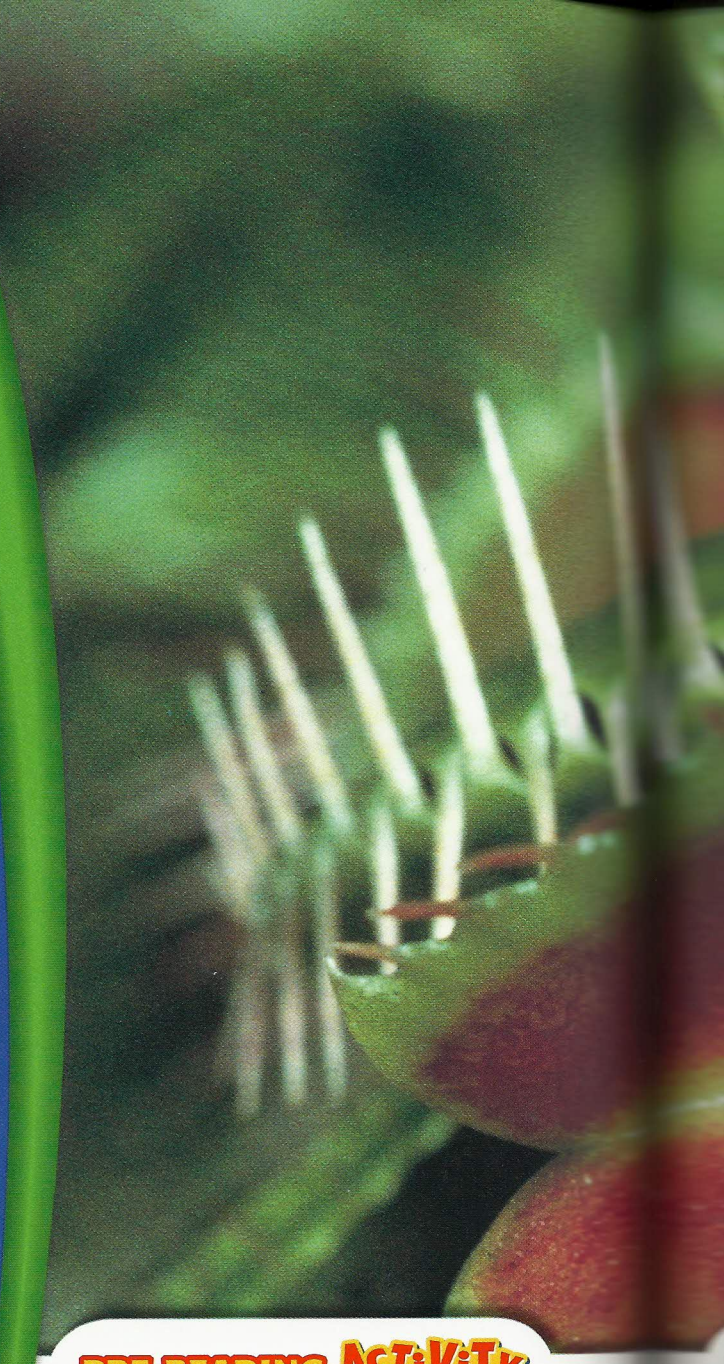
5 Plant Processes

About the PHOTO

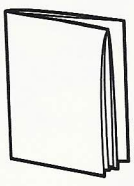
The plant in this photo is a Venus' flytrap. Those red and green spiny pads are its leaves. Like other plants, Venus' flytraps rely on photosynthesis to get energy. What is so unusual about the Venus' flytrap? Unlike most plants, the Venus' flytrap gets important nutrients, such as nitrogen, by capturing and digesting insects or other small animals.



PRE-READING ACTIVITY

FOLDNOTES

Booklet Before you read the chapter, create the FoldNote entitled "Booklet" described in the **Study Skills** section of the Appendix. Label each page of the booklet with a main idea from the chapter. As you read the chapter, write what you learn about each main idea on the appropriate page of the booklet.



START-UP ACTIVITY

Which End Is Up?

If you plant seeds with their "tops" facing in different directions, will their stems all grow upward? Do this activity to find out.

Procedure

1. Pack a **clear, medium-sized plastic cup** with slightly moistened **paper towels.**
2. Place **five or six corn seeds,** equally spaced, around the cup between the side of the cup and the paper towels. Point the tip of each seed in a different direction.
3. Using a **marker,** draw arrows on the outside of the cup to show the direction each seed tip points.
4. Place the cup in a well-lit location for 1 week. Keep the seeds moist by adding **water** to the paper towels as needed.
5. After 1 week, observe the seeds. Record the direction in which each shoot grew.

Analysis

1. In which direction did each of your shoots grow?
2. What might explain why your shoots grew the way they did?

SECTION 1

Photosynthesis

Plants don't have lungs. But like you, plants need air. Air contains oxygen, carbon dioxide, and other gases. Your body needs oxygen, and plants need oxygen. But what other gas is important to plants?

If you guessed *carbon dioxide*, you are correct. Plants use carbon dioxide for photosynthesis (FOHT oh SIN thuh sis). **Photosynthesis** is the process by which plants make their own food. Plants capture energy from sunlight during photosynthesis. This energy is used to make the sugar glucose ($C_6H_{12}O_6$) from carbon dioxide (CO_2) and water (H_2O).

Capturing Light Energy

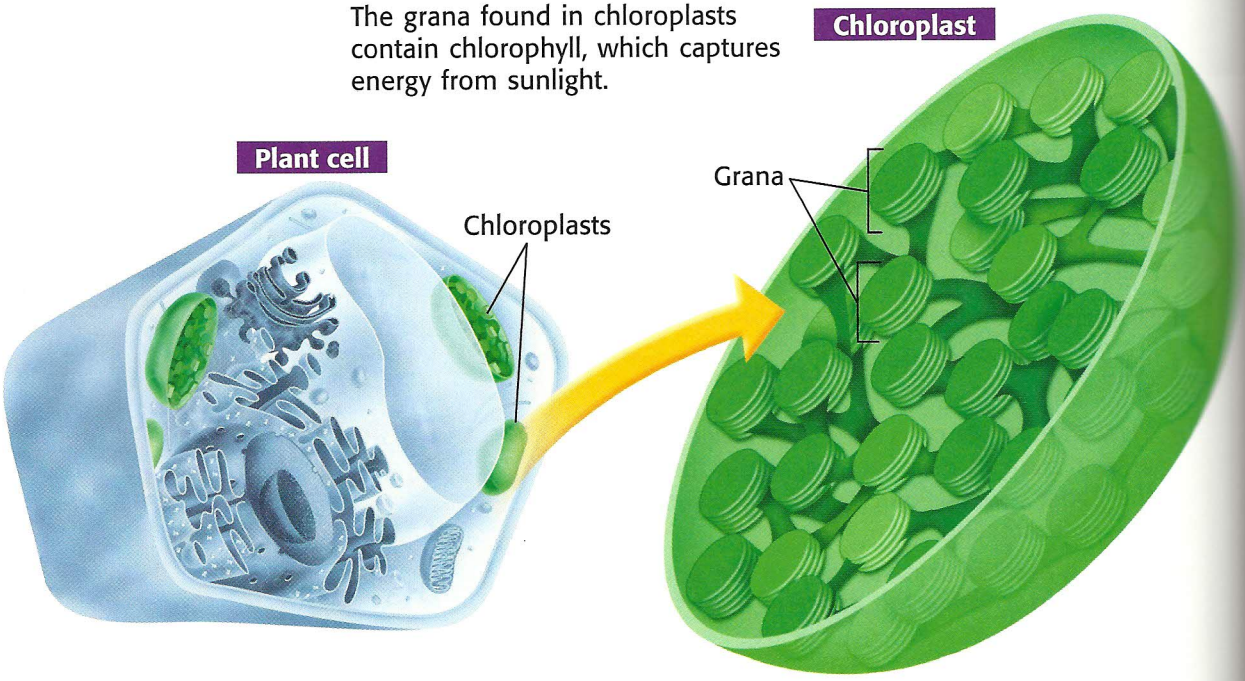
Plant cells have organelles called *chloroplasts* (KLAWR uh PLASTS), shown in **Figure 1.** Chloroplasts are surrounded by two membranes. Inside the chloroplast, another membrane forms stacks called *grana* (GRAY nuh). Grana contain a green pigment, called **chlorophyll** (KLAWR uh FIL), that absorbs light energy.

Sunlight is made up of many different wavelengths of light. Chlorophyll absorbs many of these wavelengths. But it reflects more wavelengths of green light than wavelengths of other colors of light. So, most plants look green.

Reading Check **Why are most plants green?** (*See the Appendix for answers to Reading Checks.*)

Figure 1 **Chloroplast Structure**

The grana found in chloroplasts contain chlorophyll, which captures energy from sunlight.



READING WARM-UP

Objectives

- Describe photosynthesis.
- Compare photosynthesis and cellular respiration.
- Describe how gas is exchanged in the leaves of plants.
- Describe two ways in which photosynthesis is important.

Terms to Learn

photosynthesis
chlorophyll
cellular respiration
stoma
transpiration

READING STRATEGY

Discussion Read this section silently. Write down questions that you have about this section. Discuss your questions in a small group.

Making Sugar

The light energy captured by chlorophyll is used to help form glucose molecules. In turn, oxygen gas (O_2) is given off by plant cells. Photosynthesis is a complicated process made up of many steps. But photosynthesis can be summarized by the following chemical equation:

$$6CO_2 + 6H_2O \xrightarrow{\textit{light energy}} C_6H_{12}0_6 + 6O_2$$

Six molecules of carbon dioxide and six molecules of water are needed to form one molecule of glucose and six molecules of oxygen. **Figure 2** shows where plants get the materials for photosynthesis.

Getting Energy from Sugar

Glucose molecules store energy. Plant cells use this energy for their life processes. To get energy, plant cells break down glucose and other food molecules in a process called **cellular respiration.** During this process, plant cells use oxygen. The cells give off carbon dioxide and water. Excess glucose is converted to another sugar called *sucrose* or stored as starch.

CONNECTION TO Social Studies

WRITING SKILL **Sugar** Some plants make and store large amounts of sucrose, or table sugar, during photosynthesis. People harvest these plants for sucrose. Identify a plant that produces large amounts of sucrose. Then, identify how people use the plant and which countries are major growers of the plant. Write an article about your findings in your **science journal.**

photosynthesis the process by which plants, algae, and some bacteria use sunlight, carbon dioxide, and water to make food

chlorophyll a green pigment that captures light energy for photosynthesis

cellular respiration the process by which cells use oxygen to produce energy from food

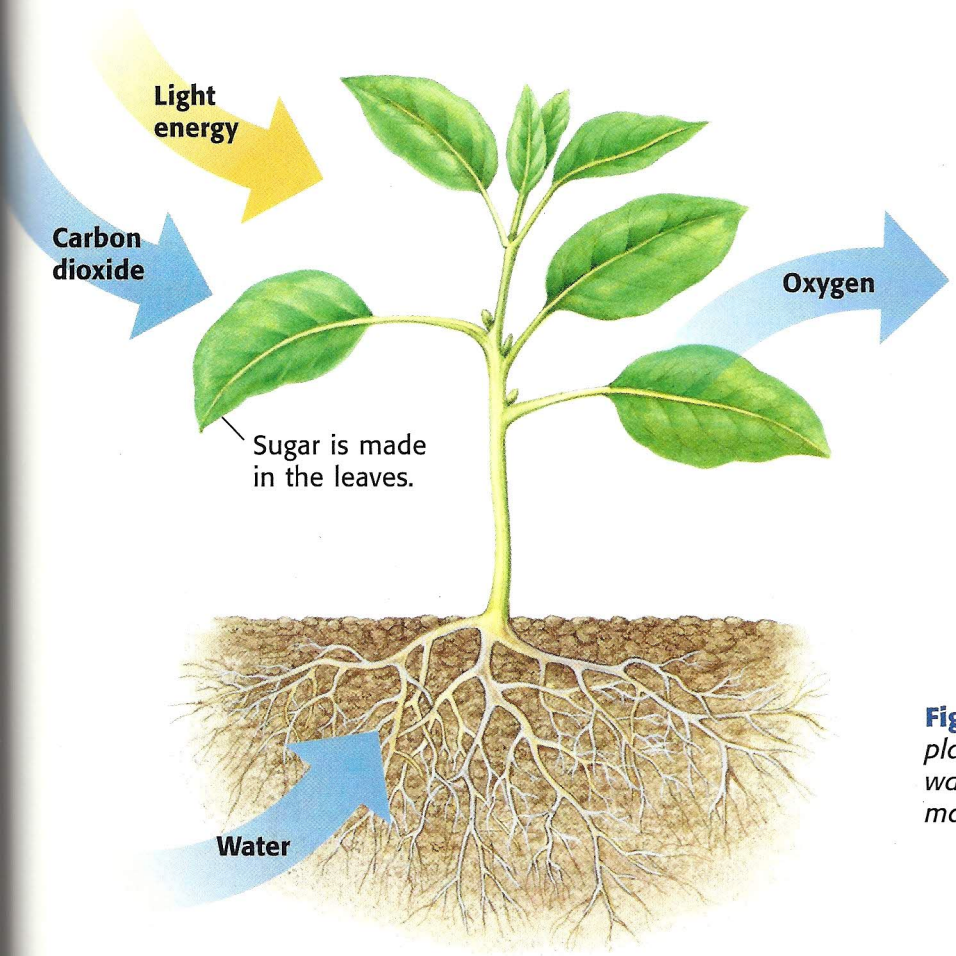
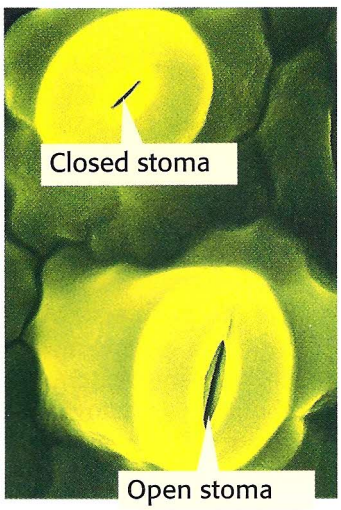
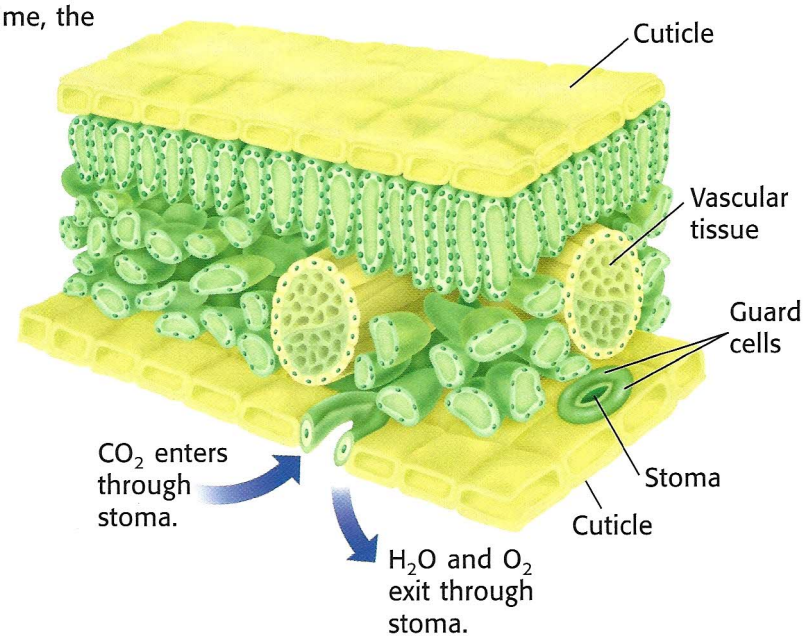


Figure 2 *During photosynthesis, plants take in carbon dioxide and water and absorb light energy. They make sugar and release oxygen.*

Figure 3 **Gas Exchange in Leaves**

When light is available for photosynthesis, the stomata are usually open. At nighttime, the stomata close to conserve water.





Gas Exchange

Many above-ground plant surfaces are covered by a waxy cuticle. The cuticle protects the plant from water loss. How does a plant get carbon dioxide through this barrier? Carbon dioxide enters the plant's leaves through stomata (singular, *stoma*). A **stoma** is an opening in the leaf's epidermis and cuticle. Each stoma is surrounded by two *guard cells*. The guard cells act like double doors, opening and closing the stoma. You can see stomata in **Figure 3.**

stoma one of many openings in a leaf or a stem of a plant that enable gas exchange to occur (plural, *stomata*)

transpiration the process by which plants release water vapor into the air through stomata

When stomata are open, carbon dioxide enters the leaf. The oxygen produced during photosynthesis exits the leaf through the stomata. Water vapor also exits the leaf in this way. The loss of water from leaves is called **transpiration.** Most of the water absorbed by a plant's roots replaces the water lost during transpiration. Sometimes, more water is lost through a plant's leaves than is absorbed by the plant's roots. When this happens, the plant wilts.

CONNECTION TO Chemistry

Transpiration Wrap a plastic bag around the branch of a tree or a portion of a potted plant. Secure the bag closed with a piece of tape or a rubber band, but be sure not to injure the plant. Record what happens over the next few days. What happened to the bag? How does this illustrate transpiration?

ACTIVITY

The Importance of Photosynthesis

Plants and other photosynthetic organisms, such as some bacteria and many protists, form the base of nearly all food chains on Earth. An example of one food chain is shown in **Figure 4.** During photosynthesis, plants store light energy as chemical energy. Some animals use this chemical energy when they eat plants. Other animals get energy from plants indirectly. These animals eat animals that eat plants. Most organisms could not survive without photosynthetic organisms.

Plants, animals, and most other organisms rely on cellular respiration to get energy. Cellular respiration requires oxygen. Oxygen is a byproduct of photosynthesis. So, photosynthesis provides the oxygen that animals and plants need for cellular respiration.

Reading Check **What are two ways in which photosynthesis is important?**

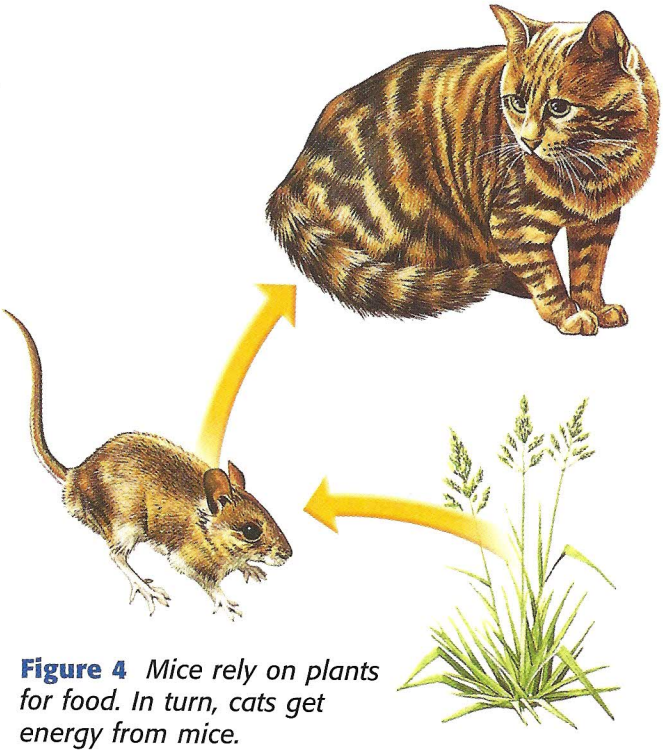


Figure 4 *Mice rely on plants for food. In turn, cats get energy from mice.*

SECTION Review

Summary

- During photosynthesis, plants use energy from sunlight, carbon dioxide, and water to make food.
- Plants get energy from food by cellular respiration, which uses oxygen and releases carbon dioxide and water.
- Transpiration, or the loss of water through the leaves, happens when stomata are open.
- Photosynthesis provides oxygen. Most animals rely on photosynthetic organisms for food.

Using Key Terms

1. In your own words, write a definition for each of the following terms: *photosynthesis*, *chlorophyll*, and *cellular respiration*.

Understanding Key Ideas

2. During photosynthesis, plants
   - **a.** absorb energy from sunlight.
   - **b.** use carbon dioxide and water.
   - **c.** make food and oxygen.
   - **d.** All of the above
3. How is cellular respiration related to photosynthesis?
4. Describe gas exchange in plants.

Math Skills

5. Plants use 6 carbon dioxide molecules and 6 water molecules to make 1 glucose molecule. How many carbon dioxide and water molecules would be needed to make 12 glucose molecules?

Critical Thinking

6. **Predicting Consequences** Predict what might happen if plants and other photosynthetic organisms disappeared.
7. **Applying Concepts** Light filters let through certain colors of light. Predict what would happen if you grew a plant under a green light filter.

SECTION 2

Reproduction of Flowering Plants

Imagine you are standing in a field of wildflowers. You're surrounded by bright colors and sweet fragrances. You can hear bees buzzing from flower to flower.

Flowering plants are the largest and most diverse group of plants. Their success is partly due to their flowers. Flowers are adaptations for sexual reproduction. During sexual reproduction, an egg is fertilized by a sperm.

READING WARM-UP

Objectives

- Describe pollination and fertilization in flowering plants.
- Explain how fruits and seeds are formed from flowers.
- List three reasons why a seed might be dormant.
- List three examples of asexual reproduction in plants.

Terms to Learn

dormant

READING STRATEGY

Reading Organizer As you read this section, make a table comparing sexual reproduction and asexual reproduction in plants.

Fertilization

In flowering plants, fertilization takes place within flowers. *Pollination* happens when pollen is moved from anthers to stigmas. Usually, wind or animals move pollen from one flower to another flower. Pollen contains sperm. After pollen lands on the stigma, a tube grows from each pollen grain. The tube grows through the style to an ovule. Ovules are found inside the ovary. Each ovule contains an egg. Sperm from the pollen grain move down the pollen tube and into an ovule. Fertilization happens when a sperm fuses with the egg inside an ovule. **Figure 1** shows pollination and fertilization.

Figure 1 Pollination and Fertilization

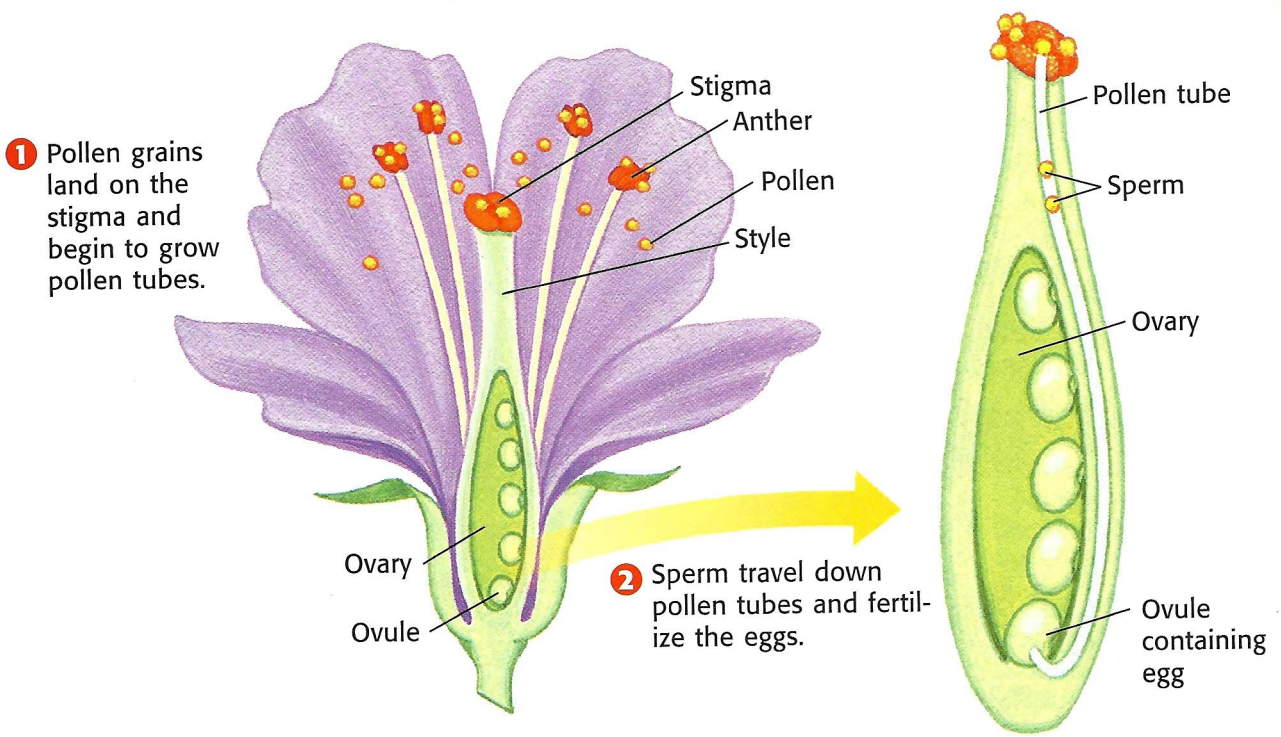
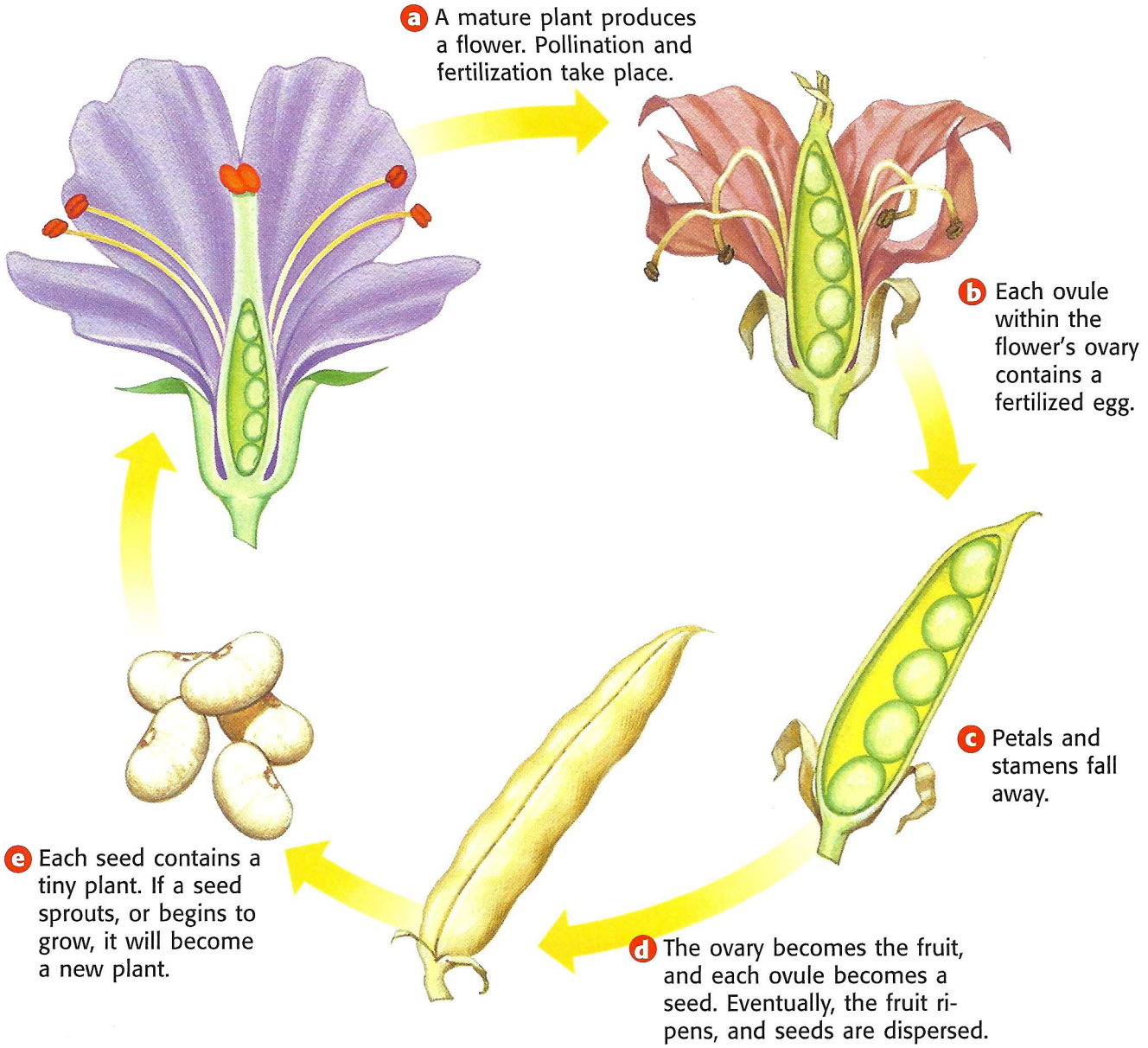


Figure 2 Seed Production



From Flower to Fruit

After fertilization takes place, the ovule develops into a seed. The seed contains a tiny, undeveloped plant. The ovary surrounding the ovule becomes a fruit, as shown in **Figure 2.**

As a fruit swells and ripens, it protects the developing seeds. **Figure 3** shows a common fruit. Fruits often help a plant spread its seeds. Many fruits are edible. Animals may eat these fruits. Then, the animals discard the seeds away from the parent plant. Other fruits, such as burrs, get caught in an animal's fur. Some fruits are carried by the wind.

Reading Check **How do fruits help a plant spread its seeds?** *(See the Appendix for answers to Reading Checks.)*

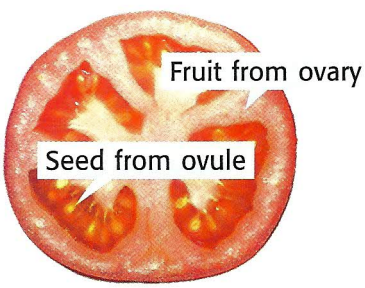


Figure 3 *Tomatoes develop from a flower's ovary and ovules.*

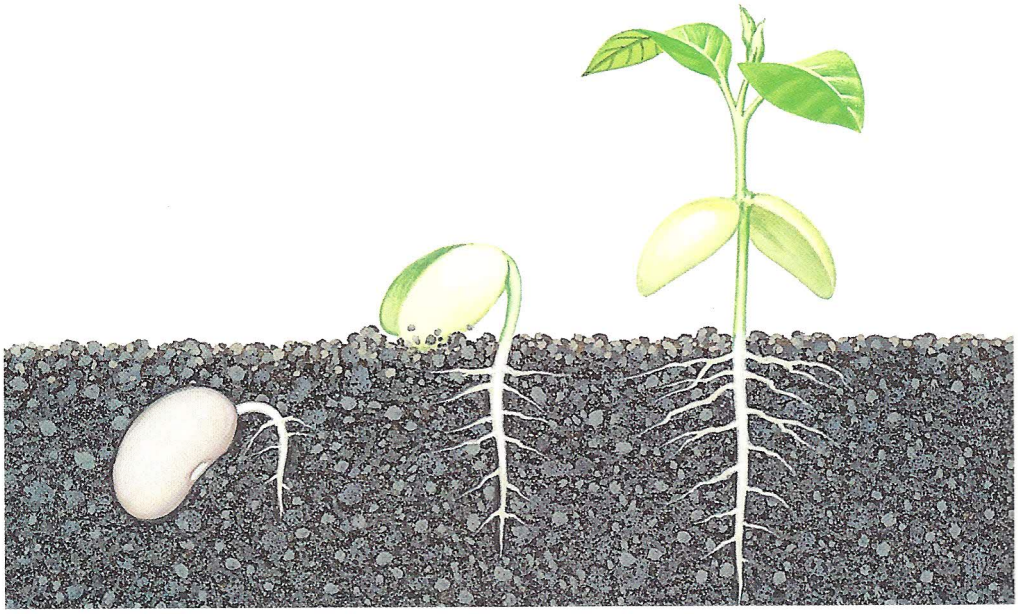


Figure 4 *Seeds grow into new plants. The roots begin to grow first. Then, the shoot grows up through the soil.*

From Seed to Plant

dormant describes the inactive state of a seed or other plant part when conditions are unfavorable to growth

Once a seed is fully developed, the young plant inside the seed stops growing. The seed may become dormant. When seeds are **dormant,** they are inactive. Dormant seeds often survive long periods of drought or freezing temperatures. Some seeds need extreme conditions, such as cold winters or forest fires, to break their dormancy.

When seeds are dropped or planted in a suitable environment, the seeds sprout. To sprout, most seeds need water, air, and warm temperatures. Each plant species has an ideal temperature at which most of its seeds will begin to grow. For many plants, the ideal temperature for growth is about 27°C (80.6°F). **Figure 4** shows the *germination* (JUHR muh NAY shuhn), or sprouting, of a bean seed.

QUICK LAB

Thirsty Seeds

1. Fill a **Petri dish** two-thirds full of **water,** and add **six dry bean seeds.** Using a **wax pencil,** label the dish "Water."
2. Add **six dry bean seeds** to a dry **Petri dish.** Label this dish "Control."
3. The next day, compare the size of the two sets of seeds. Record your observations.
4. What caused the size of the seeds to change? Why might this be important to the seed's survival?

Other Methods of Reproduction

Flowering plants may also reproduce asexually. For asexual reproduction, plants do not need flowers. Part of a plant, such as a stem or root, produces a new plant. The following are three structures plants use to reproduce asexually:

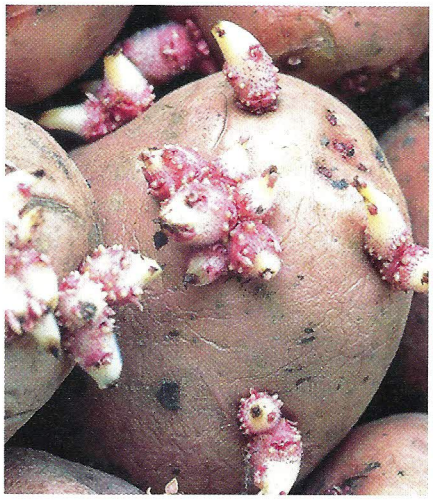
- **Plantlets** Tiny plants grow along the edges of a plant's leaves. These plantlets fall off and grow on their own.
- **Tubers** Underground stems, or tubers, can produce new plants after a dormant season.
- **Runners** Above-ground stems from which new plants can grow are called *runners*.

You can see an example of each kind of asexual reproduction in **Figure 5.**

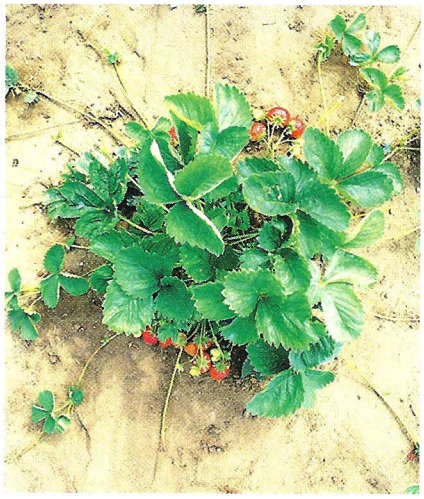
Reading Check **What are three structures plants use to reproduce asexually?**

Figure 5 Three Structures for Asexual Reproduction

Kalanchoe plants produce **plantlets** along the edges of their leaves. The plantlets eventually fall off and root in the soil to grow on their own.



A potato is a **tuber,** or underground stem. The "eyes" of potatoes are buds that can grow into new plants.



The strawberry plant produces **runners,** or stems that grow horizontally along the ground. Buds along the runners take root and grow into new plants.

SECTION Review

Summary

- After pollination, a pollen tube forms from the stigma to an ovule. This tube allows a sperm to fertilize an egg.
- After fertilization, seeds and fruit form. The seeds are protected by fruit.
- A dormant seed can survive drought and freezing temperatures. Some seeds need extreme conditions to break their dormancy.
- Some plants use plantlets, tubers, or runners to reproduce asexually.

Using Key Terms

1. In your own words, write a definition for the term *dormant*.

Understanding Key Ideas

2. Pollination happens when
   a. a pollen tube forms.
   b. a sperm cell fuses with an egg.
   c. pollen is transferred from the anther to the stigma.
   d. None of the above
3. Which part of a flower develops into a fruit? into a seed?
4. Why do seeds become dormant?
5. Describe how plants reproduce asexually.

Math Skills

6. A seed sprouts when the temperature is 27°C. If the temperature is now 20°C and it rises 1.5°C per week, in how many weeks will the seed sprout?

Critical Thinking

7. **Making Inferences** What do flowers and runners have in common? How do they differ?
8. **Identifying Relationships** When might asexual reproduction be important for the survival of some flowering plants?
9. **Analyzing Ideas** Sexual reproduction produces more genetic variety than asexual reproduction. Why is variety important?

SECTION 3

Plant Responses to the Environment

What happens when you get really cold? Do your teeth chatter? Or do you shiver? Anything that causes a reaction in your body is a stimulus *(plural,* stimuli*). But would a plant respond to a stimulus?*

Plants do respond to stimuli! For example, they respond to light, gravity, and changing seasons.

READING WARM-UP

Objectives

- Describe how plants may respond to light and gravity.
- Explain how some plants respond to night length.
- Describe how some plants respond to the changes of season.

Terms to Learn

tropism

READING STRATEGY

Discussion Read this section silently. Write down questions that you have about this section. Discuss your questions in a small group.

Plant Tropisms

Some plants respond to an environmental stimulus by growing in a particular direction. Growth in response to a stimulus is called a **tropism** (TROH PIZ uhm). Tropisms are either positive or negative. Plant growth toward a stimulus is a positive tropism. Plant growth away from a stimulus is a negative tropism. Plant growth away from a stimulus is a negative tropism.

tropism the growth of all or part of an organism in response to an external stimulus, such as light

Light

What happens if you place a houseplant so that it gets light from only one direction, such as from a window? The shoot tips probably bend toward the light. Bending toward the light is a positive tropism. A change in the direction a plant grows that is caused by light is called *phototropism* (FOH toh TROH PIZ uhm). The result of phototropism is shown in **Figure 1.** Shoots bend because cells on one side of the shoot grow longer than cells on the other side of the shoot.

Reading Check **What happens when a plant gets light from only one direction?** *(See the Appendix for answers to Reading Checks.)*

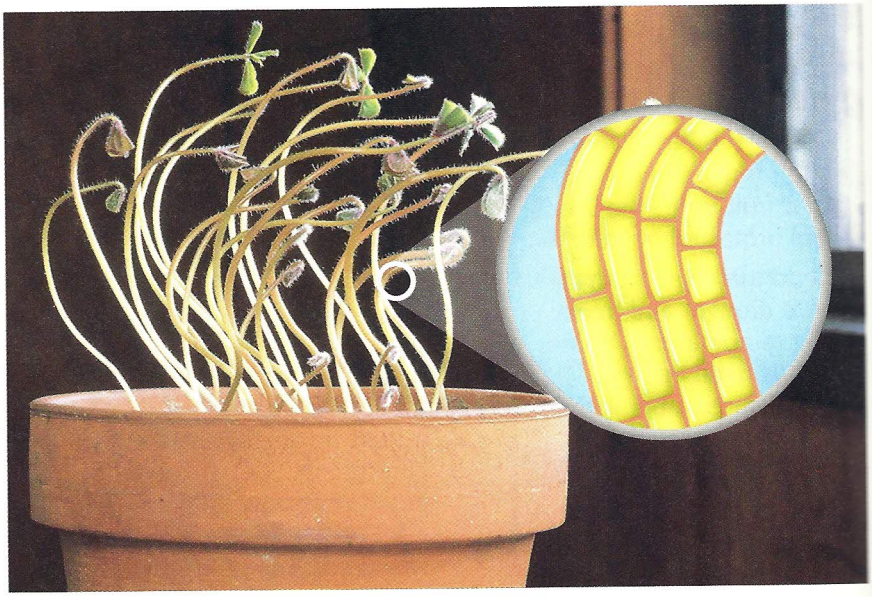
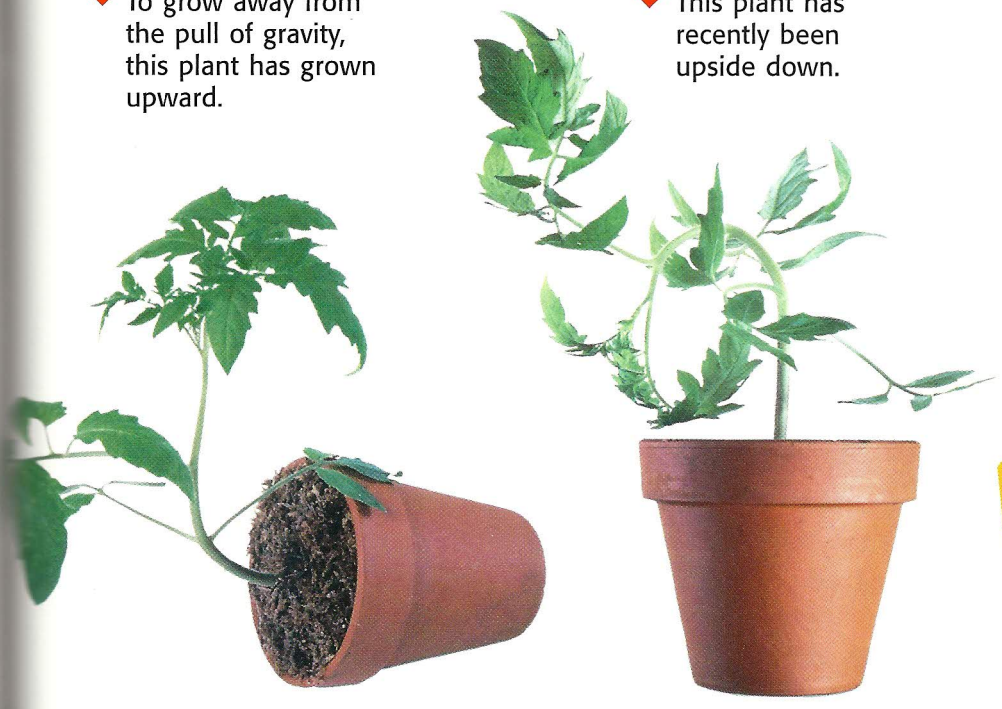


Figure 1 *The plant cells on the dark side of the shoot grow longer than the cells on the other side. So, the shoot bends toward the light.*

Figure 2 Gravitropism

To grow away from the pull of gravity, this plant has grown upward.

This plant has recently been upside down.



Gravity

Plant growth also changes in response to the direction of gravity. This change is called *gravitropism* (GRAV i TROH PIZ uhm). The effect of gravitropism is demonstrated by the plants in **Figure 2.** A few days after a plant is placed on its side or turned upside down, the roots and shoots change direction of growth. Most shoot tips have negative gravitropism. They grow upward, away from the center of the Earth. In contrast, most root tips have positive gravitropism. Roots grow downward, toward the center of the Earth.

Seasonal Responses

What would happen if a plant living in an area that has very cold winters flowered in December? Would the plant be able to successfully produce seeds and fruits? Probably not. The plant's flowers would likely freeze and die. So, the flowers would never produce mature seeds.

Plants living in regions with cold winters can detect the change in seasons. How do plants do this? As fall and winter approach, the days get shorter, and the nights get longer. The opposite happens when spring and summer approach. Plants respond to the change in the length of day.

Reading Check How do plants detect seasonal changes?

MATH PRACTICE

Bending by Degrees

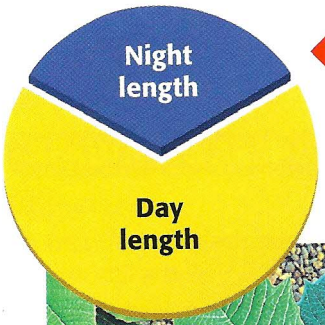
Suppose a plant has a positive phototropism and bends toward light at a rate of 0.3° per minute. In how many hours will the plant bend 90°?

INTERNET ACTIVITY

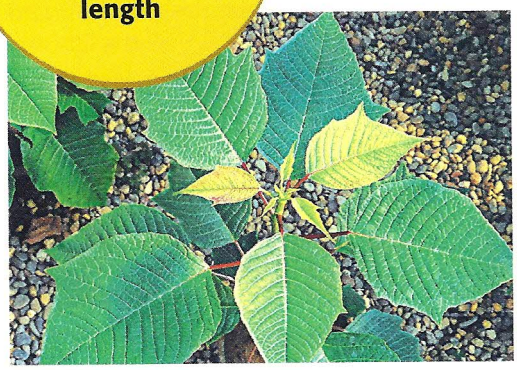
For another activity related to this chapter, go to **go.hrw.com** and type in the keyword **HL5PL2W.**

Figure 3 Night Length and Flower Color

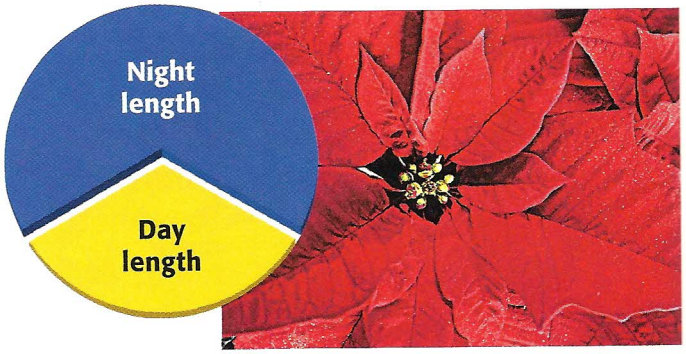
Early summer



In the early summer, night length is short. At this time, poinsettia leaves are all green, and there are no flowers.



Late fall



Poinsettias flower in the fall, when nights are longer. The leaves surrounding the flower clusters turn red. Professional growers use artificial lighting to control the timing of this color change.

Length of Day

The difference between day length and night length is an important environmental stimulus for many plants. This stimulus can cause plants to begin reproducing. For example, some plants flower in fall or winter. At this time, night length is long. These plants are called *short-day plants*. Poinsettias, such as those shown in **Figure 3,** are short-day plants. Chrysanthemums are also short-day plants. Other plants flower in spring or early summer, when night length is short. These plants are called *long-day plants*. Clover, spinach, and lettuce are examples of long-day plants.

SCHOOL to HOME

Earth's Orbit and the Seasons

The seasons are caused by Earth's tilt and its orbit around the sun. Research how Earth's orbit determines the seasons. With a parent, make a model of the Earth's orbit around the sun to illustrate your findings.

ACTIVITY

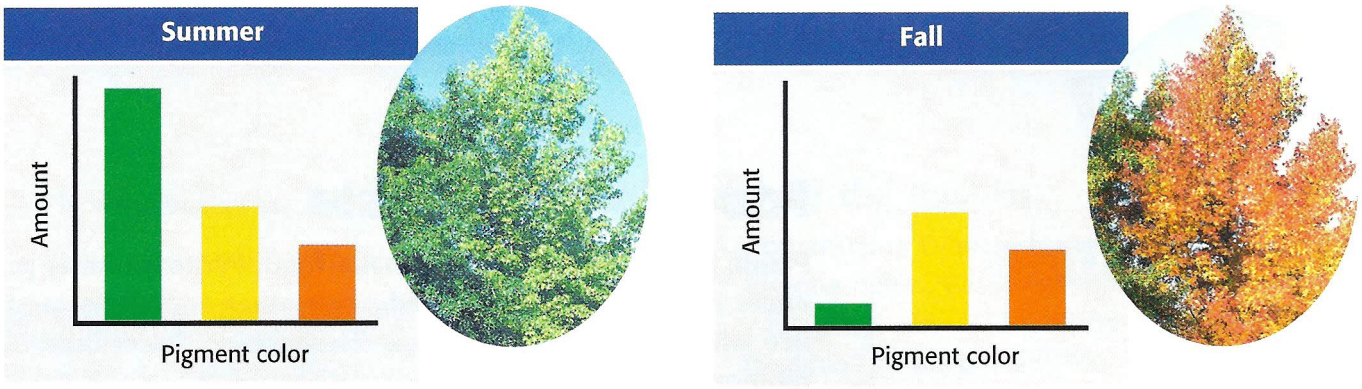
Seasons and Leaf Loss

All trees lose their leaves. Some trees, such as pine and holly, shed some of their leaves year-round so that some leaves are always on the tree. These trees are called *evergreen trees*. Evergreen trees have leaves adapted to survive throughout the year. The leaves are often covered with a thick cuticle. This cuticle protects the leaves from cold and dry weather.

Other trees, such as maple, oak, and elm trees, are called *deciduous* (dee SIJ oo uhs) *trees*. These trees lose all of their leaves around the same time each year. In colder areas, deciduous trees usually lose their leaves before winter begins. In warmer climates that have wet and dry seasons, deciduous trees lose their leaves before the dry season. The loss of leaves helps plants survive low temperatures or long periods without rain.

Reading Check **Compare evergreen trees and deciduous trees.**

Figure 4 Amount of Pigment Based on Season



Seasons and Leaf Color

As shown in **Figure 4,** the leaves of deciduous trees may change color before they are lost. As fall approaches, green chlorophyll breaks down. Orange or yellow pigments in the leaves are then revealed. These pigments were always present in the leaves. But they were hidden by green chlorophyll.

SECTION Review

Summary

- Plant growth in response to a stimulus is called a tropism. Tropisms are positive or negative.
- Plants react to light, gravity, and changing seasons.
- Short-day plants flower when night length is long. Long-day plants flower when night length is short.
- Evergreen trees do not lose all their leaves at one time. Deciduous trees lose their leaves at the same time each year.

Using Key Terms

1. In your own words, write a definition for the term *tropism*.

Understanding Key Ideas

2. Deciduous trees lose their leaves
   - **a.** to conserve water during the dry season.
   - **b.** around the same time each year.
   - **c.** to survive low winter temperatures.
   - **d.** All of the above
3. How do light and gravity affect plants?
4. Describe how day length can affect the flowering of plants.

Math Skills

5. A certain plant won't bloom until it is dark for 70% of a 24 h period. How long is the day when the plant will bloom?

Critical Thinking

6. **Making Inferences** Many evergreen trees live in areas with long, cold winters. Why might these evergreen trees keep their leaves all year?
7. **Analyzing Ideas** Some short-day plants bloom during the winter. If cold weather reduces the chances that a plant will produce seeds, what might you conclude about where these short-day plants are found?

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For a variety of links related to this chapter, go to www.scilinks.org

Topic: Plant Tropisms; Plant Growth
SciLinks code: HSM1166; HSM1159