4-H Plant , Soils, and Entomology Curriculum

Exploring the World of Plants and Soils

Project Book 2

Stems and Stamens

Virginia Cooperative Extension
Virginia Tech • Virginia State University

Publication 380-021 2014

Stems and Stamens

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Funding: Virginia Cooperative Extension

Source Citations: The following sources were helpful in developing the Virginia *4-H Exploring the World of Plants and Soil Project:*

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.

Stems and Stamens

Note to the Project Helper

Stems and Stamens is the first Project Book in the Exploring the World of Plants and Soils series. This Project Book looks at the composition of plants, the functions of individual plant parts, plant life cycles, and the many ways plants reproduce themselves. It is written to interest youth ages 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 for 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 Stems and Stamens 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 think about what she/he is experiencing and learning through active listening and open-ended questioning.
- Encourage the youth to keep a Project Journal to document activity recordkeeping requirements, answer activity questions, and record personal thoughts and ideas.
- Serve as a resource person to help the young person connect with 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 youth learn and grow as they explore the world of plants and soils.

What's Inside

The *Stems and Stamens* project activities offer you many interesting and exciting experiences for learning about plants, plant life cycles, and plant reproduction. You will also learn about different plants parts and how they work together for healthy plant life.

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
The Life Cycle of a Plant	_____	_____	Surrounded by Seeds	_____	_____
A Closer Look at Plants	_____	_____	Germinating Seeds the Easy Way	_____	_____
Getting to the Root of Roots	_____	_____	Can Shoots Grow Roots?	_____	_____
Stems in Action	_____	_____	Growing Roots in the Air	_____	_____
Looking at Leaves	_____	_____	Plants from Stems	_____	_____
What Does it Take to Make a Seed?	_____	_____	More Plants from Unique Plant Parts	_____	_____

Optional Activities

Do 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 activity requires the organization of and the participation in an event, presentation, or tour.

Leadership Experience	Date Completed	Helper's Initials
Give a project demonstration	_____	_____
Teach someone something about plants	_____	_____
Give a speech on a plant subject	_____	_____
Give a plant propagation demonstration	_____	_____
Teach someone how to take cuttings	_____	_____
Teach someone something about plant propagation	_____	_____
Organize a tour of a greenhouse business	_____	_____
Attend a gardening demonstration	_____	_____
Exhibit a plant project	_____	_____
Other leadership experiences:		
_____	_____	_____
_____	_____	_____
_____	_____	_____

Service Learning Experience

Select and participate in at least one service learning experience or devise one of your own. A service learning experience requires that you do something to enrich 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. The Stages of a Plant's Life

Sometimes it is hard to believe that plants are living organisms. We don't see plants move around, hunt for food, or any of the other things we associate with being "alive." However, like all living things, plants need food, water, and air to survive; they produce offspring (usually **seeds**); they respond to environmental changes; they maintain a stable internal condition; and they change in size by growing. In addition, like every other living thing, a plant has a **life cycle**. A life cycle is a series of stages through which a living thing passes before arriving back again at the starting point.

Activity: Identify the different stages of a plant's life cycle

Life Skill: Interpreting Information – Understands and analyzes information

Science Process Skill: Organizing and classifying information

Achievement Check: You can describe the different stages of a plant's life cycle

Virginia SOL: LS.4; 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: cardboard, glue, marker pen, garden trowel

Let's Investigate

The Life Cycle of a Plant

Since the different stages of a plant's life cycle usually occur over the course of an entire year or growing season, it is difficult to see all of the life stages at one time. Fortunately for us, as a plant lives through the different stages of its life cycle, it often leaves behind evidence of past stages either attached to its being or scattered close by. Follow these steps to discover a plant's life cycle.

1. Select a small plant growing in your garden or yard.

2. Search out evidence of the plant's growth and reproduction from the current and/or the prior year. This evidence can often be found in the **leaf litter** and soil located around the base of the plant. You may have to dig through the soil to find some of these items. You may also find the different stages still attached to the growing plant.

3. On a sheet of hard cardboard, your poster, draw a large circle.

4. Collect and mount the following parts on the circle in the correct order of a plant's life cycle:

   - Seeds
   - **Germinated** seed
   - **Fruit** or seed pod
   - **Mature** plant
   - Flower

5. Label each part and describe its function in the life cycle of the plant.

6. Present your poster to your group or helper. Explain what you learned about each part of the plant life cycle.

Considering Plants and Soil

Let's Talk

What plant parts were the easiest to find? Which were the most difficult?

What stages of the plant's life cycle were found all at the same time on the growing plant itself?

Let's Reflect

Describe the life cycle of a pet dog, cat, rabbit, or fish. How is it similar to a plant's life cycle? How is it different?

Think about a plant going through its life cycle in your garden. What environmental factors might affect the plant's ability to complete its life cycle? What features of the plant allow it to adapt to changing environmental factors?

Let's Use It

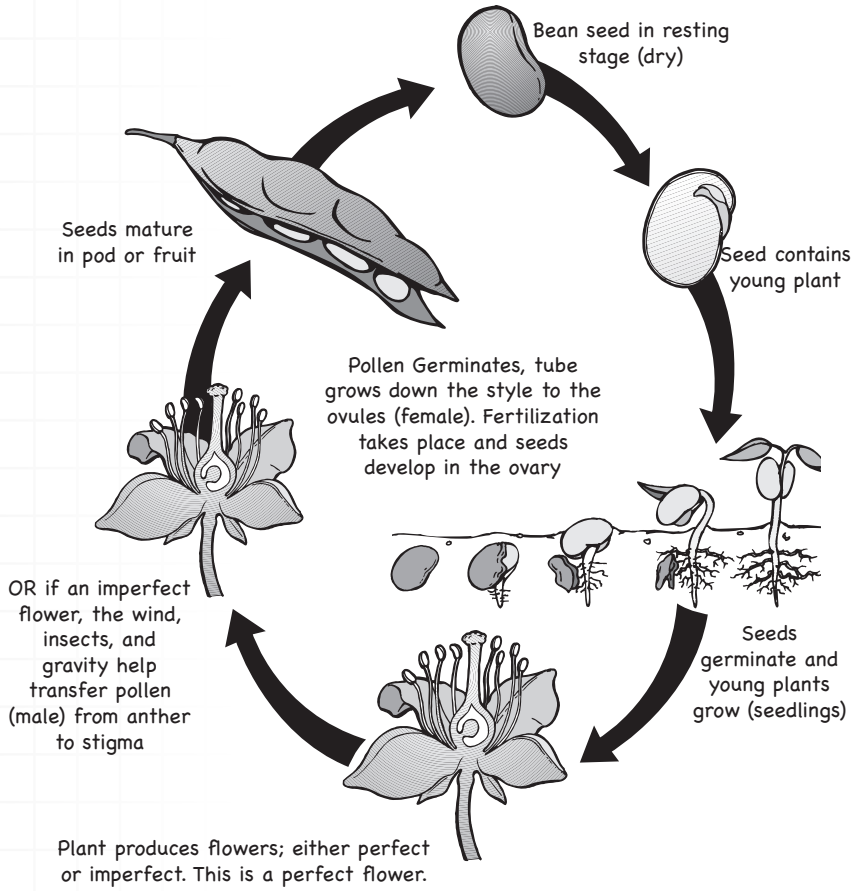
How does knowing about life cycles help you understand your own life now and in the future?

How can you use your understanding of life cycles to make plans for your future?

Diggin' In

The Cycle of Life

Have you ever been asked the question, "Which came first, the chicken or the egg?" Just as it is difficult to determine the answer to this question for a chicken, it is equally difficult to answer it for a plant. For simplicity's sake, we will say that a plant's life cycle begins with the seed. The seed germinates and produces a young plant which grows and matures into a full-grown plant. At maturity, the plant produces flowers. **Reproduction** occurs in the flowers, and new seeds are formed. From this point the life cycle starts all over again.



For a plant's life cycle to progress from beginning to end, a sprouting seed develops roots, stems, leaves, buds, and flowers which work together to ensure healthy growth. Healthy plant growth leads to the eventual production of new seed, which guarantees the continuation of the plant-type into the next generation.

Branching Out

1. Explore the life cycles of a long-lived plant, such as an oak tree, and that of a short-lived plant, such as a marigold. Write a paragraph describing the two life cycles in your journal. Discuss the similarities and differences with your helper.

2. Find out the differences among an annual, a biennial, and a perennial plant. Make a list of examples of each in your journal. Cut out or draw pictures of each type of plant. Discuss your list with your helper.

Cool Connections

The plant with the longest, normal life span is the yucca. Some yuccas have lived to be 200 to 300 years old! However the oldest known plant is the Bristlecone Pine. The record-holder is located in the Wheeler Peak area of Nevada and has lived for more than 4,900 years!

Word Power

Flower	Fruit	Germinate	Leaf litter	Life cycle
Mature	Reproduction	Seed		

Activity 2. A Closer Look at Plants

A close look at a frisky pet dog reveals the fact that he or she has four legs, a body, a head, and a constantly wagging tail. A veterinarian can explain that the playful pup is also made up of different organs such as a heart, brain, nervous system, and vascular system, that work together to support its life. All living things, including plants, are composed of different tissues and organs that work together for healthy living. Let's take a closer look at the different systems that work together for healthy plant life.

Activity: Recognize that plants have a complex structure

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

Science Process Skill: Organizing and classifying information

Achievement Check: You can describe the different parts that make up a plant

Virginia SOL: LS 3; 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: two or more small plants, garden trowel, paper tags or paper, pencil, masking tape, newspaper, cardboard or heavy paper, glue

Let's Investigate

What is a Plant?

In this activity, take a careful look at the parts of two or more plants to help you recognize the various components that makeup plants. The similarities and differences between the different parts of each plant make each of them unique.

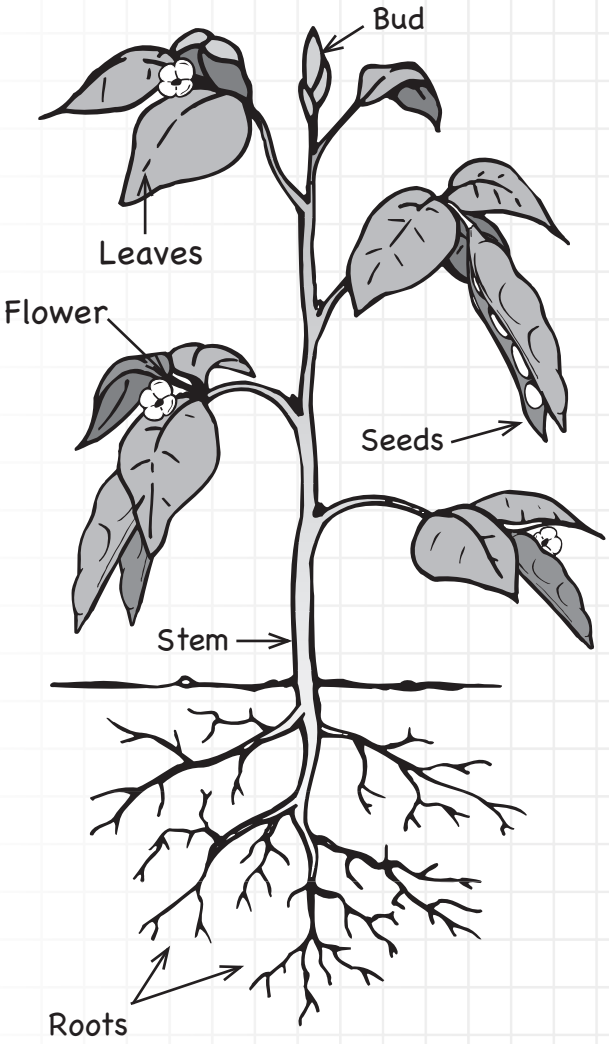
1. Select two or more small plants of differing types. Weeds and garden flowers make good plants to study.
2. Carefully dig up the plants to expose as many roots as possible. Crumble and shake the soil off the roots.
3. Label the different parts of the plants with small tags or pieces of paper. Attach the labels to the plants with masking tape. Include parts such as the **stem**, **leaf**, **flower**, **seeds**, **buds**, **fruit**, seed pods, **thorns**, **tendrils**, and **roots**.
4. Spread out the plants between two, thick sections of newspaper.
5. Place heavy boards on the newspaper to press the plants flat. You can use heavy books but remember that the moisture from the plants could damage the book covers.
6. After several weeks, check to see if the plants have dried.
7. Once the plants are dry, use glue to mount them on a piece of cardboard or heavy paper.
8. Make sure that all labels are neat and properly placed.
9. Discuss with your helper:
   - the function of each part of the plant
   - how the parts are similar between the selected plants
   - how the parts are different between the selected plants
   - how each plant is unique

Diggin' In

Plant Parts

Every type of plant is unique. Plants often show many fascinating and interesting traits, but despite their differences the majority of plants are made up of the same basic parts. Almost all plants have:

- Roots that hold the plant in place in the ground, absorb water and nutrients from the soil, and store sugars and starch for future use;
- Stems that support the leaves, buds, and flowers of the plant; transport water, nutrients, and sugars from the roots; and store sugars for future use;
- Leaves that perform **photosynthesis**, provide air to the plant, and regulate internal moisture and temperature;
- Buds that grow into new leaves, stems, or flowers;
- Flowers that produce seeds within fruit; and,
- Seeds that produce the next generation of plants.



Considering Plants and Soil

Let's Talk

Which plant part was the central feature that held all the other plant parts together? Why would this part be important to transporting water, minerals, and sugars to other plant parts?

What plant parts were you surprised to find? Why?

Let's Reflect

Why is each part of a plant important to the overall functioning of the plant? How is this similar in other living things?

Part of the plant grows in the soil, and other parts grow in the air. Which of these plant parts do you think are the most affected by their environment? Why?

Let's Use It

How does being knowledgeable about the parts that make up a dog help you better understand that animal?

How does being knowledgeable about the parts that make up your own body help you better understand yourself?

Branching Out

Find out how plants and parts of plants are used by people, animals, and birds. Make a list in your journal of what you discovered. Include such things as spices and flavoring, shelter for animals, clothing, beverages, sweeteners, paint, fuel, furniture, and medicine. Share your list with your helper.

Take a walk outside and look closely at the plants around you. How do the different visible parts of these plants (leaves, stems, flowers, buds, and possibly seeds) differ? How are they the same? Draw pictures of three of the plants you observed emphasizing the differences and similarities among them. Discuss your pictures with your helper.

Cool Connections

It is thought that the giant water lily is the fastest-growing plant. These plants grow in the Amazon Basin in South America and develop from a seed to full size in just seven months – a huge plant with 6 foot circular leaves!

Another fast growing plant is bamboo. In England, one bamboo plant was recorded growing 40 feet in just 40 days. In California, scientists documented bamboo growing 30 inches in 24 hours!

Word Power

Bud	Flower	Fruit	Leaf	Photosynthesis
Root	Seed	Stem	Tendril	Thorn

Activity 3. Getting to the Root of Roots

Since plant **roots** are usually located under the ground, they are often ignored as an important part of the plant. When people purchase a plant at the store, they forget that it is just as important to check out the plant's roots, as it is to look at the flowers and the leaves. To insure that you are buying a healthy plant, check out the roots of the plant by looking for white tips at the end of each growing root. These white root tips indicate that the roots are healthy, vigorous, and growing. Brown growing tips indicate that the roots are failing.

Activity: Demonstrate and observe root growth from a germinating seed

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

Science Process Skill: Observing and classifying

Achievement Check: You can describe different plant root systems and their functions

Virginia SOL: LS3, LS4, LS7; 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: plastic bottle, scissors, soil, water, 12 X 24 inch window glass, 6 bricks, 11 X 23 inch sheet of cellophane or thin plastic, tape, seeds (corn, cotton, or soybean), mirror, black plastic or paper, pencil, paper, plastic bag, colored wax pencils

Let's Investigate

Roots: A Plant's Collection System

Different plants have different types of **root systems**. A root system is a made up of large and small roots that grow in such a way as to provide support, water, and nutrients to the plant. Small grasses have **fibrous root** systems, while tall trees usually have branched **taproot** systems. Roots are the first plant part to emerge from a germinating seed. This activity shows you the progression of root growth from the young sprouting seed to the mature plant.

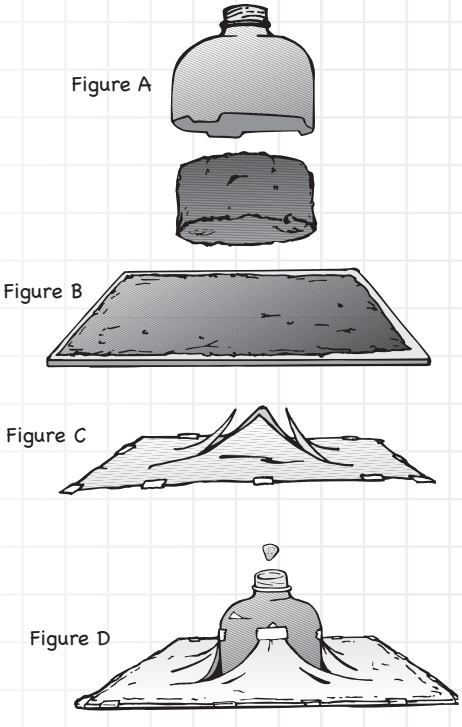
1. Cut the top from a plastic bottle just below the shoulder. Fashion three legs 1/4-inch high on its lower rim (Fig. A)

2. Pulverize one quart of soil. Slowly add water until the soil can be formed into a ball (not muddy, but moist enough to hold).

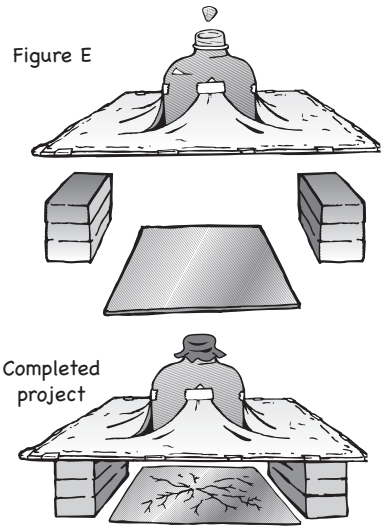
3. Crumble and spread about two cups of this moist soil evenly on the 12 X 24 inch sheet of window glass leaving one inch around all edges of the glass free of soil (Fig. B).

4. Make an X-shaped cut in the center of an 11 X 23 inch sheet of cellophane or thin plastic (Fig. C).

5. Fit this hole about the neck of the bottle (Fig. D) and center the bottle on the soil covered glass. Tape the plastic to the neck of the bottle as shown. Carefully spread the plastic sheet over the soil and fasten the edges to the glass with tape.



6. Fill the bottle top with moistened soil and insert one seed. Use corn, cotton, or soybean seeds.
7. Press the seed one inch into the moistened soil and cover. Keep moist.
8. Place the window glass on bricks (Fig. E), with a mirror below to observe growth of roots.
9. Place in a well-lighted spot but not in direct sunlight nor near a source of heat.
10. To prevent mold growth, cover soil area around the hole with black plastic or paper.
11. Check daily for signs of roots. They usually appear in four or five days at a temperature around 80° F. Record your observations.



12. If the seed fails to **germinate**, remove the old seed and the surrounding soil and repeat steps 6-11.
13. A plastic bag placed over the plant and sealed around the neck of the bottle decreases evaporation of water from the plant and soil.
14. Once a week draw the outline of the root system on the bottom side of the glass. Use a different color wax pencil each week.
15. Discuss what you observed and learned about root growth with your helper.

Diggin' In

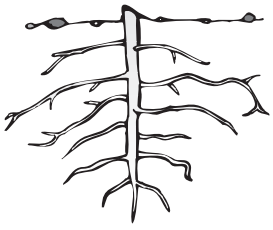
Roots

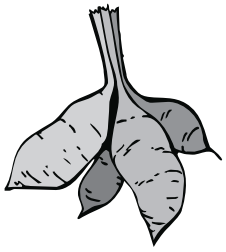
Nature provides plants with roots to:

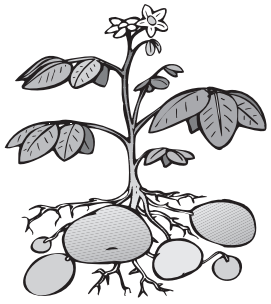
- hold the plant in place in the ground
- absorb water and nutrients from the soil
- store sugars and starch for the plant to use

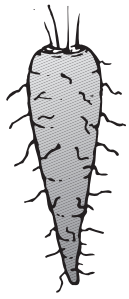
Most plant root systems can be divided into two basic types: fibrous roots and taproots. Fibrous root systems originate from the base of the plant and are usually short and thin. Grasses, palms, and lilies have fibrous root systems. A taproot system has one central root from which smaller, **lateral roots** branch. Roses, carrots, and apple trees are examples of plants with taproot systems.

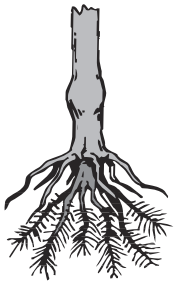
There are also specialized roots that perform special functions for different plants. For example, climbing ivies grow **adventitious roots** along their stems to help them climb and attach to walls or trees; sweet potatoes are roots that store starch for future growing needs; and, corn grows above-ground **prop roots** that help this tall plant withstand strong winds.


Branched Tap Root—Maple


Multiple Fleshy Roots—Dahlia


Tubers (Stem)—Potato


Fleshy Tap Root—Carrot


Prop roots—Corn


Adventitious—Ivy

Considering Plants and Soil

Let's Talk

Maintaining soil moisture is important to successful seed germination. How did this activity help to maintain constant soil moisture?

Did the plant used in this activity grow a fibrous or a taproot system? Explain how you know.

Let's Reflect

Why do you think the roots are the first plant part to emerge from the seed? Why not the stem or a leaf? Why is root development important to the establishment of a new plant?

Many of the foods we eat are roots, such as carrots, parsnips, and beets. In what ways do such roots help plants? In what ways do such roots help animals and people?

Let's Use It

How would root health affect the overall functioning of the plant? How does the health of your heart or lungs affect your life?

Why is it important for you to maintain a healthy lifestyle of good eating, exercise, and personal hygiene habits?

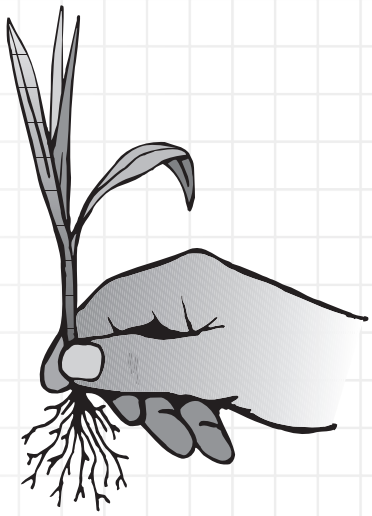
Branching Out

1. Turn a water hose onto bare soil and watch the soil wash away. Now do the same to soil on which grass plants are growing. Why is grass a good crop to grow to keep soil from washing away (**erosion**)? What part do the grass-plant roots play in preventing soil erosion? Discuss what you learned with your helper.

2. Carefully dig up several small plants and examine their roots. Try to find examples of at least three of the following root systems:

   - Fibrous roots
   - Fleshy Taproot
   - Branched Taproot
   - Multiple **Fleshy Roots**

   Identify and sketch in your journal the types of root systems that you found. Under each sketch, make a list of other plants having the same kind of root systems. Make a poster of your sketches and share it with your helper.



Fibrous Roots

3. Carefully dig two small plants (such as a grass) with branching roots and wash away the soil. Observe the branching of the roots. Note that they become smaller and smaller as you look towards the growing tips of the roots. The fine roots, those almost too small to see, are the **root hairs**. These take in water with dissolved minerals from the soil. Next, let the plants wilt until limp. Then, place one plant in water and keep the other dry. Observe both plants at intervals over a ten-hour period. What happened to each? Why? Write down your observations in your journal.

4. To answer the question, "What part of the root grows the fastest?" germinate a bean seed between two moist paper towels. Make uniformly spaced marks on the root when it is about one inch long. Record which sections of the root grow the fastest (these can be judged by the space between the marks). Can you explain why the fastest growth occurred at the root tip? Share your observations with your helper.

Cool Connections

Not all plants have "ordinary roots." The roots of some orchids grow entirely in the air and function as leaves. Spanish moss, a strange relative of the pineapple family, is neither a moss nor is it Spanish. This plant lives above the ground and spends its entire life without true roots.

Word Power

Adventitious roots	Erosion	Fibrous roots	Fleshy roots	Germinate
Lateral roots	Prop roots	Root	Root hairs	
Root system	Taproot			

Activity 4. Stems in Action

Plant stems range from the woody trunk of the mighty oak to the fragile green stem of the petunia. Although there are many different kinds of stems, their primary functions are:

- to support the leaves and flowers of the plant
- to transport water and nutrients from the roots to the leaves and other plant parts
- to transport sugars made in the leaves to the roots and other plant parts
- to store sugars made in the leaves for future use

Activity: Observation of the forces that move water through a plant stem

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

Science Process Skill: Observing and classifying

Achievement Check: You can describe different plant root systems and their functions

Virginia SOL: LS3, LS4, LS7; LA 6.2, 7.1

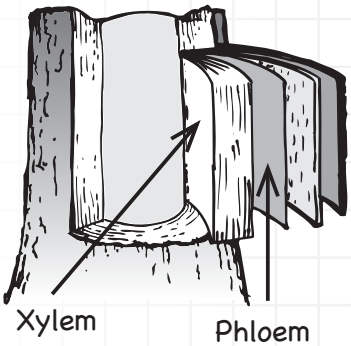
National Science Standard: Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.

Materials: glass or plastic tube, rubber tubing, small plant, stick for support, vegetable oil, paper, pencil

Let's Investigate

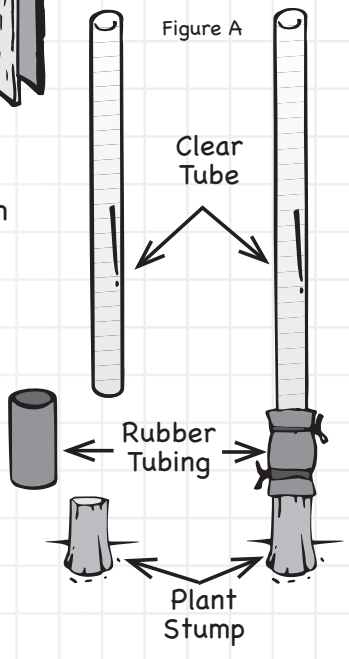
Stems: A Plant's Transport System

One of the stem's most important jobs is transporting water, nutrients, and sugars to and from different plant parts. Inside of a plant stem are special plant cells that perform this job. A plant's food and water transport system is made up of 1) **xylem** cells, which carry water and its dissolved nutrients from the roots to the rest of the plant; and, 2) **phloem** cells, which carry the plant sugars, made by photosynthesis in the leaves, to the entire plant.



This activity demonstrates how plant stems carry water in the xylem cells from the roots to the top of the plant. It works particularly well in the early spring when the weather warms, the soil is moist, and plants are just starting to grow.

1. Obtain a small glass or clear plastic tube and a short piece of rubber tubing that fits over it.
2. Select a shrub or tree shoot the size of the rubber tube. Plants like squash, sunflower, begonia, dahlia, and corn work also.
3. Cut off the plant near the ground. If water does not come from the cut, choose another plant.
4. Attach the tube and rubber tubing to the plant stump as shown (Fig. A). Support the tube as shown (Fig. B).
5. Put enough water into the tube to bring the level above the rubber tubing.



6. A drop of oil on the water in the tube helps you note the level of the liquid.
7. Place a mark on the tube at the oil level. Record the time in your journal.
8. Record changes in the oil level hourly until it stops rising. Make a graph of the changes you recorded over time.
9. Why did the water rise in the tube? If it did not rise, try another plant making sure the rubber tube is tighter around the plant stump.
10. Share what you learned about stems and water transportation within stems with your helper.

What happens: When the plant roots absorb additional soil water, the existing water in the xylem cells is pushed up the glass tube. Under natural conditions there is also a "pull" on the xylem water caused by the **transpiration** of water from the leaves.

Figure B

Diggin' In

Stems

The stem of a plant determines the form of the plant. For example, we call a plant with one large **woody** stem a tree; one with many woody stems a shrub, or, one with a long, trailing, **herbaceous** or woody stem a vine. In addition, there are many unusual stems. Think of a cactus plant. It has a very thick stem that stores water and functions as a leaf. A tulip or onion stem is located in the center of an underground bulb. Even a white potato is an underground stem!

Inside every stem there is a system of cells that transport food, water, and minerals from place to place. Xylem cells transport water and nutrients from the soil to the leaves and other plant parts. Phloem cells carry sugar made in the leaves to the roots. These two systems are grouped together in **vascular bundles** to provide the plant with the water, nutrients, and sugar it needs to grow. Plants that have xylem and phloem are called **vascular plants**. Plants that do not have these cells in their stems, such as ferns and mosses, are called **nonvascular plants**.

Considering Plants and Soil

Let's Talk

How do the xylem and the phloem cells in a plant stem work together to promote plant growth?

Why might bending a plant's stem affect the plants ability to grow?

Let's Reflect

What system inside people and animals would be similar to the vascular system found inside plants? Why?

Why do living things need an internal system to carry nutrients, water, oxygen, and waste inside their bodies?

Let's Use It

What other "transport systems" that support larger systems do you run into every day? (For example: The flow of food from the farmer, to the processor, to the wholesale distributor, to the retailer, to the consumer is a transport system that keeps people fed).

How does understanding the internal transport systems found inside living things help us better understand the importance of living a healthy lifestyle?

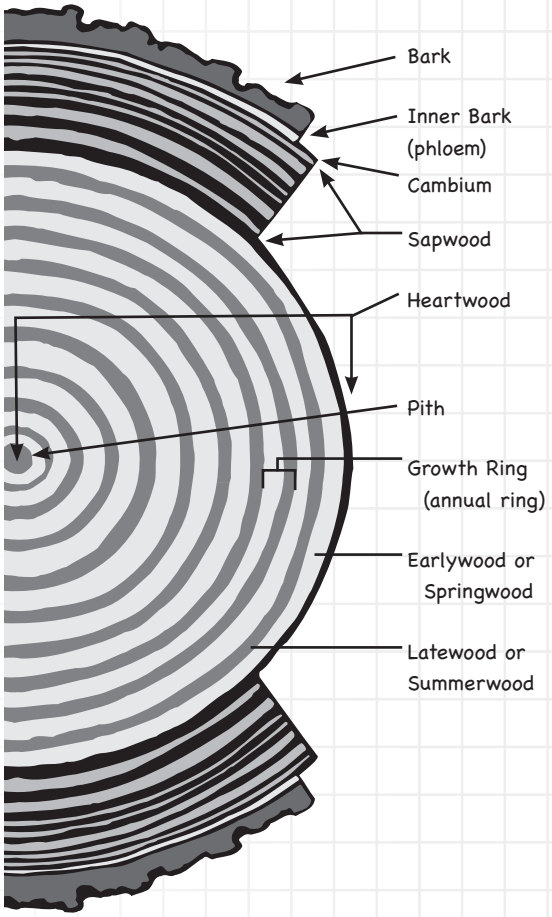
Branching Out

Locate a book on plant identification. Discuss how the form of the stem determines the identification of a plant. For example, a single woody stem makes the plant a "tree", or many woody stems make the plant a "shrub." What other plant forms are determined by the stem? Make a list in your journal of these plant forms and share it with your helper.

To demonstrate transpiration, place a clear plastic bag over a recently watered house plant. Tie the mouth of the bag around the base of the plant. Observe and record the number of hours before drops of moisture collect on the inside surface of the plastic. Where does this water come from? Explain your results to your helper.

Cut the stems of several different plants exposing a cross-section of the stem. Record the differences you see in their vascular systems as you examine fireplace logs, weeds, crop plants, garden flowers, and "bushy" plants. Draw pictures of the stem cross-sections in your journal. Discuss the differences you discovered between stem types with your helper.

Examine the sawed face of a tree log or stump. Note that the wood is arranged in rings. A tree grows a new ring of water-transporting, xylem cells every year. Count the number of growth rings you see. The number you count is the age of the tree! Show your helper the rings and discuss what you learned.



Cross Section of a Softwood Tree Stem

Cool Connections

The tallest surviving tree is a giant sequoia found in the Sierra Nevada Mountains in California. Called the "General Sherman Tree," it is slightly more than 272.4 feet tall, which is nearly the length of a football field!

Most climbing plants were originally woodland species that struggled to obtain light on the shaded forest floor. To solve this low-light dilemma, over a long period of time the tallest of these plants kept surviving and their offspring kept getting taller. Over time these plants became today's vines!

Word Power

Bud	Herbaceous	Nonvascular plants	Phloem
Photosynthesis	Stem	Transpiration	Vascular bundles
Vascular plants	Woody	Xylem	

Activity 5. Looking at Leaves

Leaves are often the most abundant part of a plant. We often identify plants by the shape and color of their leaves. Although leaves come in a wide variety of shapes, sizes, and colors, they all function to:

- perform **photosynthesis**, resulting in the production of sugar
- provide air to the plant
- regulate the moisture (**transpiration**) in a plant

Activity: Demonstrate where plants store starch made in the leaves

Life Skill: Acquiring and Evaluating Information – Acquires and evaluates information

Science Process Skill: Organizing and applying information

Achievement Check: You can describe the multiple functions of leaves

Virginia SOL: LS3, LS4, LS6; LA 6.2, 6.6, 7.1

National Science Standard: Plants and some microorganisms are producers – they make their own food.

Materials: bread, flour, peanut butter, sugar, potato, green leaf on a plant, iodine, cork

Let's Investigate

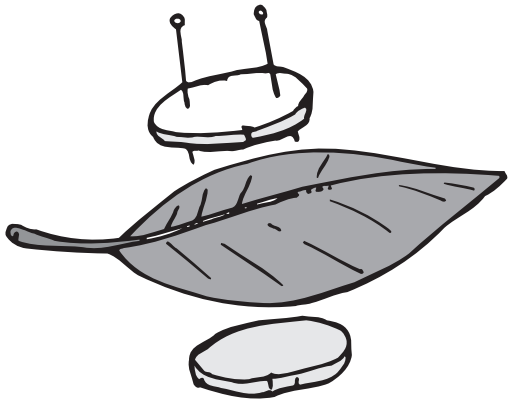
Leaves: A Recipe for Starch

Sugar produced by photosynthesis inside plant leaves often is changed into a more complex form of sugar called "**starch**." Starch is either stored or **translocated** to other plant parts for use in growth and **reproduction**. This activity demonstrates the presence of starch in various plant products and in an actively photosynthesizing leaf.

When iodine is applied to a material, it turns blue if starch is present. With the assistance of your project helper or a parent, test bread, cake, flour, peanut butter, sugar, and potatoes for starch by adding a drop of diluted iodine to the product. You will see that most plant-based products contain some starch.

To test a plant leaf for the presence of starch, select a young leaf growing in a sunny location. Do not remove the leaf from the plant.

Cover part of both sides of the leaf tightly with a cork as illustrated.



Wait for at least 24 hours.

Predict what will happen to the leaf when iodine is applied. Write down your predictions in your journal.

Test for starch by putting a drop of diluted iodine on the covered and uncovered areas. This should be done in the late afternoon on a bright sunny day.

Record and describe any differences observed in the color of the iodine. Repeat with another leaf if there is no difference.

Was there any starch in the leaf? How do you account for any difference in the amount of starch in the covered and uncovered leaf areas?

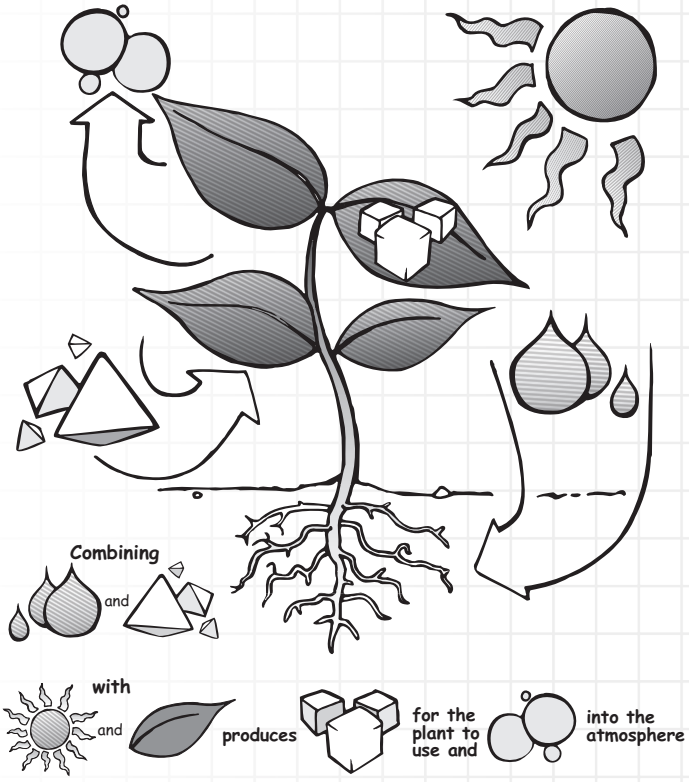
Discuss your observations and prediction results with your helper.

What happens: An actively photosynthesizing leaf produces sugars and starches. By covering up a portion of the leaf, you have prevented the light from reaching the chlorophyll and as a result you have stopped photosynthesis. You should find little or no starch in the covered portion of the leaf.

Diggin' In

Leaves

Plants rely on their leaves to act as sugar making factories. In the leaves a process called photosynthesis takes place. The purpose of photosynthesis to make sugar that is used by the plant as an energy source for growth. This process takes place in little structures located in the leaf **cells** called **chloroplasts**. A green pigment called **chlorophyll** is located in the chloroplasts. Now you know why most plants are green! Chlorophyll is the chemical that allows the plant to collect the energy from light to power the process of photosynthesis.



Put simply, photosynthesis takes place in the chloroplasts where the plant uses the energy from light, water from the soil, and **carbon dioxide** from the air to make sugar. When animals and people eat plants, they use this plant sugar for their own energy needs. The process of photosynthesis also produces oxygen, which is released into the atmosphere. People and animals use this oxygen to breath.

Considering Plants and Soil

Let's Talk

What different plant parts are used by the plant for starch storage (ex. Potato underground stems, carrot roots, etc)?

Since bright sunlight is not available when rain clouds fill the sky, how is plant starch storage similar to when people "save for a rainy day?"

Let's Reflect

Since light energy is crucial to photosynthesis, how do you think plants have evolved to maximize their exposure to light? (HINT: Look at any plant….does it have extra big leaves? A large number of leaves? Is it growing toward the light?)

Most houseplants that we grow indoors originally came from the rainforest biome (ecological community). These plants have adapted to the low-light conditions found underneath the thick forest canopy of the rainforest. What other ways do we use plants that have adapted to different light conditions?

Let's Use It

Explain how people and animals are dependent on photosynthesis for their food energy needs.

How does understanding photosynthesis help you better appreciate the importance of plants to human survival?

Branching Out

Employing the procedure used in Let's Investigate, test for starch on a leaf that has green and yellow or white areas (variegation). Are there any differences in starch content? Explain your findings to your helper.

Test for starch on a leaf that is exposed to the sun, and a leaf on a branch tightly covered with black plastic for 24 hours to exclude sunlight. Explain any differences you note to your helper.

Plants store large amounts of starch in their seeds. Find out why starch storage in seeds is important to the survival of a plant-type's future generation. Write a paragraph about the relationship between plant survival and seed starch storage in your journal. Discuss what you discovered with your helper.

Cool Connections

Leaves change color in the autumn because the green chlorophyll pigments in the leaves break down revealing the red and yellow pigments that remain behind.

Transpiration is the process of giving off water vapor through openings in the leaf. A grass plant can transpire its weight in water every day. A stalk of corn can transpire a gallon of water every day. An apple tree can transpire more than 2,000 gallons in a single season!

Word Power

Carbon dioxide	Cell	Chloroplast	Chlorophyll
Leaf	Photosynthesis	Reproduction	Starch
Translocation	Transpiration		

Activity 6. What Does it Take to Make a Seed?

We celebrate many special events throughout our lives including weddings, birthdays, holidays, and other special festivities. We use the beauty of flowers to help us celebrate when we carry a wedding bouquet, send Valentine's Day roses, or decorate with a fall festival with chrysanthemums. Since people enjoy the beauty of flowers in so many ways, it is hard to think of **flowers** as simply the "reproductive organs" of the plant. The offspring of the plant, the **seeds**, are produced inside flowers. The bright colors and fragrances that we enjoy are used by the flower to lure **pollinators** to aid in the reproductive process.

Activity: Observation of the different components of a flower

Life Skill: Acquiring and Evaluating Information – Acquires and evaluates information

Science Process Skill: Organizing and applying information

Achievement Check: You can identify the different parts of a flower

Virginia SOL: LS.3b; 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: two or three perfect flowers (see Let's Investigate), paper, pencil, plastic knife

Let's Investigate

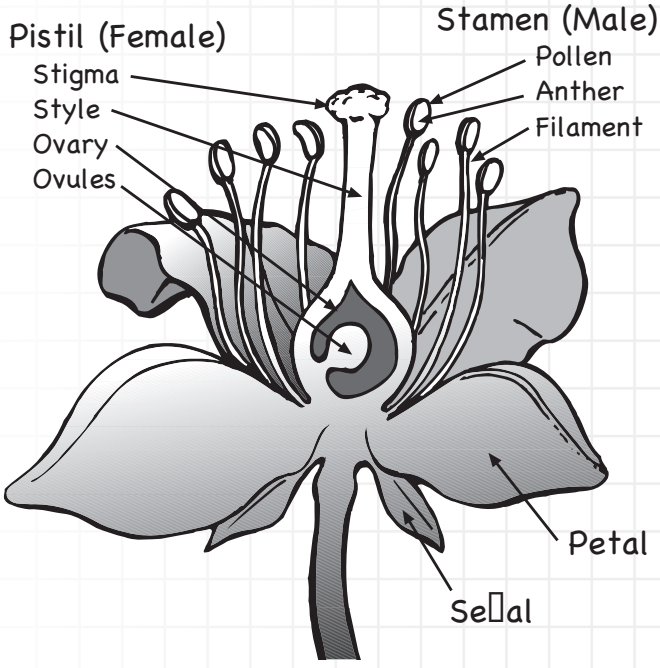
Flowers: From Blooms to Seeds

Flowers are made up of many unique parts. Each part has a specific function in **sexual reproduction**. In this activity you are going to examine the many parts that make up flowers. Each of these parts has a role in the production of seeds. Plants that have all the basic flower parts are called "perfect flowers." Flowers that are missing one or more of the basic flower parts are called "imperfect flowers." Since flowers are very different from each other, it is important that you choose a "perfect flower" for this study.

Select a two to three perfect flowers from your garden or acquire them from a florist (carnations or roses are good choices).

Carefully examine each flower and identify:

- **sepals**
- **petals**
- male **stamens** (**filament** and **anther**)
- female **pistil** (**stigma**, **style**, and **ovary**)



Draw a picture of each flower and label the flower parts you observe.

Using a plastic knife cut away the flower parts and place them on your picture.

Carefully slice the flower ovary in half. What aspects of seed formation do you see?

Discuss with your group or helper why each part of the flower is important to successful plant reproduction.

Diggin' In

How is a Seed Produced?

For a flower to make seeds it must be "pollinated." **Pollination** occurs when the **pollen**, the dust-like particles produced in the flower stamen (male), is carried to the stigma, the upper part of the pistil (female) of the flower.

After a young flower opens, such things as insects or birds can bring pollen from other similar flowers to the flower's stigma. Pollinators are attracted to flowers by their colorful petals, nectar, or fragrance. As they travel from flower to flower collecting flower nectar, pollen attaches to their bodies. As the pollinators work, the pollen falls off their bodies and is left behind on other flower stigmas. Pollination has occurred.

Wind pollinated plants do not rely on pollinators to carry pollen from plant to plant. Their flowers do not need brightly colored petals or nectar to lure pollinators. Instead, these plants produce an abundance of pollen which is carried by the wind to nearby plants. To "catch" the pollen, wind pollinated flowers have protruding stigmas.

After the flower is pollinated, the pollen grain grows a long tube down the style of the pistil and enters the ovary. **Fertilization** occurs when the pollen male **germ cell** joins with the female germ cell found inside the ovary. Once fertilization occurs, the joined germ cells form into a seed. In addition, the ovary itself can begin to swell or change. The ovary forms a protective layer that shields the seed from harm. It can also function as a way to transport the seed to a new growing place. At this point, the ovary becomes the **fruit** of the plant.

Considering Plants and Soil

Let's Talk

What differences or similarities did you find among the different types of flowers you dissected?

Farmers hire beekeepers to bring bees to their fields when their plants are in bloom. Why is it important to make pollinators available to farm crops?

Let's Reflect

Some plants, such as hollies, have flowers that have only male parts (stamens). Others of the same plant type have flowers with only female parts (pistils). Holly berries are produced on female hollies, but a male holly must be nearby to make it happen. How do you think these plants survive in nature?

Female ginkgo trees produce a very smelly fruit. What would you do to avoid the smell if you wanted to plant a ginkgo tree in your yard?

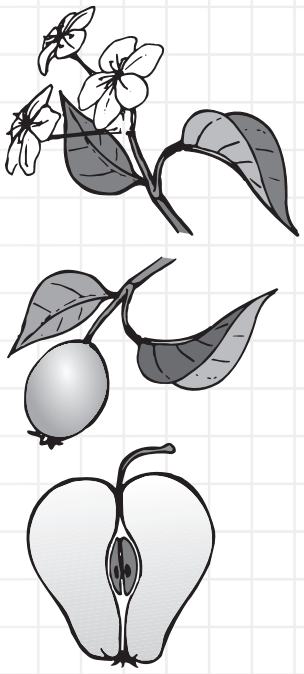
Let's Use It

Sexual reproduction produces offspring that carry characteristics from each parent. Why is this helpful to plants which must adapt to changing environmental conditions? Why is this important to every living organism?

How are you similar to both of your parents? How are you unique?

Branching Out

Using the Internet, discover other examples of how the flower ovary (ex. watermelon, tomato, coconut, peanut) changes to protect or transport (ex. maple seeds, cockleburs, dandelion) the seeds. Make a list and share it with your helper.



Sit quietly for 15 minutes in a garden, yard, or schoolyard and watch for insect pollinators. What kinds of insects did you see? Make drawings of the pollinators you observed. Label your drawings and include a description of how they carried pollen from one flower to another.

Cut an apple in half exposing the apple seeds. Compare the picture of an apple flower and the apple itself. Discuss how the ovary has changed to protect and transport the apple seeds. Share what you discovered with your helper.

Examine flowers in the yard, garden, or park. Identify the petals, stamens, stigma, style, ovary, and pistil. Look for pollen on the stamens. Press, mount, and label the different parts of one or more large flowers. Share your samples with your helper. Explain the function of each flower part.

Cool Connections

The biggest flower on record is that of the Rafflesia plant of Indonesia. The flowers are up to three feet wide and can weight up to 20 pounds each!

Pollination by bats is common in the plant world, especially in South America. A plant species called templebell attracts bats by giving out an unpleasant odor. As the bats fly around the flowers the pollen attaches to their fur, which is then taken to other flowers for pollination.

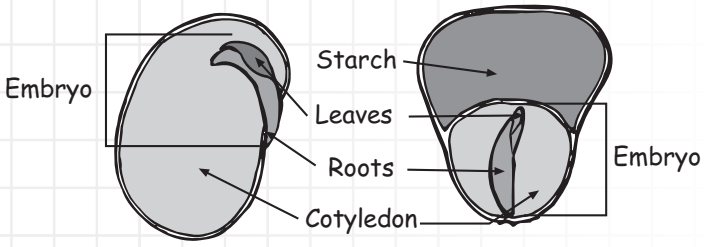
Word Power

Anther	Fertilization	Filament	Flower	Fruit
Germ cell	Ovary	Petal	Pistil	Pollen
Pollination	Pollinator	Seed	Sepa	Sexual reproduction
Stamen	Stigma	Style		

Activity 7. Surrounded by Seeds

During your lunch today check out the fruit packed with your sandwich, chips, and cookies. Carefully cut open your fruit taking care when you use the knife so as not to injure yourself, or ask an adult for assistance. Locate the **seeds** hidden inside. These seeds are the offspring of the fruit tree or plant from which your lunchtime fruit was harvested. The **fruit** itself functions only to protect those seeds, and such tasty "seed protection" it is!

A seed is a plant structure, produced in the flower **ovary**, which contains a dormant **embryo** (an immature plant) and a stored food supply, all of which are protected by a **seed coat**.



Activity: Collect different types of seeds

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

Science Process Skill: Organizing and applying information

Achievement Check: You can describe different types of seeds

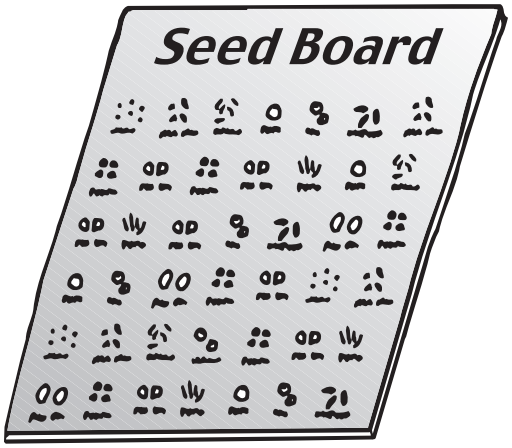
Virginia SOL: LS.5c; LA 6.2, 7.1, 7.7

National Science Standard: Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species.

Materials: seeds, newspaper, envelopes, pencil, glue, cardboard, cellophane tape, reference books on seeds

Let's Investigate

Seeds: Hope for the Future



Seeds are the end product of flower **pollination** and **fertilization**. Each seed contains a young plant called the embryo, which remains **dormant** until the environmental conditions are just right for it to begin to grow. This activity allows you to look at the variety of seeds that exist in nature.

With a parent or your helper:

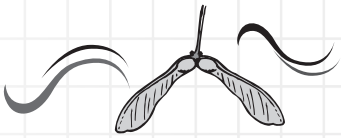
Take a trip through a park, forest, or field. Collect seeds found on the ground or attached to plants (do not remove seeds from national or state parks). Be careful not to harm any plants when collecting the seeds. Place the seeds collected in separate envelopes. Write down the date, location, and plant name of each seed collected.

Go to your kitchen and collect seeds from the vegetables and fruits found in your refrigerator.

Go to your school or home garden and collect seeds from flowers, shrubs, and trees.

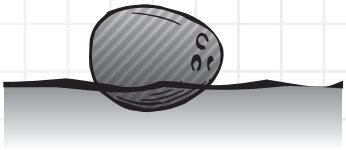
Dry the seeds by laying them out on newspaper overnight in a dry place. Store the seeds in labeled envelopes (with plant name and variety, date, and location) until you are ready to mount and label them on cardboard.

Fasten the seeds to the cardboard with a drop of glue, or place seeds in a row on the sticky side of a length of cellophane tape. Turn the tape over and press it on the cardboard. Uniform lengths of tape make a neat display.



Check with your local library for references on seed identification.

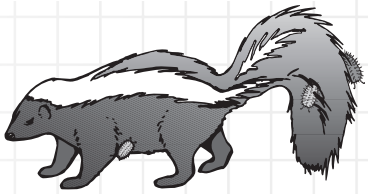
Label the seeds. You may want to group similar seeds together.



Discuss these questions with your helper:

What differences do you observe among the seeds?

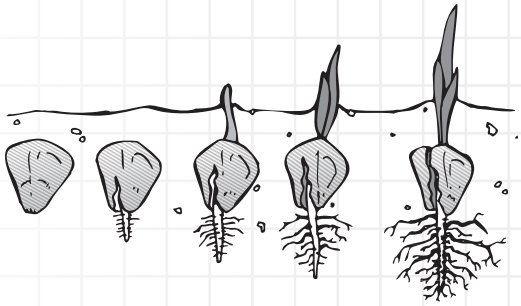
What are the different features of the seeds that allow them to be transported from place to place? How do the seeds you collected travel?



Diggin' In

Seeds

When a seed begins to **germinate**, the young embryo first grows a root down into the soil to begin absorbing water and nutrients. Once the root is functioning, the embryo then begins growing a stem or shoot that pushes upward out of the soil. The first "leaves" that are seen on some young **seedlings** are the **cotyledons**. The cotyledons are the "seed leaves" or the original seed's stored food source. The second set of leaves that develop are the **true leaves** of the plant.



Considering Plants and Soil

Let's Talk

Look at the seeds you collected. Which plant produced the largest seeds? Which plant produced the smallest seeds? Why do you think that plant size does not determine seed size? Why is there such a variety of seed types in nature?

What was the most common seed transportation system used by the plants from which you collected seeds around your home? Why do you think there are so many ways that seeds are transported?

Let's Reflect

Seeds hold the next generation of a plant type. Why do you think plants produce so many seeds at one time? Why would this be an advantage to the plant's survival?

Why do plants produce young (seeds) that are dormant? Why would this be an advantage to the plant's survival?

Let's Use It

Plants depend on sexual reproduction to provide fitting adaptations to a changing environment. How is this similar in animals and people? Why is it important that all living things have a method to adapt to a changing environment?

How does it help our communities when we have a diverse population?

Branching Out

Obtain three or four large seeds (ex. peas, beans, or peanuts) and soak them overnight. Split the seeds in half and examine the inside of the seeds. Look for the seed coat, embryo, and the stored food. Explain the function of each seed part that you observe to your helper.

Grow some of the seeds you collected in a garden or in pots. Check for growth every day. Which seeds took the longest time to grow above the ground? Which took the shortest time? Does original seed size correlate with time until growth is observed? Why or why not? Share what you learned about seed germination with your helper.

People use the oils stored in seeds to produce many products such as cosmetics, paint, linoleum, soap, margarine, etc. Find out about other ways we use seeds. Share what you discovered with your helper.

People eat many different types of seeds. Try to list the seeds that you eat during the course of a day. (Remember that bread, cereals, cookies, and pizza crust are all made from wheat seeds!) Use the Internet or another reference to find out why seeds are such an excellent source of food nutrition. Write a paragraph about seeds and human nutrition in your journal.

Cool Connections

Early European settlers carried seeds from their homes to America. They brought seeds from dandelions and crabgrass to grow for food. What do we call these plants today? Weeds!

Many seeds travel by attaching to animals and birds. In an experiment, Charles Darwin grew a splendid weed garden using seeds taken from the feet of one migratory bird. The garden was more than an acre in size!

Word Power

Cotyledons	Dormant	Embryo	Fertilization	Fruit
Germination	Ovary	Pollination	Seed	Seed coat
Seedling	Sexual reproduction		True leaves	

Activity 8. Germinating Seeds the Easy Way

As springtime approaches, gardeners begin to imagine their future gardens. They plot and plan, figuring out new ways to grow the garden of their dreams. Seeds are purchased with thoughts of a bountiful harvest and beautiful landscapes.

Growing new plants from seeds is a large part of the fun of gardening. Seeds sit quietly in their seed packages waiting for a thoughtful gardener to put them in just the right garden spot to begin growing. Out in the wild, seeds in the forest or in wildflower fields are also sitting quietly waiting for the right time to start growing. Let's find out what makes those seeds grow!

Activity: Experiment with different seed germination methods

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

Science Process Skill: Predicting outcomes and analyzing results

Achievement Check: You can germinate seeds in a variety of ways

Virginia SOL: LS.3b; LA 6.2, 6.6, 7.1

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

Materials: seeds (bean, corn, garden pea), glass or plastic tumbler, paper towels, rubber bands, plastic bag, milk carton, potting soil, plastic margarine container

Let's Investigate

Growing Seeds

Plants **sexually reproduce** by making seeds. Seeds carry the traits of both parent plants. They also remain dormant until the proper environmental factors are present to break seed **dormancy**. This activity demonstrates four methods of breaking seed dormancy and **germinating** seeds.

Between Blotter and Glass

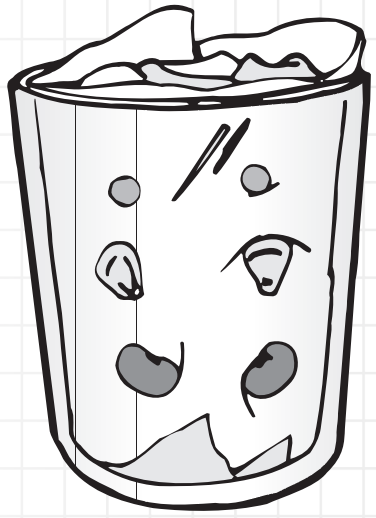
Line the sides and bottom of a glass or clear plastic tumbler with a paper towel.

Add water to wet the towel and leave a little water on the bottom of the container. Keep water in the bottom at all times.

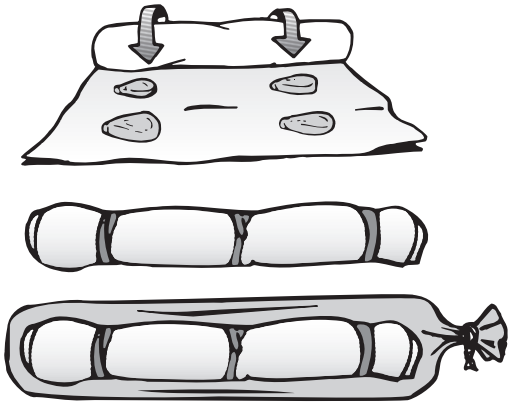
Stuff the center with other wet towels to hold the first one firmly against the sides of the container.

Slip two bean, two corn, and two garden pea seeds between the glass and the towel lining. Spread out evenly.

Examine daily. Record these observations in your journal: date the seed coat came off, how the corn, peas, and beans emerged, development of the first true leaves, and root development.



In Rolled Paper Towel



Lay seeds in rows on three layers of wet paper towels.

Roll tight and hold with rubber bands.

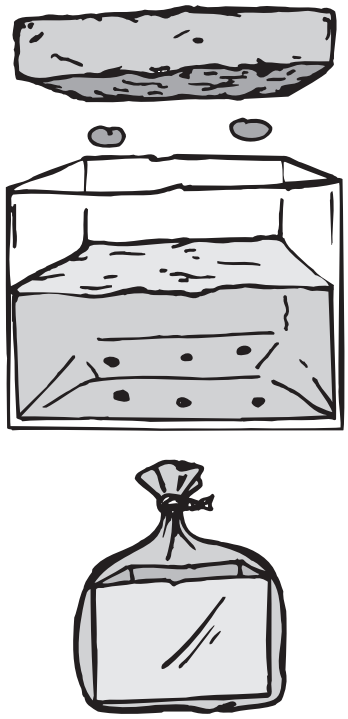
Place the roll in a plastic bag. Roll the bag and tie the end.

Keep the roll in a warm place.

Unroll and examine every two days.

With two rolls prepared several weeks apart, compare old and new seeds. Record your observations in your journal.

In Soil



Cut off the bottom four inches of a milk carton.

Punch drain holes through bottom and fill to within one inch of the top with potting soil.

Plant small seeds 1/2 inch deep and large seeds 1-1/2 inch deep.

Moisten the soil until water drains out through the bottom holes.

After water stops draining through holes, place inside a plastic bag and tie.

Set in warm place and observe daily. Record your observations in your journal.

Between Paper Towels

Place seeds between paper towels in a deep covered dish (Plastic margarine containers work well).

Moisten paper towels. Cover to prevent loss of moisture.

Keep in a warm place.

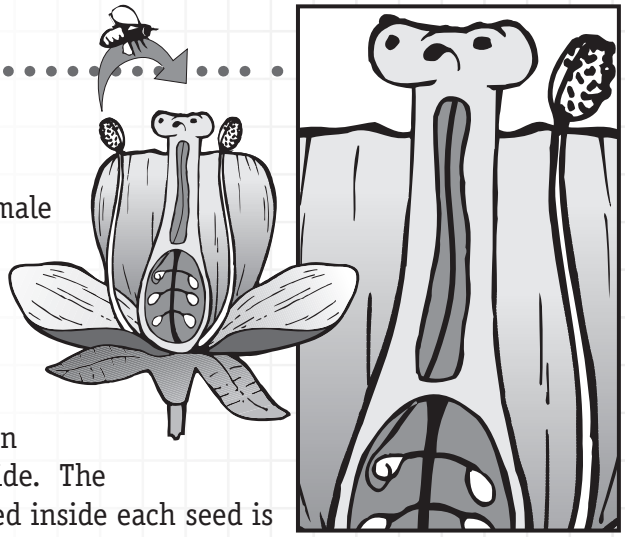
Observe daily. Record your observations in your journal.

Predict and write down which method you think will be the most effective way to germinate seeds. Explain to your helper why you made this prediction.

What environmental factors needed to be present to break the dormancy of the seeds you used in this activity? Were your predictions accurate? Why or why not?

Diggin' In

Sexual Reproduction



Sexual reproduction takes place in the **flower** of the plant where plants produce seeds from the union of male and female germ cells. Sexual reproduction occurs when insects, wind, or close contact carries **pollen** (the male germ cells) from the anthers of the flower to the pistil (female part) of the flower. The pollen grows from the stigma down the style to the flower ovary. In the ovary the male and female germ cells unite and the result is the production of a new seed. The ovary expands to protect the seeds inside. The matured, seed-filled ovary is the **fruit** of the plant. Located inside each seed is an offspring (**embryo**) that carries qualities from both of the parent plants.

Considering Plants and Soil

Let's Talk

What method of seed germination did you find most effective? Why?

Which seed type germinated first? Was this consistent with each germination method? Why do you think this happens?

Let's Reflect

Under each seed germinating method, what environmental factors had to exist for the seeds to start germinating? How are these factors provided in nature?

What happens to the seeds if the required environmental factors are not present?

Let's Use It

What advantage does sexual reproduction by seeds provide for the plant? How does this help in its survival in a changing environment?

Why do you think most animals can only reproduce sexually?

Branching Out

Seeds store starch and oils for the young embryo to use during germination. Break open two soybean seeds and two corn seeds. Try to make greasy marks on newspaper with the broken edges. Which seeds were oilseeds and which were starchy seeds? Share your findings with your helper.

Name ten vegetables that you like to eat. Which of these vegetables are actually "fruits"? (Remember: The fruit of a plant is the ovary of a flower that surrounds the seeds produced inside) Can a vegetable be a fruit? Can a fruit be a vegetable? Discuss this "dilemma" with your helper.

Seeds absorb water prior to germination. To demonstrate this process, select small bottles with a cork or rubber stopper. Fill bottles with seeds (peas or beans). Fill one bottle with water. Place stoppers on both bottles. Each hour, write down what you see happening. Explain in your own words what you see happening. Why?

Cool Connections

In early times, flowers were thought to be nature's example of goodness. It was thought that flowers simply arose from the soil that held them. In 1676, Sir Thomas Millington, an English doctor, suggested that flowers arose from plants grown from seeds. He was nearly driven from his home in London, England for even considering such a crazy thought!

Word Power

Anther	Dormancy	Embryo	Flower	Fruit
Germ cells	Germination	Ovary	Pistil	Pollen
Reproduction	Sexual Reproduction		Stigma	Style

Activity 9. Can Shoots Grow Roots?

Have you ever walked into a grocery store and seen a display of chrysanthemums for sale? And, have you ever noticed that all of those flowering plants look exactly alike? These plants are identical because they were not grown from seeds, but rather they were produced by growing roots on plant parts taken from a single plant. They are essentially clones of a single plant. This is called **asexual reproduction**.

No male and female plant parts are involved in asexual reproduction. Asexual reproduction occurs when an assortment of plant parts are encouraged to grow their own root systems. Roots grown from plant parts other than from seeds are called **adventitious roots**. This type of reproduction is usually faster than germinating seeds, and the new plant produced is exactly the same as the **parent plant**.

Activity: Learn how to root plant cuttings

Life Skill: Learning to learn – Applies new knowledge and experiences

Science Process Skill: Applying information

Achievement Check: You can successfully reproduce a plant by cuttings

Virginia SOL: LS.3b

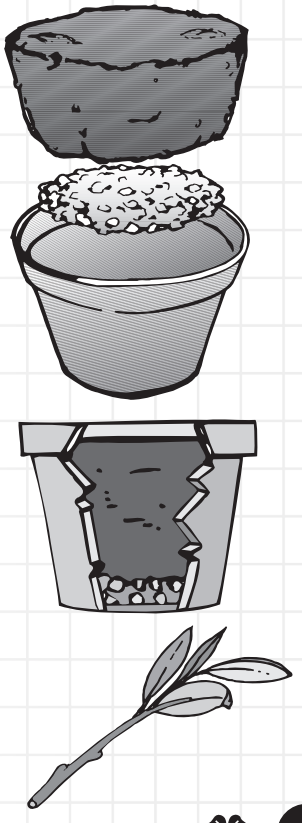
National Science Standard: Reproduction is a characteristic of all living systems. Some organisms reproduce asexually.

Materials: Plants for cuttings (as suggested in Let's Investigate), plastic container (four-inch pot, milk carton, or two-liter soda bottle), gravel, rooting mix, scissors, rooting compound (optional), plastic bag

Let's Investigate

Rooting Cuttings

Rooting **cuttings** is a form of asexual reproduction. This process involves cutting a piece of a plant stem, the "cutting," off of a parent plant and encouraging it to grow its own roots. The stem piece must have leaves attached, but the flowers should be removed. The leaves help the cutting produce the food it needs to grow roots. By removing the flowers you prevent the cutting from using its energy to make seeds. Gardeners often use this form of propagation to obtain new plants from a favorite plant.



Obtain a flowerpot, the bottom four inches of a milk carton, or similar container. If the container does not have them, make holes in the bottom, 1/4 to 1/2 inch across.

Place one inch of gravel in the bottom of the container. Fill the container within 1/2 inch of the top with rooting mix.

Select a chrysanthemum, ivy, geranium, or coleus plant.

Make a cutting about six inches long and remove the leaves three to four inches from the bottom.

Optional but desirable: dip the bottom end of the cutting in a **rooting hormone** available from a nursery or garden center.

Plant the cutting in the container with two inches (about 1/3 its height) above the surface of the soil.

Water thoroughly.

Place the container in a plastic bag.

Set in a warm area where there is indirect sunlight for most of the day.

Water as needed to keep the soil moist to the touch.

Move the plants to pots when they develop roots about three inches long. This may take three to six weeks or maybe even longer.

Enjoy your new plant!

Rooting mixes:

1/2 sand and 1/2 peat

1/2 sand and 1/2 vermiculite

1/2 perlite and 1/2 peat

Diggin' In

Asexual Reproduction

There are many ways that plants reproduce asexually in nature, and people have learned to take advantage of this ability. Asexual reproduction is used to reproduce plants that are identical with the parent plant, and at times, to hasten plant production. Methods of asexual reproduction include:

grafting	Implanting a shoot into another plant
budding	Implanting a bud into a stem
layering or air layering	Having a stem form roots while still attached to the parent plant
bulbs	New plants from a short stem enclosed by fleshy leaves
fleshy roots	New plants from a piece of an enlarged root
tubers	New plants from a piece of a short, fleshy underground stem
rhizomes	New plants from a horizontal, non-fleshy underground stem
stolons	New plants from a lateral creeping stem

Considering Plants and Soil

Let's Talk

Why do you cover newly produced cuttings with plastic? How does this help the cuttings form roots? (Remember what you learned about transpiration)

Why is rooting a cutting a faster way to reproduce plants than germinating seeds?

Let's Reflect

Do you think some people could make a living by rooting cuttings? Explain.

Why would you want a plant that is identical to its parent?

Let's Use It

Dolly the sheep was the first cloned animal. How is this similar to asexually reproducing plants?

What might be the advantages and/or disadvantages of cloning animals?

Branching Out

Take some more cuttings, but this time remove the leaves from these cuttings. Is there a difference between the root production on leafless cuttings and root production on those that kept their leaves? Discuss what you observed with your helper.

Set up an experiment that demonstrates the difference between cuttings that are rooted with rooting compound, and those that are rooted without the use of rooting compound. Record your results. Share what you discovered.

Some plants can be asexually propagated with single leaves. Take a leaf from an African violet or coleus. Cut the **leaf petiole** at an angle, one inch or more below the leaf blade. Place the petiole in a container of water (do not submerge the leaf blade). Roots should form from the petiole. Plant your rooted leaf cutting in a pot and enjoy your new houseplant!

Cool Connections

In ancient times, trees had religious significance. Greeks and Romans believed that certain trees were reserved for specific gods. The bay was the tree of Apollo; the oak was the tree of Jupiter; and the poplar was the tree of Hercules. It is fortunate that most trees can be reproduced by cuttings. Asexual reproduction made it possible for these trees to be had by all!

Word Power

Adventitious roots	Asexual reproduction	Cutting	Leaf petiole
Parent plant	Rooting hormone		

Activity 10. Growing Roots in the Air

There are many different ways to asexually reproduce a plant, but one of the most interesting is a procedure called **air layering**. This type of asexual **propagation** forces a plant to grow roots along a stem before it has been removed from the parent plant. Once the roots have grown, the stem piece can be cut off from the parent plant and grown as a new plant. The advantage of air layering is that the designated stem piece can use the parent plants roots and leaves until it is ready to be a plant on its own!

Activity: Learn how to "air layer" a plant

Life Skill: Learning to learn – Applies new knowledge and experiences

Science Process Skill: Applying information

Achievement Check: You can successfully air layer a plant

Virginia SOL: LS.3b; LA 6.2, 7.1

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

Materials: Houseplant (as suggested under Let's Investigate), pencil or toothpick, rooting hormone, sphagnum moss, clear plastic sheeting, tape or twist tie, knife

Let's Investigate

Air Layering

Air layering is usually used to propagate houseplants with thick herbaceous stems and large leaves. Air layering allows gardeners to produce roots on very large, thick stem cuttings by keeping them attached to the parent plant until they are ready to be on their own.

Select a houseplant that has thick herbaceous stems such as **Diffenbachia**, **Schefflera**, **Philodendron**, or **Agleonema**.

Cut on the underside of a stem about one quarter of the way through the limb to be layered.
WARNING: The knife used in this project can pose a potential hazard. Please use under the supervision of an adult.

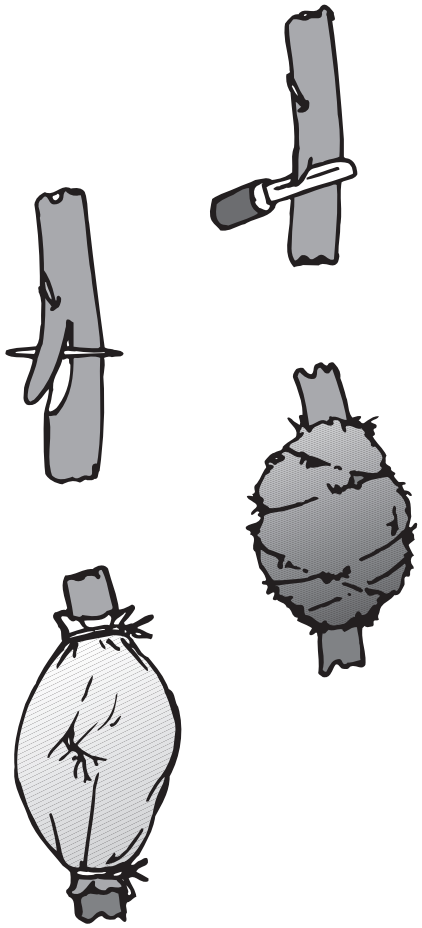
On larger stems place a pencil or toothpick in the cut to keep the cut open.

To accelerate the rooting process, apply rooting hormone to the cut.

Wrap the cut section with moist sphagnum moss or other moisture holding material.

To preserve moisture, wrap the moss with plastic. Hold in place with tape or twist ties.

After three to four weeks examine the stem for root growth. When roots are one inch long, cut below the new roots and transplant the rooted stem piece into a new pot with soil.



Using what you have learned about air layering, discuss the importance of asexual plant propagation to gardening with your helper.

The air-layered stem is ready to plant when roots are observed forming through the plastic film. Sometimes this can take up to two to three months. Once the air layer has been removed from the parent plant it should be potted in a container that is placed in cool, humid conditions. It should stay there until the air layer has grown sufficient roots to grow in the open.

Diggin' In

Layering Yesterday and Today

Air layering has been used for over a thousand years by different cultures all over the world. This effective plant propagation method has been called pot layerage, marcottage, gootee, circumposition, and Chinese layerage. Many different names for a tricky and fun way to reproduce plants!

Considering Plants and Soil

Let's Talk

What advantage is it to plants to be able to grow roots from stems or leaves?

What advantage is it to people that plants have the ability to grow roots from stems or leaves?

Let's Reflect

What advantages do you see for using air layering for asexual propagation rather than taking cuttings?

It is not uncommon to find a low growing branch of a woody shrub rooting in the soil while it is still attached to the parent plant. Speculate on how air laying was first discovered by ancient people.

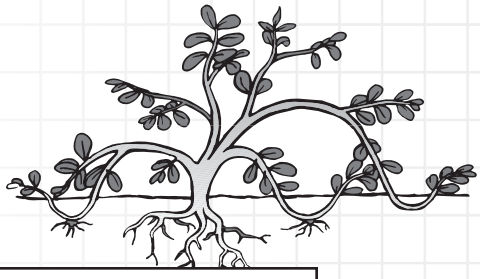
Let's Use It

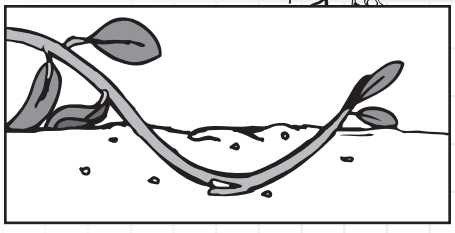
An air-layered cutting stays with the parent plant until it is able to survive on its own. How is this similar to the offspring of animals and people?

How can you use what you have learned about asexual propagation of plants to improve the environment in which you live?

Branching Out

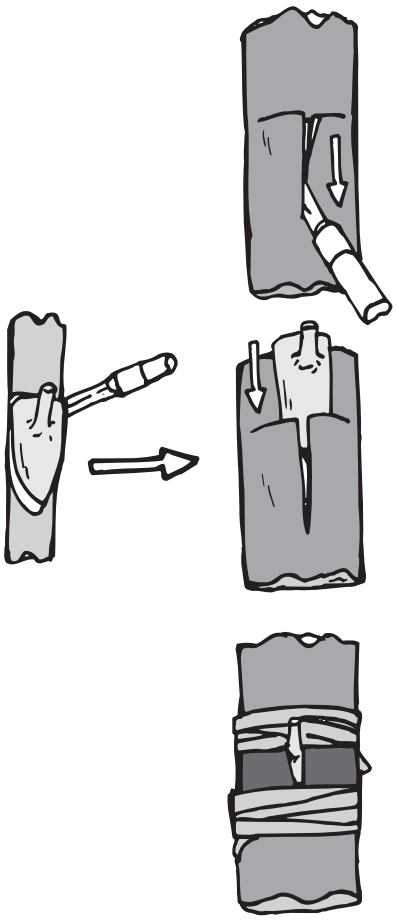
Trench layering is similar to air layering. Select a plant in your garden that grows with drooping limbs. Cut into the underside of a limb at an angle about one quarter of the way through. Cover the cut area with moist soil with the tip of the branch exposed. Cut the stem between the layer and the plant when roots are established. Share your trench layering experience with your helper.





Asexual propagation always requires that the stem or leaf get wounded or cut to initiate the rooting process. Find out why a wound is necessary for root initiation. Share what you learned with your helper.

Budding is a form of grafting. To bud, make a "T" cut into the bark of a one-year old branch. Cut a bud in a shield shape from the desired plant. Carefully slip the shield with the bud into the "T" cut. Press the shield down snugly. Hold the bud securely with a rubber band. When the bud begins to grow, remove the bands and prune the plant about three to four inches above the bud. You've made a new plant!



Cool Connections

On the islands of the South Pacific the Pisona tree manages to survive by "layering." High winds blow across the islands toppling the trees, which manage to survive even through they have been blown over time and time again. When a tree is uprooted, it simply reaches out with any handy branch, makes some new roots, and continues growing.

Word Power

Air Layering Propagation

Activity 11. Plants from Stems

Some plants have specialized stems that allow for asexual propagation of the plant. **Rhizomes** are specialized stems that grow below the ground. Examples of plants that reproduce by rhizomes are mints, lily-of-the-valley, or iris. **Stolons**, also called runners, are specialized stems that grow across the ground. Strawberries reproduce by stolons. **Bulbs** consist of scale-like leaves on a short stem enclosing one or more buds that are able to develop into new plants. Examples of bulb plants are tulips, hyacinth, Easter lily, daffodils, and onions. When a bulb is planted, it not only develops a plant, but it also grows additional bulblets from the original bulb.

Activity: Learn how to propagate plants using rhizomes, stolons, and bulbs

Life Skill: Learning to learn – Applies new knowledge and experiences

Science Process Skill: Applying information

Achievement Check: You can successfully grow a plant from rhizomes, stolons, and bulbs

Virginia SOL: LS.3b LA 6.2, 6.6, 7.1

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

Materials: Plants that reproduce by specialized stems, plastic eight-inch pots, potting soil, outdoor garden, garden trowel

Let's Investigate

Rhizomes, Stolons, and Bulbs

This activity introduces you to asexual propagation of plants using specialized stems.

Follow these steps to grow a new plant from a rhizomes or a stolon.

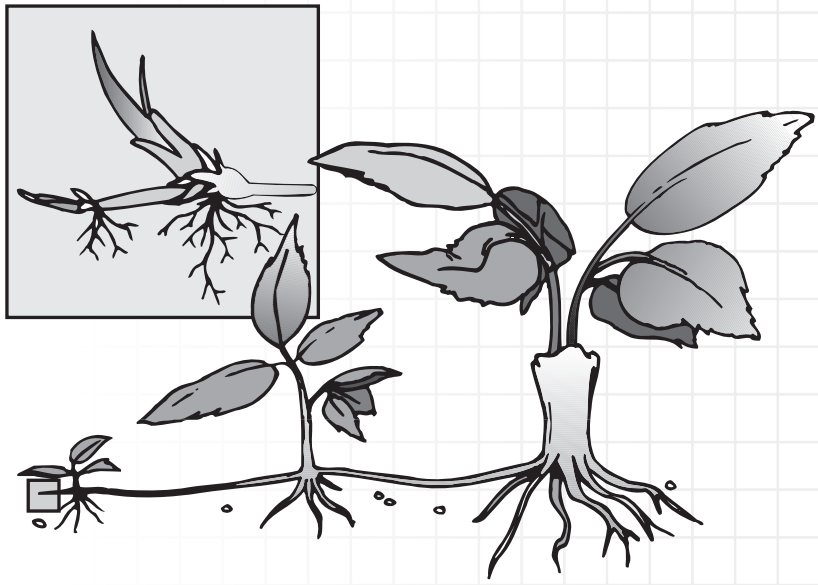
Select a plant such as strawberry, white clover, Kentucky bluegrass, red fescue, lily-of-the-valley, zoysia, or other plants that reproduce by specialized stems that grow from rhizomes, or stolons. (Strawberries should give quick results)

Plant in a loose fertile soil in a warm place in a garden.

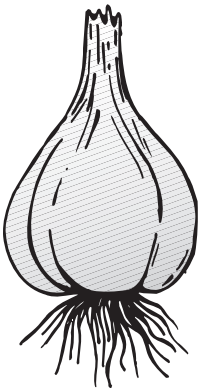
Firm the soil about the roots and keep it moist.

Water when necessary.

Observe and record your observations on the development of runners, new plants, and other features.



Follow these steps to grow a new plant from a bulb.



Select a bulb plant: For fall planting – tulip, hyacinth, lily, or narcissus; for spring planting – onion sets.

These can be planted:

In a well-drained, yet moist soil outdoors

In pots, with potting soil and submerged to the rim of the pot outdoors.

In pots, kept indoors and watered to keep moist.

When the plants mature, wash the soil from the bulbs and record any changes.

Note how new bulblets are formed and describe their characteristics.

Keep a record of your observations.

Share what you learned about growing plants from specialized stems with your helper.

Diggin' In

Forcing Bulbs

Daffodils, tulips, hyacinths and crocuses are bulb plants that bloom in the spring after a long, cold winter. These plants have adapted to seasonal climates that require they stay dormant during the cold winter months. Unfortunately for gardeners, this means they cannot grow these bulbs indoors unless they have experienced a cold period to fulfill the seasonal cold requirement.

To fool Mother Nature, gardeners chill bulbs in the refrigerator to "pretend it is winter" fulfilling the cold requirement. To do this they pot the bulbs, and then place the pots in the refrigerator or another cool, frost-free place for 10 to 15 weeks. After their chilling period is over, the pots can be placed into a sunny spot at room temperature. The bulbs start growing, and soon the gardener has beautiful flowers to enjoy.

Considering Plants and Soil

Let's Talk

Rhizomes and bulbs grow below the ground. Why are they considered to be plant stems and not roots?

Which type of plant stem was the easiest to use for propagation? Which was the hardest? Why?

Let's Reflect

Prehistoric tribes collected lily bulbs and ate them both raw and roasted. The Aztecs and Incas of South America ate dahlia rhizomes as part of their daily diet the way people eat potatoes today. Why would bulbs be an attractive plant part for human food?

What advantage does a plant have over other types of plants if it has the ability to reproduce by stolons, rhizomes, or bulbs?

Let's Use It

How important is planning to growers who provide flowering tulips and daffodils for the spring holidays?

What type of planning would you have to do if you wanted to give flowering tulips to a friend for a New Years Day gift? (Make a timeline of your plan and show it to your helper.)

Branching Out

Find out what other plants reproduce by rhizomes, stolons, and bulbs. Make a list of these plants. Share your list with your helper.

Amaryllis and paper white bulbs do not require a cold period to initiate growth. Try growing some of these bulbs and share their beauty with a friend.

Cool Connections

Tulip flowers grow from tulip bulbs. In the sixteenth century, there was a very real "tulip mania" that swept throughout Europe and single bulbs sold for hundreds of dollars. In Holland, one rare bulb was traded for 36 bags of corn, 72 bags of rice, 4 fat cows, 12 sheep, 8 pigs, 2 barrels of wine, 4 barrels of beer, 2 tons of butter, 2 pounds of cheese and a silver cup. A fortune for a single tulip bulb!

Word Power

Bulb Rhizome Stolon

Activity 12. More Plants from Unique Plant Parts

Activity: Learn how to propagate a plant using tubers and fleshy roots

Life Skill: Learning to learn - Applies new knowledge and experiences

Science Process Skill: Applying information

Achievement Check: You can successfully reproduce a plant by tubers or fleshy roots

Virginia SOL: LS.3b; LA 6.2, 7.1

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

Materials: Potato, sweet potato, **soilless potting mix**, four- to six-inch plastic containers, glass jar, knife

WARNING: Glass jars and the knife used in this project can pose a potential hazard. Please use them under adult supervision.

Some plants have specialized, underground stems called tubers. **Tubers** are considered to be stems because **buds** are located on this fleshy underground plant part. Only the stems of a plant have buds. Other plants have **fleshy roots** that look like tubers, but do not have buds. These are simply storage roots that accumulate starch to be used at a later date for growth and reproduction.

Let's Investigate

Tubers and Fleshy Roots

The potato is the best-known tuber, and the "eyes" of the potato are the buds. Potatoes found in the grocery stores are often treated with sprout inhibitors. For this activity it is best to use older potatoes whose eyes have already started to grow.

Select a potato that shows signs of growth (the potato "eyes" are swelling).

Cut the potato in half between the stem end and the seed end. The stem end is the point where the potato was attached to the plant.

Plant with the cut side down in separate containers filled with soilless potting mix.

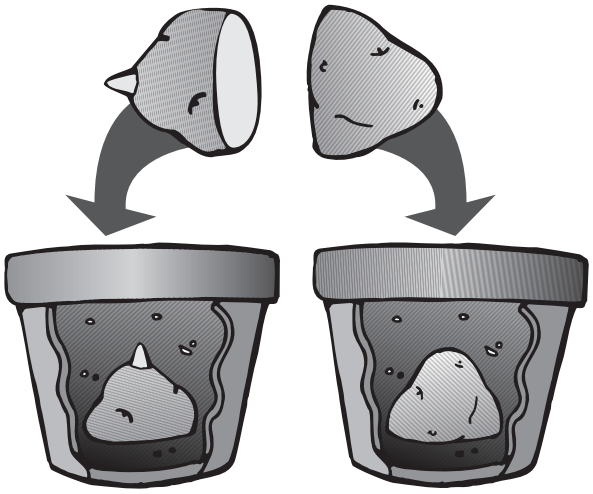
Keep the container moist and in a warm place.

Record your observations as the aerial stem starts to grow and describe how the plants develop. Note the time difference in the sprouting of the two pieces.

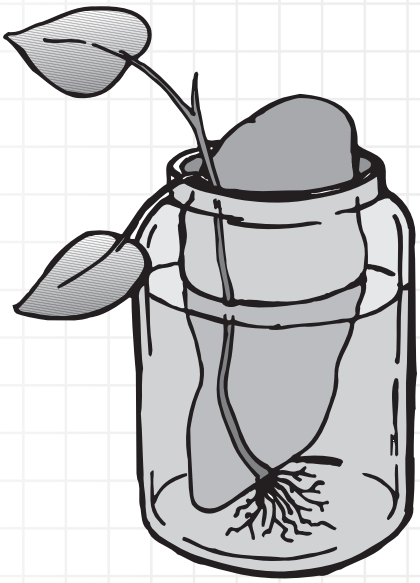
The plants are well established when the shoots are about 12 inches tall.

Carefully remove the plant from the container and wash the soil off the potatoes and roots.

Note the type of root system that has developed and the appearance of new potatoes.



Although it looks like a white potato, the sweet potato does not have any buds and is therefore not an underground stem, or tuber. However, like the white potato, pieces of this fleshy root can produce new plants asexually.



Place a sweet potato in a glass jar filled with water leaving about 1/3 of the larger end of the sweet potato exposed above the water line.

Set in a warm sunny spot such as a kitchen windowsill or ledge. The vine grows down over the edge and droops.

Keep the jar filled with water.

Record the date the project started, the date vine growth first began, where on the sweet potato that the roots and vines appeared, the increase in vine length each week, and the date the project ended.

Change the water in the jar weekly.

Explain to your helper where the food and energy came from to support growth.

Diggin'

Potatoes in the Past

Archeologists have found evidence that the Inca Indians in Peru were the first to cultivate potatoes in about 200 BC. Potatoes were used by the Incas as medicine and food. In fact, they believed that raw slices of potatoes laid on broken bones would cause them to heal. Today the potato is one of the largest food crops in the world. Potatoes are one of the most popular vegetables in America. Americans eat potatoes in one out of every three meals.

Considering Plants and Soil

Let's Talk

Potatoes and sweet potatoes contain large amounts of starch. Where did this starch come from?

Why do you think some plants store large amounts of sugars and starches, and others store very little? (Hint: Think about what you learned about annuals and perennials)

Let's Reflect

How do potato and sweet potato farmers' benefit by these plants' ability to reproduce from underground parts?

What do you think is the greatest disadvantage of reproducing plants asexually?

Let's Use It

How can you use what you learned about asexual reproduction of plants to help you become a better earth steward?

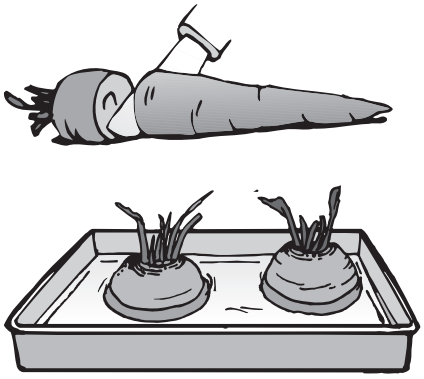
What relationship have you discovered between a plant's ability to asexually reproduce itself, and that plant's ability to compete in nature?

How would life be different if humans could reproduce asexually?

Branching Out

Make a list of other plants that reproduce by tubers and fleshy roots. How are these plants different? How are they the same? Share your list with your helper.

Set up an experiment to determine the smallest piece of potato that can produce a new potato plant. Share your results with your group or helper.



To grow a carrot from a root, cut the top off a carrot just below the root. Place the carrot top in a shallow dish with 1/2 inch of water. Watch, measure, and record the growth of the carrot tops. What do you see happening? Share your observations with your helper.

Cool Connection

The underground root system of the orchid includes tubers. The orchid comprises one of the world's largest families of flowering plants numbering more than 25,000 species. Orchids grow in virtually every part of the globe except the desert and Polar Regions.

Word Power

Bud Fleshy root Soilless potting mix Tuber

Glossary

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

air layering a method of propagation where a cut is made in a woody stem, surrounded by damp peat moss, held in place by a wrap, then when roots form, the stem can be removed and planted

anther the part of a stamen where pollen is produced – usually at the tip. A male plant part that aids in sexual reproduction of plants

asexual reproduction reproducing plants without the union of male and female germ cells, such as rooting cuttings, grafting, layering, budding, etc.

bud a small swelling or projection on a plant stem, from which a shoot or cluster of leaves or flower develops

bulb an underground food-storage organ that is essentially a modified bud consisting of fleshy leaves that surround and are attached to a small stem

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

chlorophyll green pigment essential to photosynthesis

chloroplast a plant cell structure containing chlorophyll

cotyledon the seed leaf. First source of nutrients to the developing embryo

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

dormant a state of reduced activity in which no, or very little growth takes place

embryo the undeveloped plant within a seed

erosion slow destruction of soil or rock by the action of water, wind, or ice

fertilization the formation of a new plant (a zygote) through the fusion of two germ cells (gametes)

fibrous root a root that has no prominent central axis and that branches in all directions

filament the stalk portion of a stamen

fleshy root a thickened root that resembles a tuber

flower usually the sexual reproductive part of a plant

fruit	the seed-bearing product of a plant
germ cell	a sex cell, either male or female, having half a set of chromosomes; also called a gamete
germination	the process by which a plant embryo starts to grow
herbaceous	referring to non-woody plants
lateral roots	roots that emerge from the central taproot of a taproot system
leaf	a flattened, usually photosynthetic structure arranged in various ways on a stem
leaf litter	the surface layer of the forest floor or garden, in which the leaves are slightly decomposed
leaf petiole	the stalk of a leaf that attaches to the stem
life cycle	series of stages through which a plant passes before arriving again at the starting point
mature	stage at which seeds or plants are fully developed
nonvascular plant	a plant that does not have xylem or phloem
ovary	base of a pistil, where the seed develops. The ovary is a female plant part and aids in sexual reproduction of plants
parent plant	the plant from which seeds or cuttings are taken for reproduction
petal	a unit of a flower; usually both flattened and colored
phloem	plumbing system that conducts food manufactured in the leaves to all parts of the plant; a living system of cells
photosynthesis	process by which chlorophyll and energy of light convert carbon dioxide and water into sugars and starches in growing plants
pistil	the female element of a flower – composed of stigma, style, and ovary
pollen	the male germ cells produced in the anthers
pollination	the transfer of pollen from the flower anther to the flower stigma
pollinator	a living organism, such a honeybee, bat, or bird, that transfers pollen from one flower to another
propagation	to produce plants by either sexual or asexual reproduction
prop roots	aerial roots that provide extra support for a stem
reproduction	process by which plants and animals create offspring
rhizome	an underground stem, usually horizontally oriented, which may be superficially root-like in appearance

root	the underground (usually) part of the plant that absorbs water and nutrients and anchors the plant
root hairs	the thin walled, hair-like tubular outgrowth from a growing root, which serve to absorb water and minerals from the soil
rooting hormone	a biochemical product used to induce adventitious roots on a variety of plant parts
root system	the part of a plant, usually below the ground, that lacks nodes, shoots, and leaves, holds the plant in position, draws water and nourishment from the soil, and stores food
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
sepal	a unit of the flower that frequently resembles a reduced leaf; often function tin protecting the unopened flower bud
sexual reproduction	male and female union contributing to seed production
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
stamen	pollen producing organ of a flower
starch	a complex sugar
stem	stalk, trunk, or branch of a plant; can be vertical or horizontal; above or below ground
stigma	tissue at the tip or side of the style that receives the pollen; a female plant part that aids in sexual reproduction of plants
stolon	a stem that grows horizontally along the surface of the ground
style	tube connecting the stigma of a flower with the ovary. A female plant part that aids in sexual reproduction of plants
taproot	the main root of a plant, having a single, dominant axis and providing structural support and food storage
tendril	a clasping, twining, slender outgrowth of the stem that helps support climbing plants
thorn	a stout, sharp, woody outgrowth of the stem or branch
translocation	the transport of organic food materials in solution through tissues from one part of a plant to another

transpiration	the loss of water through plant tissue, especially through stomata
true leaves	the first set of real leaves produced by a young seedling
tuber	a swollen, fleshy underground stem
vascular bundles	a unit containing both the phloem and xylem
vascular plant	a plant having xylem and phloem
woody	forming stems that mature to wood
xylem	plumbing system that conducts water and dissolved minerals to all parts of the plant; the majority of cells in this system are dead

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

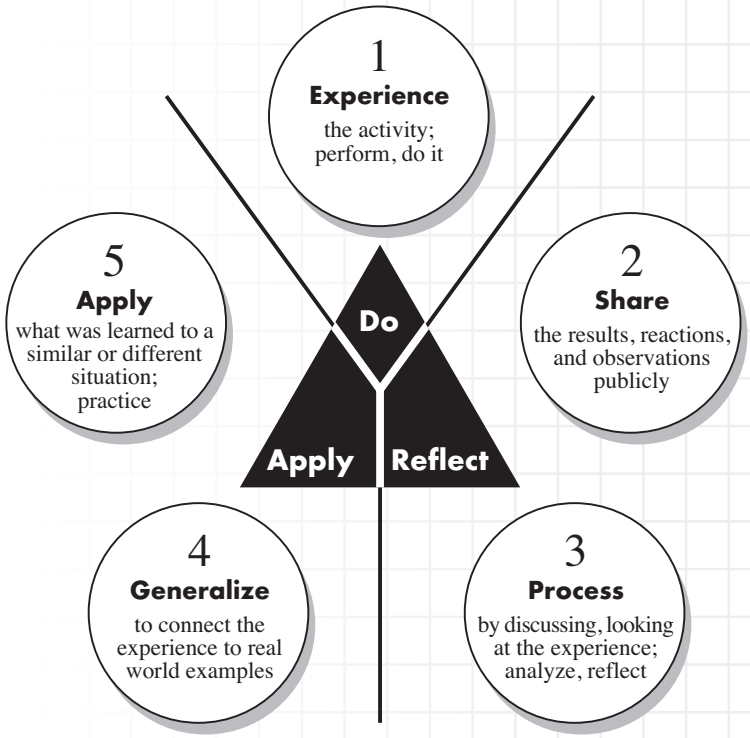
Key Concept: Analyze patterns. Key Question: "What's important?"

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.

Publication 380-021 2014

www.ext.vt.edu

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2014

VT/0114/4H-247NP