. Look at your Data Chart and determine which color plant occurred each time you withdrew two beads from the bag. In the bottom row of the Data Chart, record the plant color. Remember that green is dominant, white is recessive, and there must be two white beads to make a white plant.
7. Determine how many green plants and how many white plants occurred and record the ratio in "Actual."
8. Compile your data with other groups' data and create a class chart.

The Teenage Mutant–Corn? (concluded)

TRIALS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Plant Color																				

9. Calculate the average number of green plants that occurred.
10. Calculate the average number of white plants that occurred.
11. Using the data from this experiment, predict how many green and white plants will grow when the peach-albino seeds are planted. Record in your science journal.
12. In a large pot or flat with potting soil, plant 20 kernels of the peach-albino seeds.
13. Water thoroughly and place the newly planted seeds in a sunny area.
14. Observe them each day and record your observations in your science journal.
15. When the plants begin to sprout, count the number of green plants and the number of white plants and record the results in your science journal.
16. Continue to water the plants as needed and observe for several more weeks.

Conclusion

1. Did the actual number of green and white plants match your predictions?
2. What happened to the green plants after several weeks? Why?
3. What happened to the white plants after several weeks? Why?

Too Much of a Good Thing

Materials

Elodea or other aquatic plants
lawn fertilizer or plant food
marker or grease pencil
measuring spoons
pond water
2 large, wide-mouthed jars

Purpose

To understand how fertilizer can affect the balance of aquatic ecosystems

Background

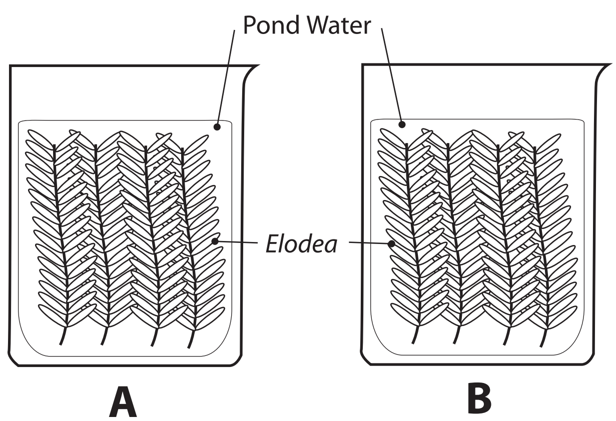
Lawn fertilizer is a combination of nitrogen, phosphorus, and potassium. These nutrients are important to plant growth and they are also commonly found in sewage. By adding fertilizer to plants, plants receive the nutrients that they need to grow bigger, better, and faster than plants without fertilizer in the same area.

Procedure

1. Using a marker, label the jars "A" and "B."
2. Fill each jar 3/4 full with pond water.
3. Place 3–4 Elodea plants in each jar.
4. Add 2–4 mL of lawn fertilizer to jar "B." NOTE: The amount of fertilizer will vary depending on brand.
5. Place both jars in a well-lighted area.
6. Observe the two jars and record your observations in your science journal.
7. Predict what will happen to each jar over the next 3 weeks and record your predictions.
8. Observe and record your observations each day for three weeks.

Conclusion

1. How did the two jars compare at the end of the three weeks?
2. How did your results compare to your predictions?
3. What effect did the fertilizer have on the Elodea?



Putting a Little Light on the Subject

Problem

To make a low-cost light chamber for plants

Teacher Note

Adult supervision is required while making and operating the plant lighthouse.

Materials

aluminum foil (heavy duty)
3/4-in. clear tape
compass
1 empty copy-paper box
electrical cord with socket
glue stick
marker
metric ruler
7–9 in. plastic plate
scissors
science journal
30-W fluorescent circle light or
39-W GE® circle light

Procedure

1. Using a ruler, find the center of the plastic plate.
2. With a marker, make a small dot at the center.
3. Using a compass, draw a 2.5-cm diameter circle around the dot.
4. Use scissors to cut out the circle.
5. Trim off the outer edges of the plate to make a 10- to 13-cm disk. See diagram 1.
6. Turn the box on one end and find and mark the center of the end on top.
7. Use a compass to draw a 2.5-cm diameter circle around the center and cut it out. See diagram 2.
8. Cut several 4-cm x 14-cm ventilation slots in the top, upper sides, and back of box. See diagram 3.
9. Use a ruler to find the dimensions of the four sides of the box. Record your measurements in your science journal.
10. Using the dimensions, measure and cut aluminum foil to cover the inside of the box.
11. Apply glue with a glue stick to each inner surface and paste the aluminum foil to cover the entire surface.
12. Use clear tape to reinforce the corners and edges.
13. Cut the aluminum foil away from the ventilation holes.
14. Place the plastic disc on top of the box so that the holes align.
15. From the inside of the box, insert the light fixture through both holes. See diagram 4.
16. Secure the fixture by attaching the socket.
17. Using several sheets of aluminum foil taped together, make a "curtain" to hang over the open side of the box.
18. Tape the curtain to the top edge. See diagram 5.
19. Tape or clip paper clips or small weights to the bottom of the curtain so that it hangs straight down.
20. Have an adult plug the lighthouse in, and it is ready for your plants. CAUTION: Always have an adult present when taking plants in or out of the plant lighthouse and never unplug or plug in the lighthouse by yourself.

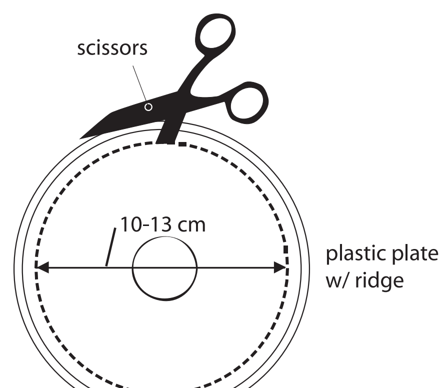


Diagram 1

Putting a Little Light on the Subject (concluded)

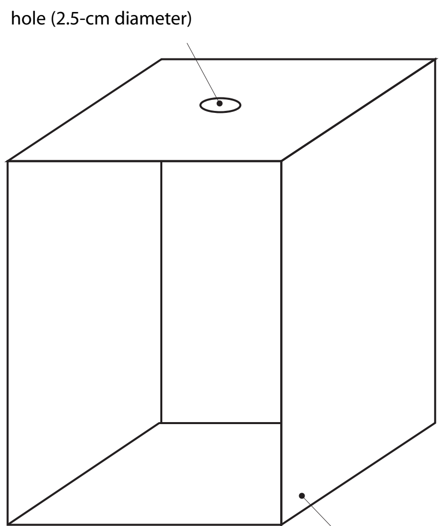


Diagram 2

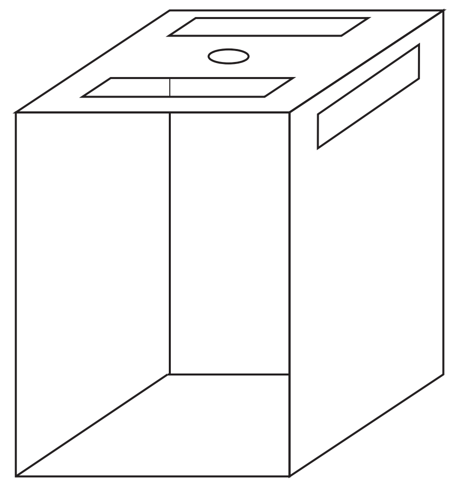


Diagram 3

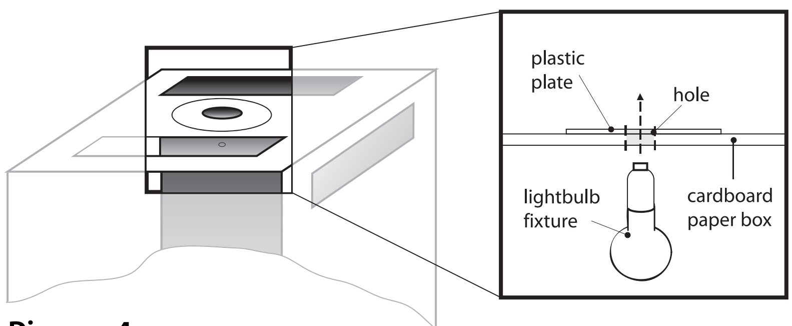


Diagram 4

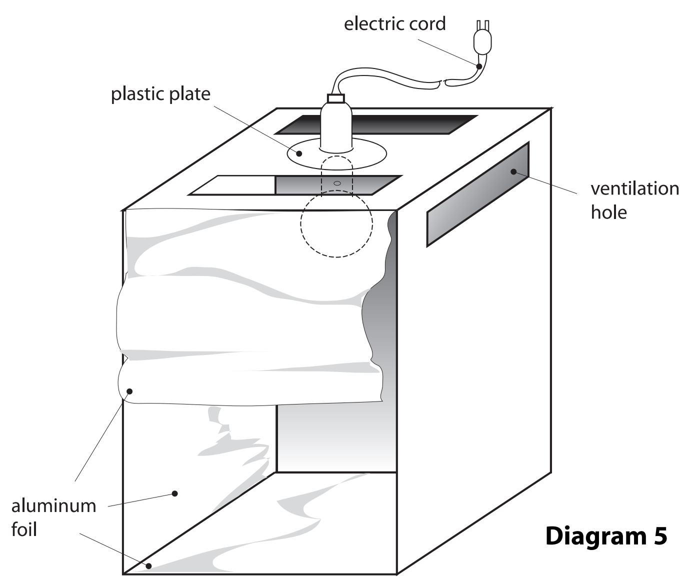
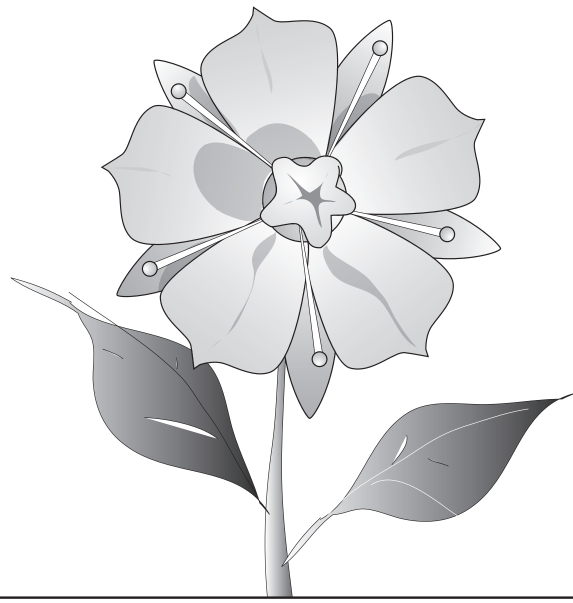


Diagram 5

Digging Up Roots



A B I B E N G I N E E R Y I R P V B I C I I

W H O E G S N E S E N B G R A T R O P E R N

C A R E S P I R E T E P N I I D A E A R G G

T E P U C W E A T H E R D N G T R R H I E E

F I R R F R E P R O D U C E O O P C P H

L E I E A E E H E R G N P P D E E S I I

I T R P S B W E T I P K I N G T O M E V

L S P Z E U P C L I A S M A R T F I

N I I I L D L A I N D N R R C T I A

F N P G I A A S Z O I E V G O U R A

O E A I T E N T S D N G P E D N D I

N T S R Y T O R T O R Y N Y A I

S I T E T F E S Z I E W T P L L

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F N E R L G G S E C I B U A A T

A K A T I I T L U N T B I E

M L S E E Z E L I S R I R Y

G A E M O H E O B T A W P F

A B U N N C N P U N Y N I K

D O C V A S C U L A R O R L

Planting Seeds

Use the words below to create your own crossword puzzle.

Vocabulary

rain forest
adaptations
bromeliad
carbon dioxide
stomata
pollen
stamen
fertilizer
spectrum
sepals
kingdom
chlorophyll
vascular
photosynthesis
spectrum
seed
pistil
pineapple
petals
flower

Add your own:

____
____
____
____

Across

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

Down

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

Answer Key

Too Much of a Good Thing

1. Answers will vary, but the jar with the fertilizer should have grown bigger than the jar without fertilizer.
2. Answers will vary.
3. The fertilizer caused the Elodea to grow larger and faster than the plant that did not receive fertilizer.

A Glowing Report

1. The first light stick began to glow brightly in only a few seconds because the hot water defrosted the liquid and activated the chemicals to glow. The second light stick began to glow, but it took a little longer (about 10 seconds). The third light stick eventually began to glow, but not very brightly because the cold water delayed the activation of the chemicals in the light stick.
2. Answers will vary. By genetically engineering plants grown on Mars to report their condition to scientists on Earth, we will be able to discover the difficulties of growing plants before we send humans there. Food, water, and oxygen are all essential for human life to exist on Mars. These vital staples for survival would cost a fortune to "ship" to Mars in the large quantities needed. By learning how to successfully grow plants on Mars, we will lay the groundwork for a bioregenerative system that would provide the essentials to support human life.
3. Answers will vary, but reporter genes should be helpful when growing plants on Earth. By having an early indication of stressors such as low water, not enough light, and so on, the problem could be corrected before the plant died.

The Teenage-Mutant Corn?

1. Answers will vary.
2. If conditions are right, the green plants should continue to grow and develop into healthy young plants because all their basic needs are met (light, air, water, and the ability for photosynthesis).
3. The white plants will eventually die because they will use up the food reserves in their seed and they are not able to make any new food (photosynthesis).

Digging Up Roots