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4-H Plant , Soils, and Entomology Curriculum

Exploring the World of Plants and Soils

Project Book 3

Sprouting Out and Growing Up

Virginia Cooperative Extension
Virginia Tech • Virginia State University

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Sprouting Out and Growing Up

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Behme, R.L. (1992). *Incredible Plants: Oddities, Curiosities, and Eccentricities*. Sterling Publishing Co., Inc. New York, N.Y.

Exploring the World of Plants and Soils: 4-H Plant and Soil Science Project Series. National 4-H Council , Chevy Chase, Md.

Stern, L.R. (2000). *Introductory Plant Biology. McGraw Hill*: Boston, Mass.

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Sprouting Out and Growing Up

Note to Project Helpers

Sprouting Out and Growing Up is the second Project Book in the Exploring the World of Plants and Soils series. This Project Book looks at environmental and internal factors that affect plant growth. It is written to interest youth aged 12 to 14.

The *Exploring the World of Plants and Soils* Project Books include:

It's More Than Just Dirt

Stems and Stamens

Sprouting Out and Growing Up

Exploring the World of Plants and Soils Project Goals

The objectives of this series are to give young people the opportunity to:

- Learn basic facts about plants and soils including plant growth factors, plant reproduction, plant characteristics, how people utilize plants, and the function and characteristics of soil.
- Gain knowledge about plants and soils through experimentation and exploration.
- Stimulate an interest in gardening, plants, soils, and the natural world.
- Appreciate human accountability towards responsible earth stewardship and environmental decision making.
- Relate to life cycles and other cycles found in nature.

Project Helper's Role

For youth to gain the most from this learning experience you should:

- Review the **Sprouting Out and Growing Up** Project Book.
- Support the youth as he or she sets goals and completes each activity.
- Play a proactive role in selecting activities, assisting in activity completion, and answering questions.
- Help the young person to think about what s/he is experiencing and learning through active listening and open-ended questioning.
- Encourage the youth to keep a Project Journal to document activity record-keeping requirements, answer activity questions, and record personal thoughts and ideas.
- Serve as a resource person to help connect the young person to the community, resource materials, and others knowledgeable about plants and soil.

These experiences can be fun and educational for both you and the young person who takes on this challenge. You don't have to be an authority on plant and soil science to be a leader in this project, but you do need the enthusiasm and desire to help the youth learn and grow as s/he explores the world of plants and soils.

What's Inside

As you participate in the *Sprouting Out and Growing Up* project activities you will have many interesting and exciting experiences learning about plants and the many internal and external factors that affect their growth.

Here is a look at the various sections found in each activity:

Skills: The 4-H life and science process skills practiced as you do the activity. You will also have many opportunities to share what you learned with others.

Educational Standards: The Virginia Standards of Learning (SOL) for life sciences (LS), mathematics (Math), and language arts (LA) and the National Science Standards (grades 5 to 8) addressed by the activity.

Achievement Check: The skill you should learn by finishing this activity. Keep working on the activity until you have mastered each skill.

Materials: The supplies and equipment needed for each activity.

Let's Investigate: The exploration or experiment you carry out to learn about plants and soil.

The following information is found in each activity:

Considering Plants and Soil

Considering Plants and Soil: Questions you answer and discuss with your helper that are related to what you have learned about plant parts, plant life cycles, and plant reproduction.

Diggin' In

Diggin' In: The information needed to help you complete the activity.

Branching Out

Branching Out: Additional activities to help you utilize and understand what you learned in the activity.

Cool Connections

Cool Connections: Interesting facts about plants and soil.

Word Power

Word Power: New words to learn and use. New words are found in bold print in the activities. Definitions are found in the glossary at the end of this book.

Project Guidelines

To complete the *Stems and Stamens* project you must:

- Select a 4-H Project Helper
- Complete a minimum of four Required Activities and four Optional Activities in the *Stems and Stamens* Project Book
- Participate in a minimum of two Leadership Experiences
- Participate in a minimum of one Service Learning activity
- Keep a Project Journal

4-H Project Helper

Select an adult project helper to support and assist you with these activities. This person may be a parent, family member, 4-H project leader, teacher, neighbor, or friend. The choice is yours. As you do the activities, discuss the activity process and your conclusions with your helper. Ask your helper to assist you throughout this project. Your helper can assist you as you set your project goals, discuss activity questions with you, and help you locate resources.

Name _____ Phone _____ Email _____

Project Activities

Carry out at least four Required Activities located under Let's Investigate. Ask your helper to date and initial this log as you complete the activities.

Required Activity	Date Completed	Helper's Initials	Required Activity	Date Completed	Helper's Initials
Building Strong Plants	_____	_____	**Rooting Revelry**	_____	_____
You Are My Sunshine!	_____	_____	**How Low Can You Go?**	_____	_____
Looking for Light	_____	_____	**Concerning Cotyledons**	_____	_____
Total Transpiration	_____	_____	**Growing Roots in the Air**	_____	_____
Airing Our Differences	_____	_____	**Old Seed, New Seed**	_____	_____
Plants in Battle	_____	_____	**How Do They Do It?**	_____	_____

Optional Activities

Carry our at least four Optional Activities located under Branching Out and list them here.

	Date Completed	Helper's Initials
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Leadership Experiences

Select and participate in at least two of these leadership experiences or devise one of your own. A leadership experience requires the organization of and the participation in an event, presentation, or tour.

Leadership Experience	Date Completed	Helper's Initials
Give a demonstration on plant growth needs	_____	_____
Teach someone something about plant adaptations	_____	_____
Plan a tour of a greenhouse	_____	_____
Attend a gardening demonstration	_____	_____
Give a speech on a plant subject	_____	_____
Exhibit a plant project	_____	_____
Give a seed planting demonstration	_____	_____
Teach someone something about plant tropisms	_____	_____
Other Learning Experiences:		
_____	_____	_____
_____	_____	_____
_____	_____	_____

Service Learning Experience

Select and participate in at least one of these service learning experiences or devise one of your own. A service learning experience requires that you do something for someone in your community.

	Date Completed	Helper's Initials
Plant something to improve the environment	_____	_____
Share something you have grown with someone	_____	_____
Plant a vegetable garden and share the produce with a food bank, neighbor, or family	_____	_____
Gather flowers to share with an elderly person	_____	_____
Other Service Learning Experiences:		
_____	_____	_____
_____	_____	_____
_____	_____	_____

Project Journal

Keep a Project Journal to document activity record-keeping requirements, answer activity questions, and record personal thoughts and ideas.

Activity 1. Building Strong Plants

Have you ever thought about how you use plants in your everyday life? Did you know that the air you breathe is recycled through plants, and many of the clothes you wear are made from plant fibers? Or, that the food you eat comes from plants, and items such as medicines, luxury items, beverages, and fuel come from plants? We are dependent on plants for our continued existence on earth; therefore, it is important for us to care for and understand the plants in our world.

Activity: Demonstrate the importance of soil nutrients in healthy plant growth

Life Skill: Acquiring and Evaluating Information – Create data gathering processes

Science Process Skill: Experimenting and controlling variables

Achievement Check: Explain a plant's need for soil nutrients

Virginia SOL: LS.4a and c; LA 6.2, 7.1

National Science Standard: All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

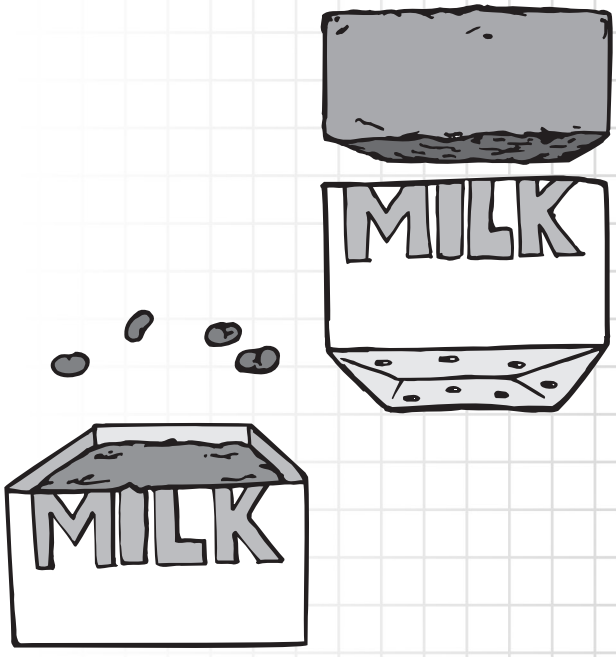
Materials: two milk cartons or two 6-inch pots, **soilless potting mix**, bean seeds, masking tape, marker, liquid fertilizer

Let's Investigate

Plants Need Soil Nutrients

Many things in nature help or hinder plant growth. These factors include such things as the type of soil present, air quality, water quality and availability, climate, temperature, and the availability of light. These environmental factors are components of every plant's habitat or environment. Environmental factors affect the growth and health of a plant through every stage of its life.

One important environmental factor that affects plant growth and reproduction is the presence and availability of soil **nutrients**. Soil nutrients are used by plants as components of plant cells and life processes. Every soil type differs in its ability to provide the nutrients plants need (refer to the **It's More Than Just Dirt** Project Book). This activity demonstrates plants' need for soil nutrients.



1. Cut off the bottom three inches of two milk cartons or use two 6-inch pots. Punch holes in the bottoms of the milk cartons for water drainage.
2. Fill the cartons with soilless potting mix (most potting mixes contain very few plant nutrients).
3. Plant four bean seeds 1 inch deep in each carton.

4. Using the masking tape and marker, label one container "No Nutrients" and the other container "Nutrients."

5. Water thoroughly and place in a sunny windowsill. Water when necessary.

6. When the growing bean plants have put on their first set of **true leaves** feed the container labeled "Nutrients" with a liquid fertilizer according to the package directions. Continue to feed and water these plants as directed for four weeks.

7. Do not feed the plants with "No Nutrients" step, but continue to water them when necessary for four weeks.

8. Make a prediction as to how these plants will grow under the different fertilizer treatments. Record your prediction in your journal.

9. Measure and record the growth of your plants every week. Describe the color, stem strength, and overall health of the plants as they mature.

10. Compare your observations and results with your prediction. What were the differences in plant height? Stem strength? Green color? Overall health? Why do you think the application of soil nutrients improved plant health? Share what your learned about plant nutrients with your helper.

Diggin' In

Soil Nutrients

Most plants need fifteen (15) elements from the soil to sustain growth. The elements used in large amounts are nitrogen, potassium, calcium, phosphorus, magnesium, and sulfur. The nutrients used in very small amounts are iron, sodium, chlorine, copper, manganese, cobalt, zinc, molybdenum, and boron. Plants need soil nutrients to grow and function properly. Nutrients are used in the structure of plant **cells** and play a part in life processes such as photosynthesis, reproduction, and growth. Gardeners and farmers realize that a **fertile soil** is needed for healthy plant growth. They often add and replenish soil nutrients in the form of **fertilizers**, **manure**, and **compost**.

Considering Plants and Soil

Let's Talk

What function did the bean plants' roots perform in this activity?

Why are healthy plant roots crucial to healthy plant growth?

Let's Reflect

How are the vitamins that people take similar to the nutrients plants need?

Fertilizer is often called "plant food." Is fertilizer plant food, or is the sugar produced by photosynthesis the plant's food? Why or why not?

Let's Use It

Where do people and animals obtain the nutrients they need for healthy growth?

How are the nutrients you use for healthy living related to the availability of soil nutrients?

Branching Out

1. Find out how plants that do not live in soil, such as bromeliads and orchids, obtain their nutrients. Start a portfolio of "Unusual Plants" by drawing pictures of these plants. Label each picture with the plant's name and a paragraph describing its unusual growing requirements. Share your portfolio with your helper.

2. Fertilizers are described by three numbers such as 10-10-10 or 20-5-5. These numbers tell the nitrogen-phosphorus-potassium content of the fertilizer. A 10-10-10 fertilizer contains 10% Nitrogen, 10% Phosphorus, and 10% Potassium. Find out why these three nutrients are so important to plant growth. Share what you learned with your group or helper.

Cool Connections

Some bacteria and fungi growing on plant roots can actually take nitrogen from the air and share it with the plant! These are lucky plants!

Word Power

Cells	Compost	Fertile soil	Fertilizer	Manure
Nutrients	Soilless potting mix		True leaves	

Activity 2. You Are My Sunshine!

The availability of light energy is an important environmental factor that influences plant growth. Exposure to light is crucial to plant growth because light energy is the power source that drives the process of **photosynthesis**. Photosynthesis produces the sugar which plants use as their energy source for growth and reproduction. In the case of plants, light equals life!

Activity: Demonstrate how plants adapt to different light levels

Life Skill: Acquiring and Evaluating Information – Creates data gathering processes

Science Process Skill: Experimenting and controlling variables

Achievement Check: You can demonstrate a plant's need for light

Virginia SOL: LS.4a and c, LS.6; Math 6.9, 7.5; LA 6.2, 6.6, 7.1

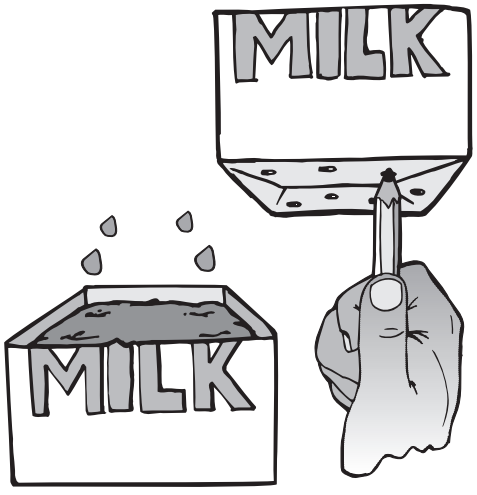
National Science Standard: For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transformed by producers into chemical energy through photosynthesis.

Materials: Three milk cartons or three 6-inch pots, soilless potting mix, labels, marker, tomato seeds, journal, pencil, ruler, graph paper, camera (optional)

Let's Investigate

Plants Need Light

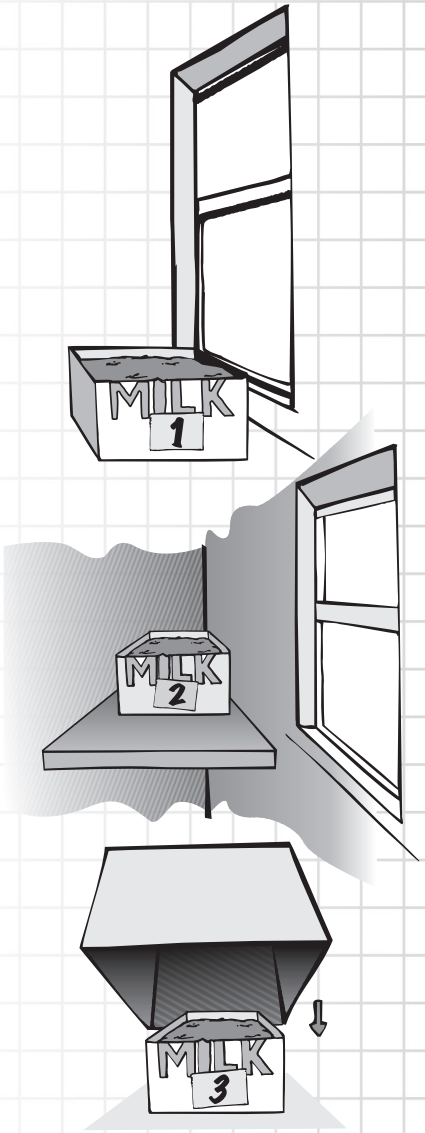
Plants have adapted to the many different light situations found around the world. For example, plants growing in shady areas produce big, flat leaves to improve their chances of catching light that filters through the forest canopy. Or, plants growing in sunny, dry areas have small, thick leaves that use the intense light but minimize water loss. Even the leaves on one plant can be different depending on where they are located on the plant. The leaves on the top of the plant where the light is strong are small and thick, and the leaves in the shady bottom of the plant are big, flat, and thin.



1. Cut off the bottom three inches of three milk cartons and cut holes in the bottom for drainage, or use three 6-inch pots. Label the containers #1, #2, and #3.
2. Fill the cartons or pots with soilless potting mix.
3. Plant four tomato seeds in each carton ¼ to ½ inch deep.
4. Add water until the water just runs out the bottom drainage holes.
5. Do the following:
   - Place container #1 near a window on the sunny side of the house

- Place container #2 near a window on the shady side of the house
- Place container #3 under a cardboard box to keep out all light.

6. Write down in your journal your predictions about how plant growth responds to different light levels for this activity.
7. Check the plants weekly, and water when necessary.
8. When the plants are two to three inches high **thin** to one strong plant. Once thinned, keep your plants for six more weeks.
9. Each week do the following for each plant and record in your journal:
   - Measure the plant height
   - Measure the area of a mature leaf or trace on graph paper
   - Describe the color of the leaves
   - If possible, take a photo
10. Record what you see happening to the appearance of the three plants. Using what you have recorded and observed, explain the effect of light on plant growth to your group or helper.
11. Compare your results to your predictions. Share what you learned about plants and light with your helper.



What you should see: You should observe that the plant in the sun grows a short, strong stem and large, dark green leaves. The plant in the shade grows a skinny, weak stem that grows toward the light, and small, light green leaves. The plant in the box grows to a very small size, and could possibly die. Plants grown in the dark lose their chlorophyll and turn a whitish color.

Diggin' In

Light

Green plants depend on light energy supplied by the sun or other sources to power the food-making process called photosynthesis. In plant cells special structures called **chloroplasts** contain a green pigment called chlorophyll. The **chlorophyll** gives plants their green color. Chlorophyll also gives plants the ability to use light energy to combine carbon dioxide from the air and water from the soil into sugar. This sugar is used as the plants' energy source for growth. Plant growth is slowed or stopped when a plant does not receive light because it stops the production of sugar, the plant's "food source."

Other living creatures also benefit from photosynthesis. A waste product of photosynthesis is the oxygen that animals and people breathe. Also, the stored sugars and starches in plants are the food energy animals and people obtain when they eat plants. A plant's ability to store light energy in sugar form is the key to the survival of life on earth.

Light can also initiate flowering (**photoperiodism**) in a plant or determine the direction of plant growth (**phototropism**).

Considering Plants and Soil

Let's Talk

Explain the connection between light availability, photosynthesis, and their effect on plant growth as observed in this activity.

Was your prediction correct? How was your prediction different from what you observed? Why do you think this occurred?

Let's Reflect

When a seed is planted underground it begins to grow without light. Where do you think the young seedling gets its food energy before its leaves push above the soil surface?

Why is it important to know if a plant has adapted to low or high light levels when planning a garden?

Let's Use It

If plants are the largest group of living things that can convert light energy into sugar energy, discuss our responsibility for maintaining a healthy environment for plant growth.

Discuss why we use plants found naturally growing under the canopy of the rainforest as "houseplants."

Branching Out

1. Go out to your garden or neighborhood. Find a minimum of three different light levels created in a natural environment. Take a close look at the plants growing in these different light levels. Take photographs of these plants and write a paragraph describing the variability of light in which they survive. Describe to your helper how the plants have adapted to maximize their exposure to light.

2. Some plants, such as dodder and mistletoe, live as parasites on other green plants. Find out more about these plants and how they have adapted to some unusual conditions. Include labeled drawings of these plants in an "Unusual Plants" portfolio. Share your portfolio with your helper.

Cool Connections

The only "plants" that can grow without light are fungi or mushrooms. These organisms use plants and animals for their food source just like animals and people.

Word Power

Chlorophyll Chloroplast Photoperiodism Photosynthesis Phototropism

Thin

Activity 3. Looking for Light

Have you ever wondered why the roots of a seed planted upside-down don't grow upward toward the soil surface? Since seeds are moved about by wind and birds, the world would look quite different if roots growing from seeds could not compensate for bad planting! A root's ability to respond to an outside environmental influence is called a **tropism**. In this case, the root responds to the force of gravity, which allows it to change direction, and grow downward through the soil.

Tropisms are plant movements made in response to changes in their environment. Plants respond to outside environmental forces to improve their chances of survival. Plants respond to such external factors as gravity, light, water, temperature, and availability of physical support. The external changes in plant growth occur due to internal chemical changes in the plant.

Activity: Demonstrate how plants move toward a light source, and to observe a plant tropism

Life Skill: Acquiring and Evaluating Information – Create a data gathering process

Science Process Skill: Predicting outcomes and analyzing results

Achievement Check: You can describe why a plant needs light to live and grow

Virginia SOL: LS.4a and c, LS.6, LS.11a; LA 6.2, 6.6, 7.1

National Science Standard: Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

Materials: two 4 to 6-inch growing containers, soilless potting mix, seeds of climbing plants, cardboard box, scissors, journal, pencil

Let's Investigate

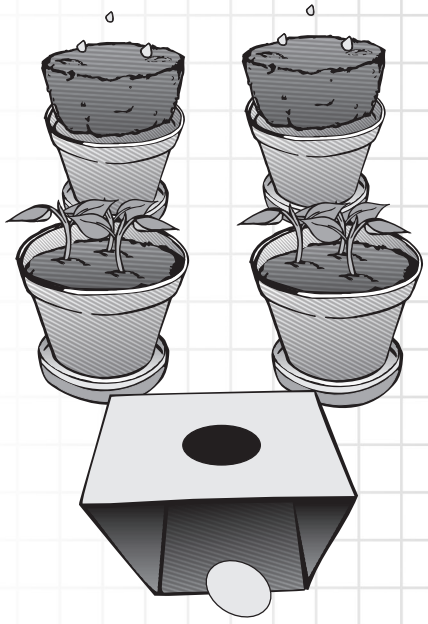
Plant Tropisms

Phototropism is a plant's ability to move or turn toward the light source (usually the sun) to improve it's exposure to light. The energy provided from light is essential for photosynthesis to occur, so a plant's ability to move toward the light improves its chances for survival.

1. Fill two 4 to 6-inch growing containers with soilless potting mix.

2. Plant three seeds of a climbing plant in each container (suggestions: runner beans, peas, or Hyacinth Bean). Water thoroughly and place in a warm, well-lighted window.

3. When the seedlings are three to four inches tall, cut a hole (a circle two inches in diameter) in one side of a box that is large enough to hold one of the containers.



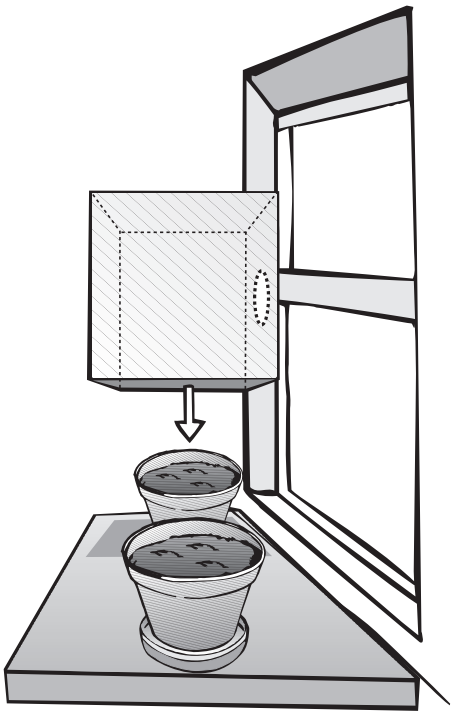
4. Place one container with three seedlings into the box. Cover the box with the lid so that light gets in only through the hole in the side of the box.

5. Place the covered box on a sunny windowsill. Make sure the hole in the box faces the window. Open the box only to water the seedlings. Make sure that the lid is put back each time.

6. Place the other container of three seedlings in the same windowsill.

7. Make a prediction on how the plants will respond to the different light levels. Write down your prediction in your journal.

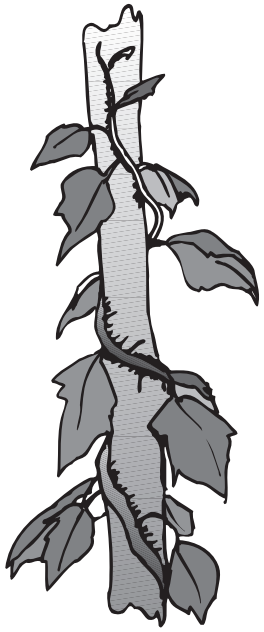
8. After two weeks, open the box and observe the seedlings. Discuss the observed differences in plant growth between the seedlings in the box and the seedlings growing in full sun on the windowsill. Write about your observations. Were your predictions correct? Discuss what you observed with your helper.



Diggin' In

Plant Tropism

A plant tropism is a plant's response to an environmental factor that benefits the plant's growth and survival. A tropism is triggered by a buildup of plant **hormones**, which are concentrated in the growing tips of stems and roots. Some plant tropisms are:



Geotropism	a stem's ability to grow upward, and a root's ability to grow downward regardless of its original position. A gravity-sensing system that orients roots, stems, and leaves in the appropriate direction.
Hydrotropism	a root's ability to grow toward water.
Phototropism	a plant stem's ability to grow towards the light
Thigmotropism	a climbing plant's ability to grow toward and around a support object.

Considering Plants and Soil

Let's Talk

How does phototropism improve a plant's chances of survival?

What advantage might a climbing plant have over a non-climbing plant in competition for light?

Let's Reflect

How do tropisms improve a plant's ability to survive in a changing environment?

What role might tropisms play in a plant's ability to compete with other plants for limited resources?

Let's Use It

What are ways that your body adapts to meet changes in environmental conditions?

Why is it important that you can adapt to changing environmental conditions?

Branching Out

1. To observe "geotropism," place two lima bean seeds on a wet paper towel. Place the paper towel and seeds in a plastic sandwich bag and lightly seal the bag. Tape the bag to a window. Watch the seeds over the next few days and wait for the root to emerge from the seed – they grow toward the earth. Now turn the bag ¼ turn. Watch as the roots turn toward the earth. Turn the bag again and watch as the roots turn again. Why is root geotropism important to plant growth? Can a gardener always guarantee that a seed is planted exactly right side up? Share your project with your helper.

2. To observe "thigmotropsim" plant the seeds of a climbing plant in a 6-inch pot filled with soilless potting mix. Put an 8-inch dowel rod in the pot next to the seedling and allow it to climb to the top of the stick. Once the plant has reached the top put a 12-inch dowel rod in the pot about four inches away from the first rod. Watch over a period of time as the climbing plant grows and circles until it grabs hold of the second rod. Share what you learned about plant growth with your helper.

3. Place plastic wrap over the soil of a well watered potted plant to keep the soil in place. Place the plant on its side near a window where it can get indirect sunlight. Record your observations of the direction of growth. Explain your findings to your helper.

Cool Connections

The word "tropism" comes from the Greek word meaning "to turn."

Word Power

Hormones Phototropism Tropism

Activity 4. Total Transpiration

As with all living things, plants need water to survive. Water transports soil nutrients through the plants "plumbing system" from the roots, through the stem, to the leaves, buds, and flowers. Water is also a crucial part of the photosynthetic process, which produces the sugars needed for plant growth. In addition, water is used to transport photosynthetic sugars to areas in the plant where they are needed. Lastly, water constitutes about 90% of a plant's weight. Think about what happens to a plant when it does not have enough water…it wilts!

Activity: Explore water and plant relationships

Life Skill: Acquiring and Evaluating Information – Obtain and interpret information

Science Process Skill: Observing and analyzing observations

Achievement Check: You can demonstrate a plant's need for water

Virginia SOL: LS.4a and c; LA 6.2, 6.6, 7.1

National Science Standard: All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Materials: two houseplants, plastic bags, string or twist-ties, three 4 to 6-inch pots, soilless potting mix, seeds (lettuce, corn or tomato), labels, marker

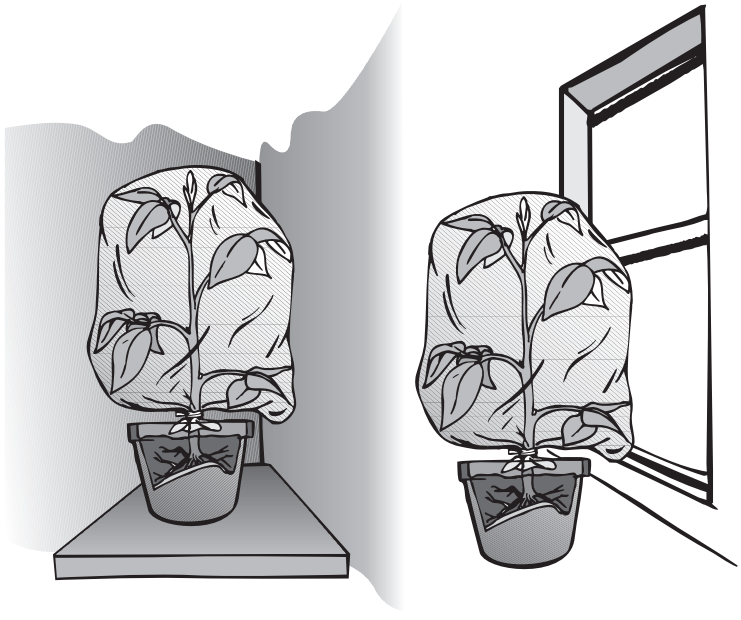
Let's Investigate

Plants Need Water

A plants loses water all of the time through a process called **transpiration**. This process helps the plant stay cool by removing heat that builds up inside of the plant. This continuous loss of water also means that the plant must continually take up water to replace the water that is lost. The following two activities demonstrate plant water loss through transpiration and plant response to differences in soil water availability.

Tracking Transpiration

1. Obtain two small houseplants in 4 to 6-inch pots.
2. Place the each plant in a clear plastic bag and seal at the base of the plant with a string or a twist-tie.
3. Place one plant in a sunny window. Place the other plant out of direct sunlight.
4. Predict which plant will transpire the most. Write down your predictions in your journal.



5. Watch the plants over a two-day period. Observe how water forms on the inside of the plastic bag and answer these questions:
   - Where did the water in the plastic bag come from?
   - Which plant formed the most water in the plastic bag? Why?
   - From where does the plant get water to replace the water lost through its leaves?
6. Compare your results with your predictions. Share what you learned about water and plant relationships with your helper.

Adventures in Watering

7. Obtain three pots with drainage holes and fill with soilless potting mix.
8. Select several seeds of lettuce, corn, or tomato.
9. Plant three lettuce, corn, or tomato seeds in each of the pots. Label the pots #1, #2, and #3. Note the day you plant the seeds.
10. Provide the following levels of water availability:
    - Water pot #1 just enough to get the plants growing and then stop watering (too little).
    - Water pot #2 just enough to keep the soil mix moist at all times (just enough).
    - Close the drainage hole and water pot #3 to keep it soaking wet all the time (too much).
11. Predict how different water levels will affect the plants. Write down your predictions.
12. Describe the response of each plant to the different levels of water availability. Note the day that any of the plants died. Explain the differences observed to your helper. Compare your results with your predictions.

Diggin' In

Water

Plants obtain most of their water from the soil through their roots. However, if there is too much water in the soil, plant roots can drown and die. Without roots, the plant wilts and dies. The opposite condition also holds true. Not enough water in the soil can also cause the plant to wilt and die.

In nature, plants have adapted to differing amounts of water availability. The amount and distribution of rainfall (water) in an area determines the type of vegetation that grows in that area. In dry deserts, cacti and tumbleweeds have adapted to low water availability. In the cold taiga, pine trees and other evergreens have adapted to the seasonal availability of water. In the rain forest, orchids and bromeliads have adapted to the continuous availability of water.

Considering Plants and Soil

Let's Talk

What was the most interesting thing you learned about transpiration?

What does it mean when a plant wilts?

Let's Reflect

To eliminate body heat and keep cool, dogs pant and people sweat. To keep warm, dogs grow thicker coats of fur and people put on jackets. Why is maintaining body temperature important to the functioning of all living creatures? How do plants maintain their temperature?

How is the rate of transpiration affected by such environmental factors as wind, heat, or low humidity?

Let's Use It

It is said that people can live weeks without food, but live only a few days without water. Why do you think this might be true?

Why is it important that we make good decisions about water purity and water pollution?

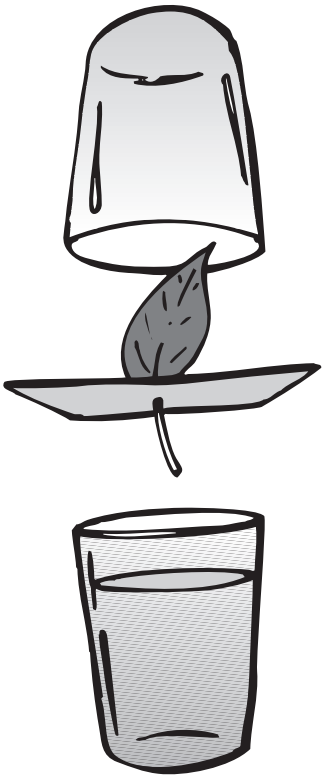
Branching Out

1. Find out about the ways that different plants have adapted to control the amount of water they lose through transpiration. Share what you discover with your helper.

2. Mulch is used in the garden to keep the soil water from evaporating. Gardeners use black plastic, newspaper, grass clippings, straw, or leaves as mulches because they recognize the importance of maintaining soil moisture to enhance plant growth. Set up an experiment in your garden that demonstrates the effectiveness of different mulching materials and their effect on plant growth. Share what you learned with your helper.

3. Select a large, light-colored celery stalk with some leaves. Cut the root end of the celery stalk off square and put one end in a glass of water dyed with food coloring. Observe the conduction of water through the stalk. Why do you think the leaves were important to the success of this experiment? Share your experiment with your helper.

4. Fill a clear glass with water. Cut a piece of cardboard to cover the top of the glass. Punch a small hole in the center of the cardboard and place over the full glass. Locate a fresh green leaf about two to three-inches long. Insert the leaf stem through the hole in the cardboard down into the water. Put an empty glass upside down over the cardboard. Set in a warm place and note when water forms in the top glass. Describe how the moisture was moved from below the cardboard to above the cardboard. Share your demonstration with your helper.



Cool Connections

Cypress trees living in bogs or swamps have adapted to growing directly in the water. Their roots grow nodules that rise above the water to absorb oxygen from the air so they do not drown.

Word Power

Transpiration

Activity 5. Airing Our Differences

Try this! Hold your breath as you slowly count to fifty. Can you do it? How long before you needed to grab a gulp of air? Probably not too long! All living things, including plants, need air to live. Plants use the **carbon dioxide** in the air for photosynthesis, and the **oxygen** found in air for other life processes. Like all other living creatures, if a plant were deprived of air, it would eventually die.

Activity: Explore the importance of air to plant life processes

Life Skill: Acquiring and Evaluating Information – Obtains and interprets information

Science Process Skill: Organizing, gathering, and analyzing data

Achievement Check: You can demonstrate a plant's need for air

Virginia SOL: LS.4a and c, LS.9d; LA 6.2, 6.6, 7.1

National Science Standard: All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Materials: grain (wheat, oats, or barley) seeds, paper towels, two similar small jars with tight fitting lids

Let's Investigate

Plants Need Air

A seed consists of a dormant young plant surrounded by a food source and a protective coat. A seed sitting in your hand does not seem to be alive because it remains **dormant** until it is exposed to water and suitable temperatures. In addition, dormant seeds need air to **germinate**. This activity shows the importance of air to the process of seed germination.

1. Obtain six to ten ounces of wheat, oat, or barley seeds.
2. Soak the seeds in water for 24 hours. Drain the water.
3. Spread seeds on paper towels to remove excess water.
4. Fill one of the jars to the top with seeds and apply the jar lid securely.
5. Fill the other jar to the top with seeds but leave the jar uncovered.
6. Predict and write down what you think will happen to the seeds.
7. Let the jars stand at room temperature (about 70 F.) for four to five days.
8. Observe and record any differences in seed germination. What is the affect of air availability on the germination of the seeds? Discuss what you learned about seed germination with your helper.
9. Compare your results with your predictions.

Diggin' In

Air

The oxygen, carbon dioxide, and nitrogen found in the atmosphere are required for plant growth. Oxygen is a basic component of plant cells, carbon dioxide is a crucial ingredient in the photosynthetic process, and nitrogen is used in making plant proteins.

Plants obtain these atmospheric elements through their roots and through leaf **stomata**. Stomata are minute pores or openings in the **epidermis** of leaves and **herbaceous** stems which regulate gas exchange and transpiration. The air flow through the stomata allows the plant to regulate its internal temperature and provides carbon dioxide for the photosynthesis.

Considering Plants and Soil

Let's Talk

How can you tell that plants need air to grow? What are the differences between animal intake of air, and plant intake of air?

If seeds need air for germination, what other plant parts need air for good health?

Let's Reflect

Think about and discuss what would happen to people and animals if all of the green plants on the earth instantly disappeared (Remember that oxygen is a waste product of photosynthesis).

Overwatering is the most common way that people kill their houseplants. Explain why overwatered plants die. What do people need to know to prevent overwatering from happening?

Let's Use It

Why would air quality be an important issue for a farmer or gardener? Why is it important that we make good decisions about air quality and air pollution?

If you were locked in an air tight plant-filled greenhouse with lots of food and water could you survive? Why or why not?

Branching Out

1. Observe and record methods by which foreign material gets into the air. Include such sources as chimneys, automobiles and airplane exhausts, factories, trains, etc. Make a list of the effects of airborne foreign material on plants. Include how dust from these sources settles on plants and decreases the intensity of the sun's rays. Discuss your list with your helper.

2. **Legumes** are a group of plants that form a **symbiotic** relationship with bacteria called *Rhizobium*. This bacteria is able to take and use nitrogen from the air. Since it lives in the roots of these plants, the plants themselves are able to access this source of nitrogen for their own growth. Find out more about this relationship and share what you learn with your helper.

Cool Connections

"Air plants" are plants that grow in the branches of trees such as Spanish moss or mistletoe. They get their food and water by sending roots into the tree limbs and taking water and nutrients from the trees. These plants are considered to be parasites, much like a leech would be a parasite on you!

Word Power

Carbon Dioxide	Dormancy	Epidermis	Germination	Herbaceous
Legumes	Nitrogen	Oxygen	Stomata	Symbiotic

Activity 6. Plants in Battle!

Plants compete with the other plants in their locality for water, sunlight, and soil nutrients. Plants with larger roots may out-compete other plants for water. Plants with big leaves or those that grow faster may out-compete other plants for light. When gardeners plant their gardens they are very careful to space the plants far enough apart so that **competition** between the plants does not harm plant health or production. Gardeners also are diligent in controlling weeds. They do not want the weeds to get all the soil nutrients, light, and water!

Activity: Demonstrate how plants compete for air, water, light, and nutrients

Life Skill: Acquiring and Evaluating Information – Create data gathering processes

Science Process Skill: Observing and interpreting observations

Achievement Check: You can describe how plants compete for resources

Virginia SOL: LS.4a and c, LS.8a, LS.9c; Math 6.9, 7.5; LA 6.2, 6.6, 7.1

National Science Standard: The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

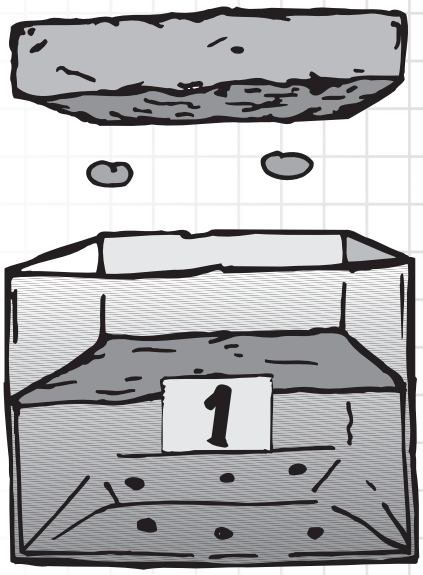
Materials: four half-gallon milk cartons or four 6-inch pots, soilless potting mix, labels, marker, corn or bean seeds, ruler, paper, pencil

Let's Investigate

Plants Compete with Each Other

Let's take a look at how plants compete with each other for water, sunlight, and soil nutrients.

1. Cut the bottom four inches from four ½-gallon milk cartons and punch several holes in the bottom for drainage, or use four 6-inch pots
2. Label the cartons #1, #2, #3, and #4. Fill the cartons with soilless potting mix up to 2 inches from the top of the container.
3. Provide the following
   - Space two corn or bean seeds on the potting mix surface in the carton labeled #1.
   - Space ten corn or bean seeds on the potting mix surface in the carton labeled #2.
   - Space 20 corn or bean seeds on the potting mix surface in the carton labeled #3.
   - Space 30 corn or bean seeds on the soil surface in the carton labeled #4.
4. Cover with one inch of potting mix.
5. Wet the mix in all of the containers and let them drain.



6. Place in a warm, well-lighted site and water when necessary to keep mix moist.
7. Measure and record the height of the plants in each container every three days and explain any differences observed.
8. Predict which set of plants will have the most developed root growth. Write down your predictions.
9. When the largest plants reach ten to thirteen inches in height remove the mix and plants from the containers and carefully remove the mix from the roots.
10. Record the kind of root growth and any differences you observe between plantings #1, #2, #3, and #4.
11. Discuss what you learned about plant growth and competition with your helper. Compare your results with your predictions.

Diggin' In

Competition From Other Plants

All plants live in communities with other plants; therefore, all plants compete with other plants for water, sunlight, and soil nutrients. When people grow plants to produce a crop, the crop plants compete with each other, and with weeds that are in the field, for these vital factors. Good weed control practices and proper plant spacing reduce plant competition and improve crop plant growth and production.

Considering Plants and Soil

Let's Talk

How do you think competition for resources affects the growth of plants in a garden?

Which natural resources do you think are the most important for healthy plant growth?

Let's Reflect

What can you do in your garden to minimize competition between the plants in your garden? Why would a weed-filled garden produce fewer vegetables than one without weeds?

What resources can you add to your garden to help meet the needs of the plants in your garden?

Let's Use It

The adults in a family need more water and food than their two-year-old child. Why? Explain how this compares with plants.

All living things compete with other living things for available resources. What do you compete for? Who do you compete with?

Branching Out

1. Try the Let's Investigate experiment again using different types of seeds such as a type of grass. How do different kinds of plants respond to overcrowding? Share the results of this experiment with your helper.

2. Plant a handful of birdseed mix in a container. After a few days the seeds begin to grow. Which plant in this seed mixture of sunflowers, millet, corn, and peanuts grows first? What advantage does a plant with quick germination have over other plants? Over time, which plant survives best, and which plants do not compete as well? Share your project with your helper.

3. Plants protect themselves in many ways. Take a walk outside and look for prickles on Canada thistles; spines on cacti; stinging hairs on nettles; teeth on the edges of hollies; thorns on roses; poisonous substances on poison ivy; disagreeable odors from gingko, etc. Give a speech to your group or family on "How Plants Protect Themselves."

Cool Connections

We think of dandelions and crabgrass as "weeds," but wouldn't a corn plant be a weed in a soybean field? Would a carrot be a weed in a row of spinach? In a natural ecosystem, are dandelions and crabgrass really weeds?

Word Power

Competition

Activity 7. Rooting Revelry

Many plant growth processes are influenced by plant **hormones**. Hormones are chemical substances produced in one part of a plant, but are transported to another part of the plant where they have specific effects on plant growth. The major types of natural hormones identified in plants are **auxins**, gibberellins, cytokinins, abscisic acid, and ethylene. Gardeners know how to manipulate these plant hormones to improve or change the growth of the plants.

Activity: Demonstrate the effects of rooting hormone on cutting root production

Life Skill: Acquiring and Evaluating Information – Obtain and interpret information

Science Process Skill: Questioning and looking for evidence

Achievement Check: You can demonstrate how rooting hormones promote the development of adventitious roots on a plant part

Virginia SOL: LS.4a and c; LA 6.2, 7.1

National Science Standard: Reproduction is a characteristic of all living systems. Some organisms reproduce asexually.

Materials: Multi-stemmed houseplant, eight small pots, soilless potting mix, scissors, rooting hormone, clear plastic bags

Let's Investigate

Plant Hormones

A common hormone used in the agriculture industry is the auxin-based rooting hormone used to improve the rooting ability of plant **cuttings**. Rooting hormones cause plant cells to multiply rapidly (**cell division**) improving the cutting's ability to quickly grow **adventitious roots**. By quickly rooting, a cutting improves its chances for survival. This activity demonstrates how hormones affect plant growth.

1. Locate a plant that can provide multiple cuttings. Some recommended plants are chrysanthemums, coleus, geraniums, ivy, and begonia.
2. Prepare eight small pots with soilless potting mix. Moisten the mix in the pots before taking the cuttings.
3. Cut eight 4 to 5-inch cuttings from the plant and remove the lower leaves from the cuttings.
4. Dip the cut end of four cuttings in a commercially prepared rooting hormone. Label these plants with the date and treatment. Do not treat the other four cuttings with rooting hormone.
5. Place each cutting in its own pot. Water the pots thoroughly and place them inside clear plastic bags to help maintain a high humidity around the cuttings. Do not place in direct sunlight.

6. Predict how much faster roots will grow from the hormone treated plants than the untreated plants. Write down your predictions.

7. After one week gently tug on the cuttings. You should be able to feel the pull of the roots that are forming on the stem. Do this every three days until you know that roots are forming. This can take two to three weeks.

8. Discuss these questions with your helper: Which cuttings rooted first? What was the difference in rooting dates between the different treatments? Was there an advantage to using the rooting hormone? How much of an advantage?

9. Compare your results with your predictions.

Diggin' In

Growth Regulators and Hormones

Plant growth regulators or hormones are substances that are produced by plants in small amounts, can move from one place to another in a plant, and can affect the process of growth. Some plant growth regulators occur naturally in plants, but gardeners have found that they can apply man-made growth regulators to plants to affect their growth. The man-made growth regulators used in the agriculture industry include weed and pest control chemicals, rooting hormones, and sprout inhibitors.

Considering Plants and Soil

Let's Talk

What was the hardest part about taking cuttings? What was the easiest? Why?

Why is it important to keep the humidity high around new cuttings? (Remember what you learned about transpiration in Activity 4)

Let's Reflect

A cutting has the same characteristics as the parent plant. Why would this be an advantage to the plant production industry?

How can you use what you have learned about taking cuttings to improve the houseplants in your home?

Let's Use It

Taking cuttings is a step-by-step process. What step-by-step processes do you do during your typical day?

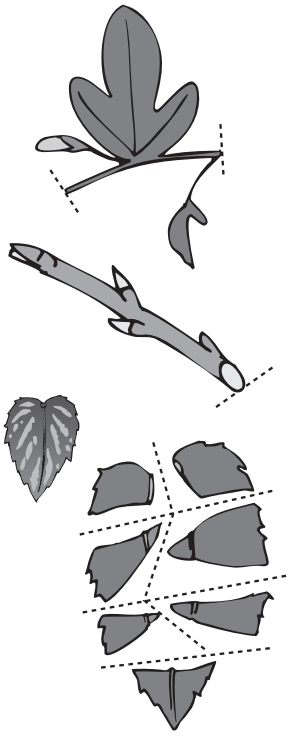
Why is it important to follow the steps of a process in order when you are making cookies or putting together a model?

Branching Out

1. Find out more about the hormones that occur naturally in plants. What growth processes do these hormones affect? How do gardeners use this information to improve the growth and production of their crops? Share what you discovered with your helper.

2. Try taking cuttings from a variety of indoor and outdoor plants. Make observations and record how long it takes for these cuttings to grow roots. Notice if plants with green stems root faster than those with woody stems. Find out why a wound is necessary to induce adventitious root production.

3. Examine several plant nursery catalogs. Record the names and uses of various chemical growth regulators, such as rooting hormones, growth inhibitors, and weed control agents. List and describe the uses of each group of regulators. Share your list with your helper.



Cool Connections

The word "auxin" comes from the Greek word "auxe" meaning "to increase." Auxins increase plant size and the number of roots….a very accurate word!

Word Power

Adventitious roots Auxins Cell division Cuttings Growth regulator

Hormones

Activity 8. How Low Can You Go?

If you look on the back of any **seed** packet you will find planting instructions. These instructions include such things as the proper time of year for planting, optimum temperatures, optimum soil conditions, and seed spacing.

In addition, information is provided on the proper seed planting depth. **Seedlings** growing from seeds planted too deep may not reach the soil surface and die. Furthermore, air and light are limited to the lower part of moist soil, which may prevent some seeds from germinating. Roots growing from seeds planted too high push the seed above the soil surface where it dries out and dies. Seedlings growing from seeds planted at the proper depth reach the soil surface while the roots hold the plant firmly in the soil.

Activity: Demonstrate the importance of seed planting depth to successful seed germination

Life Skill: Acquiring and Evaluating Information – Obtain and interpret information

Science Process Skill: Experimentation and controlling variables

Achievement Check: You can describe how planting depth affects seed growth

Virginia SOL: LS.4a and c; LA 6.2, 7.1

National Science Standard: Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

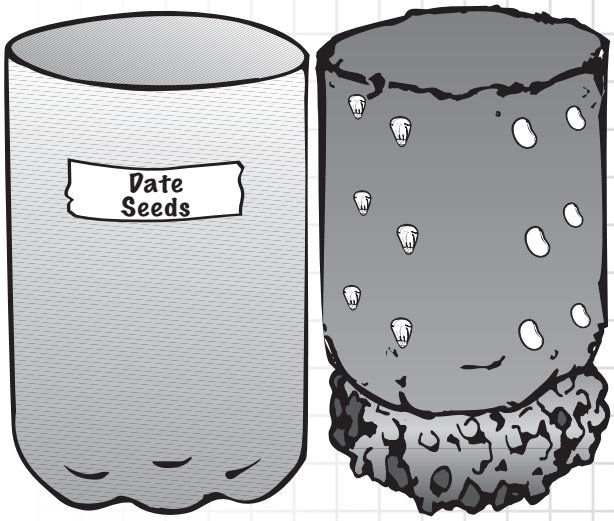
Materials: four 2-liter soda bottles, gravel, soilless potting mix, large and small seeds, masking tape, black marker, construction paper, scissors

Let's Investigate

Seed Planting Depth Determines Seed Growth

Follow these steps to demonstrate how planting depth affects the germination of seeds.

1. Use scissors to cut the top off of four plastic, 2-liter soda bottles as shown. Recycle the tops of the soda bottles.
2. Fill the bottom of each soda bottle with two inches of gravel.
3. Fill each bottle with soilless potting mix up to two inches from the top of the bottle.
4. Select four different kinds of seeds. Make sure you use one or two large seeds (corn or lima beans) and one or two small seeds (tomato or carrot).
5. Using masking tape and the marker, label each bottle with the name of the seed you are planting in it and the planting date.



6. Plant two seeds (two inches apart) at each of three depths - half inch, three inches, and five inches deep in the soil (six seeds total). Make sure the seeds lie next to the side of the bottle so you can see them from the side. Now do the same with the other seeds in the other three bottles.

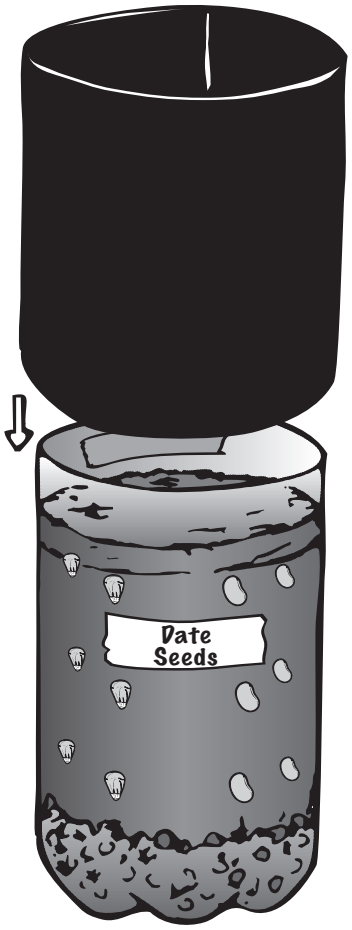
7. Water the containers thoroughly until you see water is seen draining into the gravel.

8. Make a sheath of construction paper that fits snuggly around the bottles (but not so tight that it does not easily slide up-and-down). Surround the bottles with the paper sheath and leave it on the bottle. The roots grow away from the light and into the soil unless they are provided with darkness (reverse phototropism).

9. Predict the likely results in each bottle. Write down your predictions in your journal.

10. Make a table and record the number of seeds that come up at each depth of planting for each kind of seed planted.

11. Discuss what you learned about planting depth and seed germination with your helper. Compare your results with your predictions.

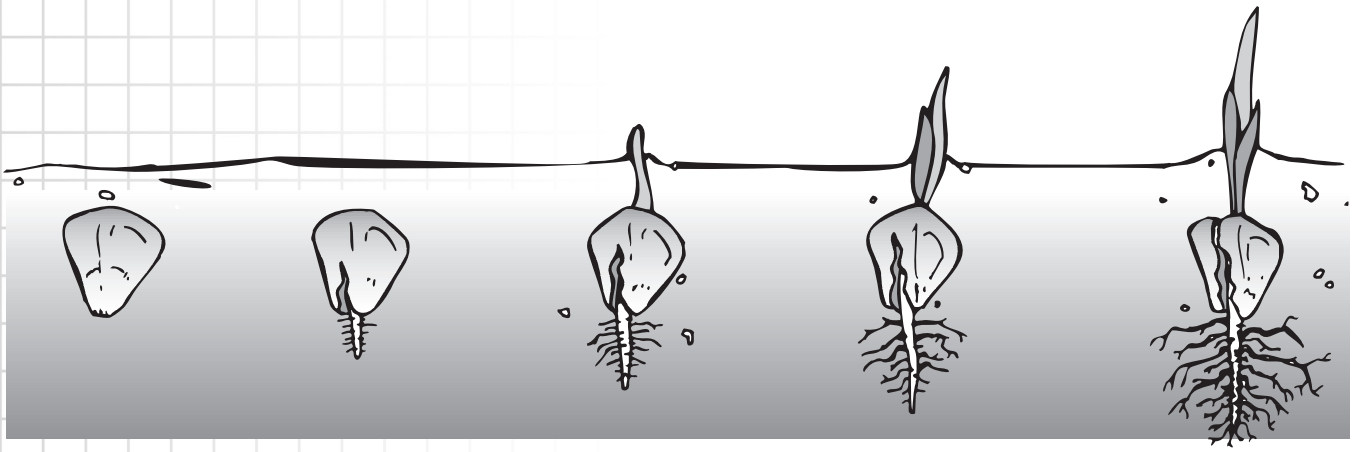


Diggin' In

Seed Features

A seed contains a **dormant embryo** (the immature plant) and **cotyledons** (the stored food supply), all of which are protected by a **seed coat**. The two survival features of seeds that affect the future of a plant's existence are 1) its dormancy, which allows the embryo to survive until outside conditions are just right for growth, and 2) the amount of food stored in the cotyledons that help it survive the initial period of growth, or **germination**.

When a seed begins to germinate, the first "leaves" often seen on a young seedling are the seed cotyledons. Cotyledons provide the food energy needed for early plant growth. The second set of leaves that develop are the **true leaves** of the plant. These leaves resemble the shape and color of the adult plant.



Considering Plants and Soil

Let's Talk

Large seeds contain large amounts of starch to support the growth of a germinating seed. Small seeds contain small amounts of starch. How does this fact affect their success of different planting depths?

Why is it important to follow the planting depth directions on the back of a packet of seeds?

Let's Reflect

Seeds require optimum planting depths for successful germination and plant development. Why can't a plant survive if it is planted too deep or too shallow?

How can understanding optimum planting depths help a gardener improve his or her garden?

Let's Use It

Many activities require that we follow directions. Why is it important to follow directions? What often happens when we don't follow directions?

Why is it important that we understand the natural limitations on plant growth? (seed depth, amount of sunlight needed, etc)

Branching Out

1. Collect a variety of seeds. Predict how deep the seeds must be planted by looking at the size of the seeds. Why is seed planting depth determined by seed size? From where do seeds get their initial energy to germinate and grow before they have leaves to use for photosynthesis? Discuss this relationship with your helper.

2. Take a trip through a park, wood, or field. Collect seeds and make notes on how each seed moves to a new location. Mount and identify your seeds on a poster. Indicate how each one moves from place to place. Seeds are moved by the wind, flowing water, attached to animal fur, birds, and man. Share your poster with your helper.

Cool Connections

In ancient times, gardeners would stomp on basil seeds and yell at them to make them grow! This may sound silly, but these gardeners were actually doing the right thing (except for the yelling). Basil seeds are covered with a jelly-like material, which makes it easy for rain to wash them away. By stomping on them, the growers were making sure the seeds stayed in place!

Word Power

Cotyledons Dormancy Embryo Germination Seed Seed coat

Seedlings True leaves

Activity 9. Concerning Cotyledons

A close look at a lima bean seed reveals a line that encircles the outside of the seed. If you stick your fingernail into this line crack, the seed splits in two. Inside the seed you see a tiny plant **embryo**. The two sides of the seed are called the **cotyledons**. The cotyledons of a seed contain stored starches and sugars, which are used by the seed embryo for energy to initiate growth. The young seedling is dependent on this energy until it can establish a working root system and a set of leaves that can start producing new sugars through photosynthesis.

Activity: Explore the importance of cotyledons to the growth of young seedlings.

Life Skill: Acquiring and Evaluating Information

Science Process Skill: Experimenting, controlling variables, and collecting data

Achievement Check: You can explain the function and importance of cotyledons to seedling growth

Virginia SOL: LS.4a and c; LA 6.2, 7.1

National Science Standard: Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.

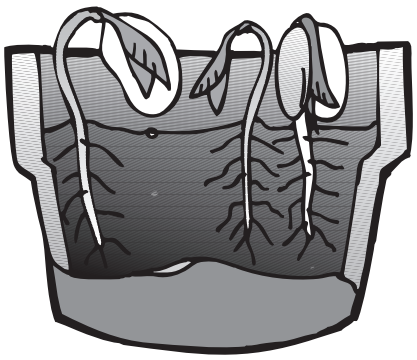
Materials: 6 to 8-inch pot, soilless potting mix, bean seeds, scissors, pencil

Let's Investigate

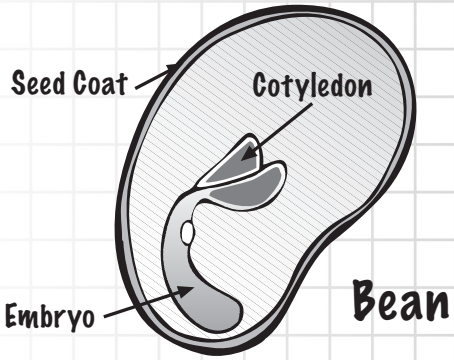
Seeds and Stored Food

How important are cotyledons to the healthy growth of a young seedling? What do you think would happen to an emerging seedling if its cotyledons (stored food) were removed? This activity demonstrates the importance of the stored food in seeds to the early growth of seedlings.

1. Fill a 6 to 8-inch pot with soilless potting mix.
2. Plant six to eight bean seeds ¾-inch deep.
3. Moisten potting mix with water until it drains out of the bottom of the pot. Record the planting date.
4. Place in a well-lighted window and water when necessary to keep the potting mix moist.
5. Observe the pot daily. Record the date that the bean seedlings emerge.
6. Using sharp scissors, carefully follow these treatments:
   - Remove one cotyledon from two of the seedlings
   - Remove both cotyledons from two of the seedlings
   - Leave both cotyledons on the remaining seedlings



7. Predict the outcome of these treatments. Write down your predictions in your journal.
8. Observe and record how the seedlings grow with differing amounts of stored food.
9. Explain the differences noted between treatments to your helper or group. How did the absence of the cotyledons affect the growth of the seedlings? Compare your results with your predictions.



Dates Seed were planted _____ . Date seedlings came through soil_____ .

Cotyledons Removed	Height in Inches	Plants Dead	Plants Alive	Leaf Color
A. One				
B. Both				
C. None				

Considering Plants and Soil

Let's Talk

How did comparing plant growth differences help you answer the original question, "How important are the cotyledons to seedling growth?"

What did you learn about seedling growth that you didn't know before?

Let's Reflect

Young plant embryos are dependent on the food stored in the seed until they are able to produce their own sugars through photosynthesis. How are young plants similar to young animals? How are they different?

Why do you think most plants produce large numbers of seeds? If every seed a plant produced actually grew into a plant, what would our world be like?

Let's Use It

During a typical day, what comparisons do you make when making decisions?

How does the process of comparing differences between two objects or situations help in everyday decision making?

Branching Out

1. Find out more about the different places in a plant where sugars and starches are stored for future growth. List ten foods that we eat that are organs of plant food storage. Share your list with your helper.

2. How does food storage change in a plant at different times of the year? When are plants more dependent on using stored food? Draw a picture representing the life cycle of an apple tree through the seasons of the year. Using your drawing, discuss the times of the year when the apple tree is dependent on stored sugars and starch.

Cool Connections

The word "cotyledon" comes from the Greek word meaning "cup-shaped hollow." Can you see how the cotyledons got their name?

Word Power

Cotyledon Embryo Photosynthesis

Activity 10. Old Seed, New Seed

In the springtime a gardener often starts dreaming of growing fresh fruits and vegetables, or enjoying the beauty of a flower garden. To make this dream come true the gardener must be careful to search out fresh seed to plant. As a general rule, seeds lose their ability to **germinate** as they age. Every seed packet has a date stamped on the back that indicates the year the seeds were harvested and packaged. This date tells you if you are using fresh seed.

Activity: Explore the relationship between seed age and germination rates

Life Skill: Acquiring and Evaluating Information

Science Process Skill: Organizing and classifying data

Achievement Check: You can use percentages to determine germination rates of seeds

Virginia SOL: LS.4a and c; Math 6.1, 7.1; LA 6.2, 7.1

National Science Standard: Some traits are inherited and others result from interactions with the environment.

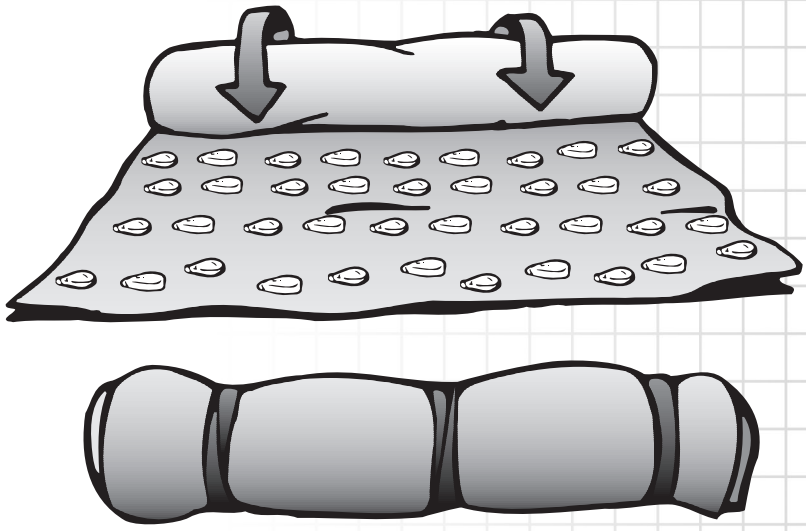
Materials: Old and new grain seed, paper or cloth towels or newspaper, rubber bands or string, pail, burlap sack or old towel, calculator

Let's Investigate

The Age of Seeds

Seed companies stake their reputations on providing a gardener with fresh seed. Dating seed packages ensures the gardener that he or she has the freshest seed available. You can test the germination rates of the seeds you purchase using this simple procedure.

1. To compare the germination rates between new and old seed, locate 200 seeds of corn, oats, or other grain - 100 that are old seed (last year's seed) and 100 that are new seed (current year).
2. Wet some paper towels, cloth towels, or a double thickness of newspaper and spread two sets flat on a table.
3. Space 100 new seeds in rows on one and 100 old seeds in rows on another.
4. Cover the seeds with another wet newspaper, towel, or cloth.
5. Roll the paper or cloth towels loosely leaving space for the sprouts to develop.
6. Hold the rolls together with rubber bands or strings spaced every two or three inches.



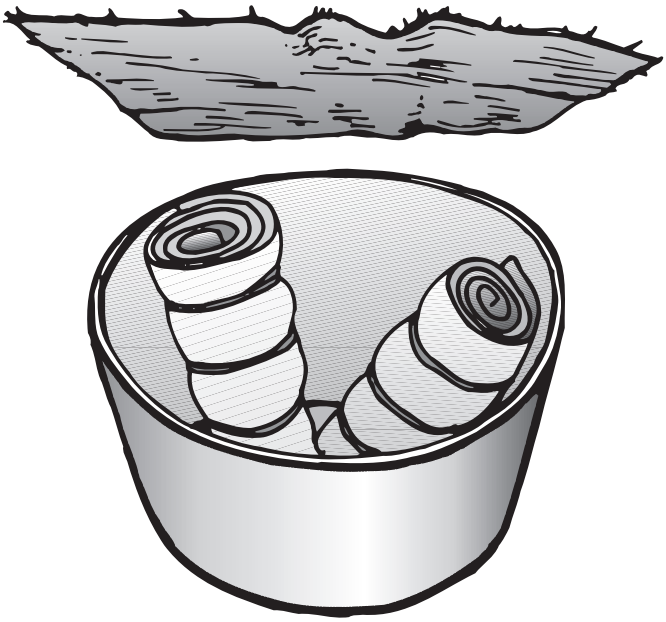
7. Stand the rolls on its end in a pail, and cover with moist burlap sack or old towel. Drain excess moisture into the pail.

8. For greater accuracy, make two or three tests of the same seed lots and average the results.

9. Place the pail where the temperature remains around 70 F. Many species germinate in seven days, while others take longer. Keep the covering moist.

10. Predict what will happen to the seeds. Write down your predictions.

11. After seven days, unroll the paper towels. Count only strong sprouts having both a root and a shoot. With 100 seeds, the number of strong sprouts equals the percentage of germination.



12. Calculate and compare the germination percentage between old and new seed. Was there a difference? How did your results compare with your prediction?

13. Discuss what you learned about seed germination and seed age with your helper or group.

Diggin' In

Don't Grow Yet!

Believe it or not, plants have made many **adaptations** to keep their seeds from germinating. These adaptations ensure the survival of the plant species during times of environmental change or times when essential growth factors are not present. Some seeds have a hard coat that must be worn away over a period of years before the seedling begins to grow. This ensures that there are seeds around in the future when optimum growing conditions are on hand. Some seeds are immature and must mature over a period of time. This ensures that the young seedlings do not grow during cold winter months or during dry seasons. There are even some seeds that must pass through the digestive system of an animal before they germinate. This ensures that the seeds are distributed to different, and possibly better, growing locations!

Considering Plants and Soil

Let's Talk

Germination percentages help us determine seed quality. How did this experiment help you understand seed quality?

How did this experiment help you understand seed aging?

Let's Reflect

As seeds get older they loose their ability to germinate. What other examples can you think of that link aging with loosing an ability to do something?

Why would a decrease in seed germination as related to age be an advantage to the survival of the plant species?

Let's Use It

What are some ways that you use percentage calculations to help you make decisions?

How does your ability to calculate percentages help you in your everyday life?

Branching Out

1. Some seeds lose their ability to germinate faster than other seeds. Repeat this experiment using flower or vegetable seeds. How did their germination rates differ from those of the grains used in the Old Seed, New Seed experiment? Why do you think there is a difference? Discuss variable germination times with your helper.

2. Crabgrass seeds can live up to twenty years in your lawn and still germinate! Discuss with your helper how this information would affect the weed control plan for your lawn.

3. Cut a tomato in half and select 20 plump seeds. Wash 10 seeds thoroughly, but do not wash the remaining 10 seeds. Spread out the seeds to dry in a saucer. Using soilless potting mix, plant the seeds in containers labeled "washed seed" and "not washed seed." Moisten the potting mix, place each pot in a plastic bag, and seal the bags. Set pots in a warm, well-lighted area. Note the differences in the number of seeds germinating and the time required. Discuss how substances in the fruit prevent seed germination with your helper.

4. Locate hard seeds such as crown vetch, crimson clover, mimosa, or morning glory. Divide the seeds into 4 groups of about ½ teaspoonfuls each and number them group 1 to 4. Treat seed groups as follows: #1 - place in boiling water for 3 minutes; #2 - shake in a jar with sandpaper strips; #3 – pierce the seed coat with a needle; and #4 - leave untreated. Plant groups in pots bearing same label. Observe and record differences in germination. Discuss how hard seed coats prevent seed germination with your helper.

Cool Connections

Although all seeds have a certain life span, this length of time can range form a few weeks, as in the case of some maple species, to 2,000 years, as in the case of lotus plants.

Word Power

Adaptation Germination

Activity 11. Climate Quest

The **climate** has a direct effect on the types of **vegetation** growing in an area. Think about how the temperature and humidity in a desert determine the types of plants that grow there. Now, think about the cold tundra climate or the northern taiga. The pine trees growing in these areas are much different from the cacti growing in the desert. Plants have adapted to the many different climates found around the world in a variety of different ways.

Activity: Explore how climate affects plant characteristics and growth

Life Skill: Acquiring and Evaluating Information

Science Process Skill: Observing and classifying data

Achievement Check: You can describe how hardiness maps are used in landscape plant selection

Virginia SOL: LS.10, LS.11, LS.14; LA 6.2, 6.6, 7.1, 7.7

National Science Standard: The number of organisms an ecosystem can support depends on the resources available, including abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Materials: paper, pencil, Plant Hardiness Map

Let's Investigate

Plants Have Adapted to Different Climates

These two activities explore different climates and their affect on plant characteristics and growth.

The Small Picture

Take a walk around your neighborhood and locate two different habitats. For example, you might locate a forest and an open field. Compare the types of vegetation found in these two different habitats. Note the differences and similarities in the types of leaves, density of vegetation, life cycles, and the rate of growth of the plants found in these two areas. If possible, take a picture of the plants in the two areas. Discuss how two different habitats can be found in essentially the same climate area or **biome**. Share the photographs and what you learned with your group or helper.

The Big Picture

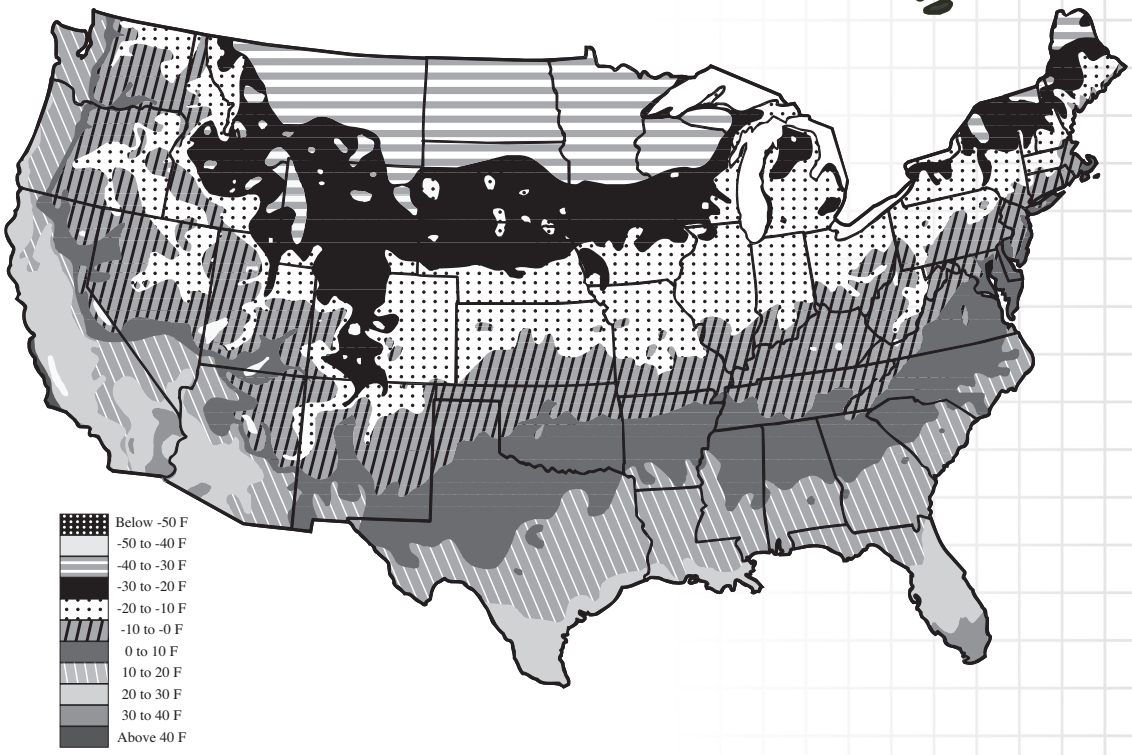
Locate your hometown on the Zones of the Plant **Hardiness** map. Hardiness as used in this activity refers to cold adaptability. Write down the number of your local Hardiness Zone and its defined minimum temperature range. Take a walk around your neighborhood and make a list of at least ten plants growing in your zone. How have these plants adapted to the minimum temperature range found in your zone? How do plant temperature requirements determine which plants gardeners and landscapers select for a garden or landscape?

Select a zone on the map that is completely different from your hometown's zone. Using the Internet or other resources, make a list of plants that are characteristic of this zone. How are these plants different from those found in your hometown's zone? How have these plants adapted to the minimum temperatures in their zones?

Diggin' In

Temperature and Climate

Every type of plant has an optimum temperature range for growth. These optimum temperatures may be different at different stages of growth, but essentially there is a minimum and a maximum temperature at which plants grow. Plant adaptations to temperature are demonstrated by the different types of plants growing in different climatic zones of the earth. We see cacti growing in the hot, dry desert, pine trees growing in the cold taiga, and orchids growing in the hot, humid tropical rain forests. Now imagine pine trees or orchids in the desert, and cacti in a rainforest! It's hard to think of, isn't it?



Considering Plants and Soil

Let's Talk

Explain in your own words the part climate plays in determining the kinds of plants that grow in an area.

What was the most interesting thing you observed as you made the list of plants found in your hometown's hardiness zone?

Let's Reflect

Why is acclimating to climate important to plant survival? Would it be better if the entire world had the same climate? Why or why not?

How do landscapers use hardiness zone maps to help them with their work? Why is understanding your local climate important to plant selection for your garden?

Let's Use It

How have you acclimated to your local climate? What do you do when you visit an area with a different climate? Why don't we need hardiness maps for people?

What decisions do we make every day related to the local climate?

Branching Out

1. Identify the problems that you would expect to encounter if you tried to grow:
   - A plant with a high water requirement such as a water lily in the desert
   - A long season crop such as watermelon (110 days from planting to harvest) in an area such as Alaska where the frost-free period is short (60 days)
   - A cool season crop such as spinach in a hot climate
   - A desert cactus in a swamp
   - An orange tree in the state of Vermont
2. Locate several plant catalogs. Look at the information provided in the plant descriptions. What information is included that helps you know if you can grow that plant in your local climate? Discuss with your helper the importance of this information to making an informed plant purchase.
3. Complete this table for your city or town, or any other area that interests you. Use the Internet, library, or Virginia Cooperative Extension office to find out about the climate in your selected area. Share your chart with your helper.

	Examples		Your Area	Other Areas	
	Nothern N.Y.	Florida			
A. Precipitation	35″ – 40″	55″ – 60″			
B. July Temperature	65˚ – 70˚F	80˚			
C. Frost-free period	120 days	320 + days			
D. Hours of sunshine (day)	9 hours	9 hours			
Other*					

* Note: You may also be interested in humidty and the number of days snow covers the ground.

Cool Connections

Some arctic plants can survive at sub-zero temperatures only to bloom, flower, and make seed during the one or two weeks of the warm arctic spring. They have really adapted to their climate!

Word Power

Biome Climate Hardiness Vegetation

Activity 12. How Do They Do It?

Plants have adapted to all sorts of environmental extremes – from the hot, dry desert to the cold tundra or the hot, humid rain forest. Plants can be found in every **biome** on earth in one form or another! Plants have adapted to variations in light, temperature, humidity, soils, water availability, and wind. This activity explores some **adaptations** that have allowed plants to exist in the different climates found around the world.

Activity: Explore plant adaptations to different climates

Life Skill: Acquiring and Evaluating Information - Evaluates relevance of data

Science Process Skill: Questioning, and looking for evidence

Achievement Check: You can explain the advantage of plant adaptations to different climates

Virginia SOL: LS.10, LS.11, LS.14; LA 6.2, 6.6, 7.1, 7.7

National Science Standard: The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

Materials: Visit to a local greenhouse, paper, pencil

Let's Investigate

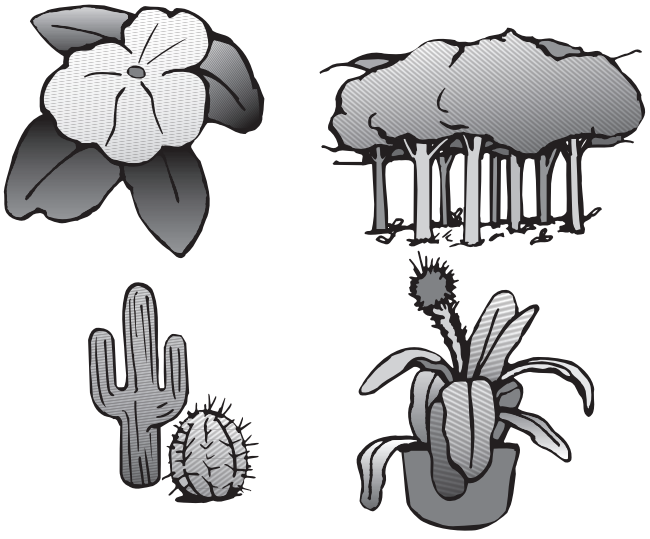
Plant Adaptations

1. Visit a local greenhouse to compare plant adaptations to different amounts of light, heat, and water.

2. Using your journal, write down the names of three leafy houseplants and list the features that distinguish these plants. Most green houseplants come from the understory layers of the rainforest. They have adapted to low light and low water levels. What physical features do these plants have in common? Draw a picture of these plants.

3. Write down the names of three cactus plants found in the greenhouse and list the features that distinguish these plants. Most cacti originated in a desert environment and have adapted to high light and low water levels. What features do these plants have in common? Draw pictures of these plants.

4. Locate and write down the names of three bromeliads and list the features that distinguish these plants. Bromeliads live in the forest canopy of a rain forest and have adapted to low light and high water levels. What features do these plants have in common? Draw a pictures of these plants.



5. Locate and write down the names of three African Violets and list the features that distinguish these plants. These plants originated on the rocky mountain slopes in Africa. They have adapted to high light and low water levels. What features do these plants have in common? Draw a picture of an African Violet.

6. Compare and discuss the plant adaptations you have observed with your helper.

Diggin' In

Plant Adaptations

Plant adaptations to different climates demonstrate the vast variability found in the plant world. A few examples of plant adaptations are:

- Pine tree needles have deeply embedded **stomata** covered with a waxy substance that prevents water loss during the long, cold months of a northern winter.
- Desert cactus plants have few leaves, which helps decrease water loss. In fact, water is stored in the cactus waxy stem. In addition, the stem contains chlorophyll which allows cacti to make sugars by photosynthesis without leaves.
- Bromeliads grow in the upper branches of trees in the tropical rain forest. Since they cannot depend on soil for nutrients, their leaves grow in a "cup" shape, which catches both rainwater and insects. The rainwater fills the plants' water needs and the insects that drown in the cup, decay and fill the plants nutritional needs.

Considering Plants and Soil

Let's Talk

Describe the most unique plant adaptation you observed at the greenhouse. Why was this adaptation so distinctive?

How did the greenhouse you visited provide the different climates required by each type of plant?

Let's Reflect

How have people taken advantage of different plant adaptations for their own uses?

Plants grow in almost every region of the world, except for the coldest mountain tops and driest deserts. How might plants adapt to begin growing in these two regions?

Let's Use It

In our changing world, what types of adaptations might plants need to make in the future? Would it be better if scientists forced the plants to adapt through genetic engineering?

Why is it important that we understand how plants and people must change to meet future changes in our environment?

Branching Out

1. Read about plants that are found growing in the ocean. What features of these plants allow them to live in salt water? Share what you learned about ocean plants with your helper.

2. Read about the Venus flytrap. What adaptations have these plants made to accommodate their environment? Include a drawing and description of this plant in your "Unusual Plants" portfolio.

3. Look at an annual precipitation or rainfall chart for the United States on the Internet. Find the rainfall (inches) in your location. Compare this with extremes of rainfall (high and low) in other areas of the United States. Describe the type of vegetation found in your local area in terms of water requirements. Describe to your helper what kinds of plants you would expect to find in the high- and low-rainfall areas you selected.

4. To demonstrate the effect of temperature on plant growth, place a thermometer out of doors on the north side of the house away from the direct rays of the sun. Make hourly readings for one day. Record your readings in your journal. Then take two readings at the same time every day for at least two weeks (around 7 a.m. and 3 p.m.).Write down the way the temperature varies during the day and also note the differences between day and night temperatures. Record any differences you notice in the appearance of outdoor plants in the morning and afternoon. Discuss the effects of variable temperatures on plants with your helper.

Cool Connections

Plants grown in a greenhouse or indoors must be "hardened off" before they can be placed outdoors in a garden or pot. Taking the plants outdoors during the day for a few hours to get them adjusted to stronger light and cooler temperatures hardens them off in one or two weeks. That's a great adaptation!

Word Power

Adaptation Biome Stomata

Glossary

adaptation a change in structure, function, or form that produces better adjustment of an animal or plant to its environment

adventitious roots roots that occur in unusual or abnormal places on the plant, such as along the stem or from the leaves

auxins organic substances which in low concentration are able to modify plant growth

biome an extensive community of plants and animals whose makeup is determined by soil and climatic conditions

carbon dioxide a gas in the atmosphere used by green plants in combination with energy from light to produce sugars and starch

cell the basic unit of structure in plants and animals

cell division a process by which one cell splits into two complete cells. This is how plants grow

chlorophyll green pigment essential to photosynthesis

chloroplasts a plant cell structure containing chlorophyll

climate the prevailing or average weather conditions of a place

competition the struggle among individual organisms for food, water, space, etc. when the available supply is limited

compost a mixture of decomposing vegetable refuse used for fertilizing and conditioning the soil

cotyledon the seed leaf; it acts as the first source of nutrients to the developing embryo

cutting slip or a shoot cut away from a plant for rooting or grafting

dormancy period of growth inactivity in seeds, buds, bulbs, and other plant organs

embryo the undeveloped plant within a seed

epidermis the exterior tissue, usually one cell thick, of leaves, young stems and roots, and other parts of plants

fertile soil soil capable of sustaining abundant plant growth

fertilizer plant nutrients that can be applied to help plants grow better

germination the process by which a plant embryo starts to grow

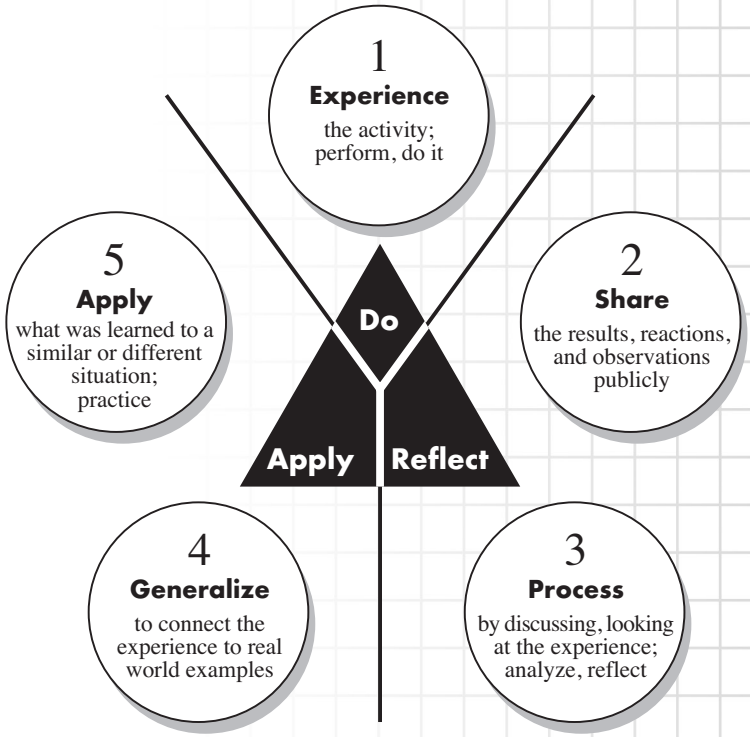
growth regulator substance other than nutrients which in small amounts influence plant growth

hardiness	the ability to survive certain temperatures without special care
herbaceous	referring to non-woody plants
hormone	plant regulating substances used to induce rooting, fruit setting, prevent pre-harvest fruit drop, or as selective weed killers legume a family of plants bearing pods. They are capable of fixing nitrogen from the air for their own use with the aid of proper inoculum (bacteria)
manure	animal excrement put onto or into the soil to fertilize it
nitrogen	a colorless, tasteless, odorless gaseous chemical element that forms nearly 80% of the atmosphere; a component of all living things
nutrient	a substance that furnishes the elements and energy for the organic molecules that are the building blocks from which an organism develops
oxygen	a colorless, tasteless, odorless gaseous chemical element that forms nearly 20% of the atmosphere; is essential to life processes
photoperiodism	the initiation of flowering and certain vegetative activities of plants in response to relative lengths of day and night
photosynthesis	process by which chlorophyll and energy of light convert carbon dioxide and water to sugars and starches in growing plants
phototropism	movement of a part of a plant toward or away from light sources
seed	a dormant embryo enclosed in a seed coat with the endosperm
seed coat	the outer boundary layer of a seed
seedling	first growth stage of a plant; a young plant grown from seed
soilless potting mix	a growing medium used for growing plants in containers composed of peat moss and a component to enhance aeration such as perlite or vermiculite
stomata	a minute pore or opening in the epidermis of leaves and herbaceous stems; it regulates gas exchange and transpiration
symbiotic	the intimate living together of two kinds of organisms, especially where such association is of mutual advantage
thin	to remove some plants to make room for the growth of the plants that are left behind
transpiration	loss of water in vapor form; most transpiration takes place through the leaf stomata
true leaves	the first set of leaves produced by a seedling which resemble the leaves of the adult plant
tropism	response of a plant organ or part to an external stimulus, usually in the direction of the stimulus
vegetation	plant life or total plant cover (as of an area). The collective plant growth of an area

The Experiential Learning Model

The experiential learning model is used in each activity as a means to help the young person gain the most from the experience.

The five steps in this learning model encourage the young person to try to do the activity before being told or shown how. The Experiential Learning Model asks youth to:



1) **Do** the activity

Key Concept: Attention is on the learner. Key Activity: Discovery

2) **Share** what they did

Key Concept: Response to learning and feeling. Key Question: "What happened?"

3) **Process** what was most important about the experience

Key Concept: Analyze patterns. Key Question: "What's important?"

4) **Generalize** the life skill to their own lives

Key Concept: Inference. Key Question: "So What?"

5) **Apply** the life skill or science process skill to a new situation

Key concept: Application. Key Question: "Now What?"

To fulfill the experiential learning process, the youth must complete all the steps, including the review questions found in the Considering Plants and Soil section of each activity. Sharing, answers with a helper and others enriches the youth's reflection process and learning. The experiential model enhances learning and adjusts to a wide variety of learning styles.

Evaluating the Experience

An *Achievement Check* assessment is located in the introduction of each activity. You will evaluate the achievement of the youth by their mastery of this indicator. Also, ask the questions under *Considering Plants and Soil* found in each activity to continue to improve your youth's understanding of the key concepts and life skills practiced in each activity.

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