SECTION 1

What Is a Plant?

Imagine spending a day without plants. What would you eat? It would be impossible to make chocolate chip cookies and many other foods.

Without plants, you couldn't eat much. Almost all food is made from plants or from animals that eat plants. Life would be very different without plants!

READING WARM-UP

Objectives

- Identify four characteristics that all plants share.
- Describe the four main groups of plants.
- Explain the origin of plants.

Terms to Learn

nonvascular plant
vascular plant
gymnosperm
angiosperm

READING STRATEGY

Reading Organizer As you read this section, create an outline of the section. Use the headings from the section in your outline.

Plant Characteristics

Plants come in many different shapes and sizes. So, what do cactuses, water lilies, ferns, and all other plants have in common? One plant may seem very different from another. But most plants share certain characteristics.

Photosynthesis

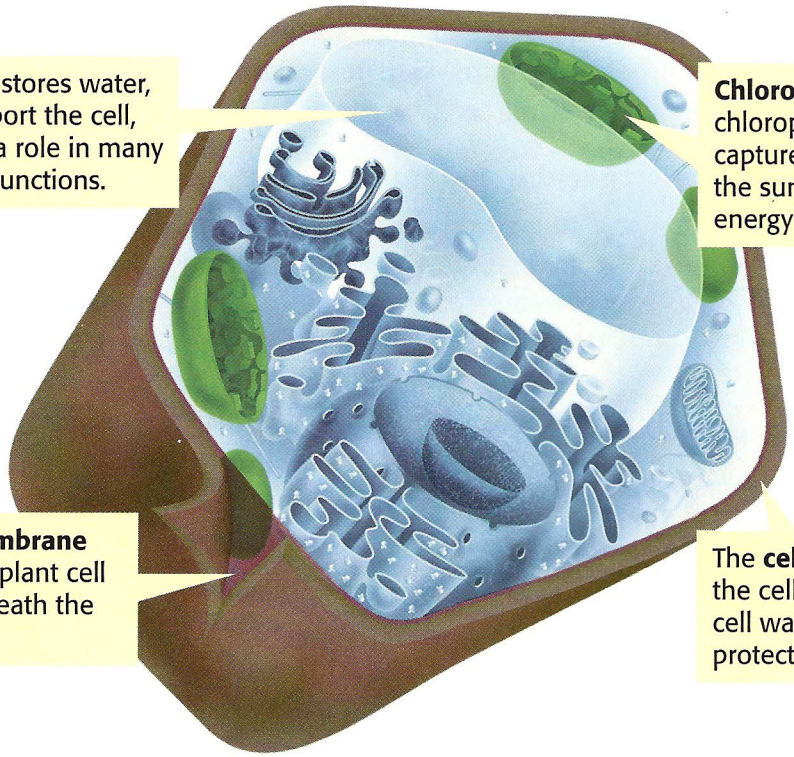
Take a look at **Figure 1.** Do you know why this plant is green? Plant cells contain chlorophyll (KLAWR uh FIL). *Chlorophyll* is a green pigment that captures energy from sunlight. Chlorophyll is found in chloroplasts (KLAWR uh PLASTS). Chloroplasts are organelles found in many plant cells and some protists. Plants use energy from sunlight to make food from carbon dioxide and water. This process is called *photosynthesis* (FOHT oh SIN thuh sis). Because plants make their own food, they are called *producers*.

Cuticles

Most plants live on dry land and need sunlight to live. But why don't plants dry out? Plants are protected by a cuticle. A *cuticle* is a waxy layer that coats most of the surfaces of plants that are exposed to air. The cuticle keeps plants from drying out.

Figure 1 *Chlorophyll makes the leaves of this plant green. Chlorophyll helps plants make their own food by capturing energy from sunlight.*

Figure 2 Some Structures of a Photosynthetic Plant Cell



Cell Walls

How do plants stay upright? They do not have skeletons like many animals do. Instead, plant cells are surrounded by a rigid cell wall. The cell wall lies outside the cell membrane, as shown in **Figure 2.** Carbohydrates and proteins in the cell wall form a hard material. Cell walls support and protect the plant cell. Some plant cells also have a secondary cell wall that forms after the cell is mature. When this wall has formed, a plant cell cannot grow larger.

Reproduction

Plants have two stages in their life cycle—the sporophyte (SPAWR uh FIET) stage and the gametophyte (guh MEET uh FIET) stage. In the sporophyte stage, plants make spores. In a suitable environment, such as damp soil, the spores of some plants grow. These new plants are called *gametophytes*.

During the gametophyte stage, female gametophytes produce eggs. Male gametophytes produce sperm. Eggs and sperm are sex cells. Sex cells cannot grow directly into new plants. Instead, a sperm must fertilize an egg. The fertilized egg grows into a sporophyte. The sporophyte makes more spores. So, the cycle starts again.

Reading Check **How do plants reproduce?** (*See the Appendix for answers to Reading Checks.*)

CONNECTION TO Social Studies

Countries and Crops Without plants, most life on land couldn't survive. But plants are important for more than the survival of living things. Many countries rely on plants for income. Identify five major food crops. Then, find out which countries are the main producers of these crops and how much the countries produce each year. Make a table to show your findings.

Plant Classification

Although all plants share basic characteristics, they can be classified into four groups. First, they are classified as nonvascular plants and vascular plants. Vascular plants are further divided into three groups—seedless plants, nonflowering seed plants, and flowering seed plants.

Nonvascular Plants

nonvascular plant the three groups of plants (liverworts, hornworts, and mosses) that lack specialized conducting tissues and true roots, stems, and leaves

vascular plant a plant that has specialized tissues that conduct materials from one part of the plant to another

gymnosperm a woody, vascular seed plant whose seeds are not enclosed by an ovary or fruit

angiosperm a flowering plant that produces seeds within a fruit

Mosses, liverworts, and hornworts are nonvascular plants. A **nonvascular plant** is a plant that doesn't have specialized tissues to move water and nutrients through the plant. Nonvascular plants depend on diffusion to move materials from one part of the plant to another. Diffusion is possible because nonvascular plants are small. If nonvascular plants were large, the cells of the plants would not get enough water and nutrients.

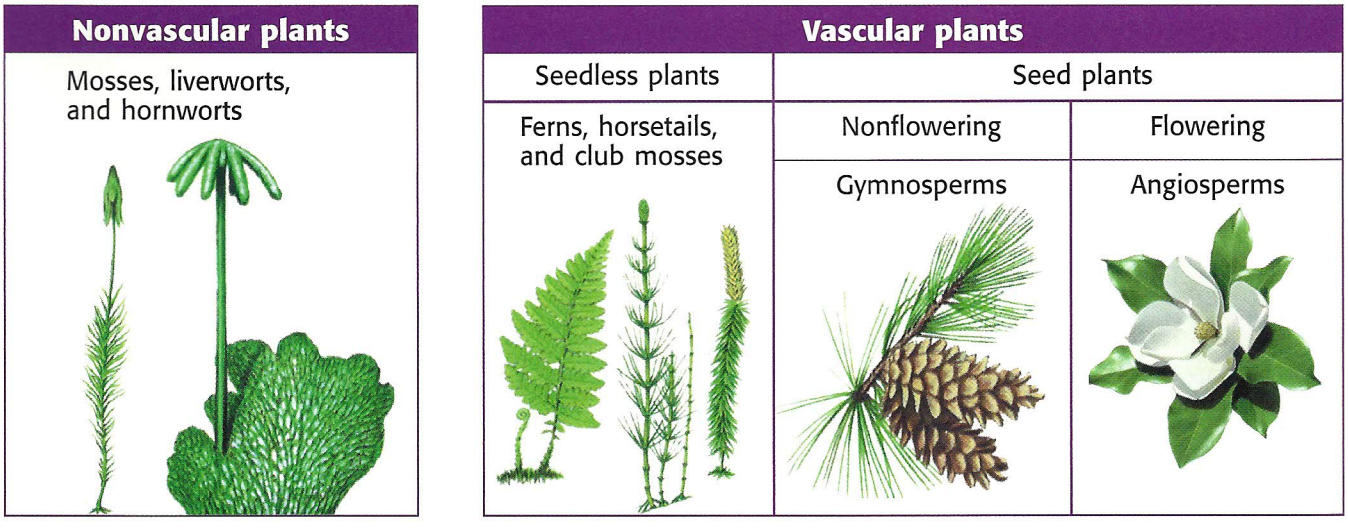
Vascular Plants

In the same way that the human body has special tissues to move materials through the body, so do many plants. A plant that has tissues to deliver water and nutrients from one part of the plant to another is called a **vascular plant.** These tissues are called *vascular tissues*. Vascular tissues can move water to any part of a plant. So, vascular plants can be almost any size.

Vascular plants are divided into three groups—seedless plants and two types of seed plants. Seedless vascular plants include ferns, horsetails, and club mosses. Nonflowering seed plants are called **gymnosperms** (JIM noh SPUHRMZ). Flowering seed plants are called **angiosperms** (AN jee oh SPUHRMZ). The four main groups of plants are shown in **Figure 3.**

Reading Check What are the four main groups of plants?

Figure 3 The Main Groups of Plants



The Origin of Plants

Imagine that you traveled back in time about 440 million years. The Earth seems like a strange, bare, and unfriendly place. For one thing, no plants live on land. So, where did plants come from?

Take a look at **Figure 4.** The photo on the left shows a green alga. The photo on the right shows a fern. The green alga may look like a plant, such as a fern, but it isn't a plant. However, green algae and plants have many similarities. Green algae cells and plant cells have the same kind of chlorophyll. They have similar cell walls. Green algae and plants make their own food through photosynthesis. Both store energy in the form of starch. Like plants, green algae have a two-stage life cycle. Because of these similarities, some scientists think that green algae and plants share a common ancestor.

Reading Check **What are some characteristics that green algae and plants have in common?**

Figure 4 *The similarities between a modern green alga (left) and plants, such as ferns (right), suggest that both may have originated from an ancient species of green algae.*

SECTION Review

Summary

- All plants make their own food and have cuticles, cells walls, and a two-stage life cycle.
- Plants are first classified into two groups: nonvascular plants and vascular plants. Vascular plants are further divided into seedless plants, gymnosperms, and angiosperms.
- Similarities between green algae and plants suggest they may have a common ancestor.

Using Key Terms

For each pair of terms, explain how the meanings of the terms differ.

1. *nonvascular plants* and *vascular plants*
2. *gymnosperms* and *angiosperms*

Understanding Key Ideas

3. Which of the following plants is nonvascular?
   - **a.** ferns
   - **b.** mosses
   - **c.** gymnosperms
   - **d.** club mosses
4. What are four characteristics that all plants share?
5. What do green algae and plants have in common?
6. Describe the plant life cycle.

Math Skills

7. A plant produced 200,000 spores and one-third as many eggs. How many eggs did the plant produce?

Critical Thinking

8. **Making Inferences** One difference between green algae and plants is that green algae do not have a cuticle. Why don't green algae have a cuticle?
9. **Applying Concepts** Imagine an environment that is very dry and receives a lot of sunlight. Water is found deep below the soil. Which of the four groups of plants could survive in this environment? Explain your answer.

SECTION 2

Seedless Plants

When you think of plants, you probably think of plants, such as trees and flowers, that make seeds. But two groups of plants don't make seeds.

One group of seedless plants is the nonvascular plants—mosses, liverworts, and hornworts. The other group is seedless vascular plants—ferns, horsetails, and club mosses.

READING WARM-UP

Objectives

- List three nonvascular plants and three seedless vascular plants.
- Explain how seedless plants are important to the environment.
- Describe the relationship between seedless vascular plants and coal.

Terms to Learn

rhizoid
rhizome

READING STRATEGY

Paired Summarizing Read this section silently. In pairs, take turns summarizing the material. Stop to discuss ideas that seem confusing.

Nonvascular Plants

Mosses, liverworts, and hornworts are small. They grow on soil, the bark of trees, and rocks. These plants don't have vascular tissue. So, nonvascular plants usually live in places that are damp. Each cell of the plant must get water from the environment or from a nearby cell.

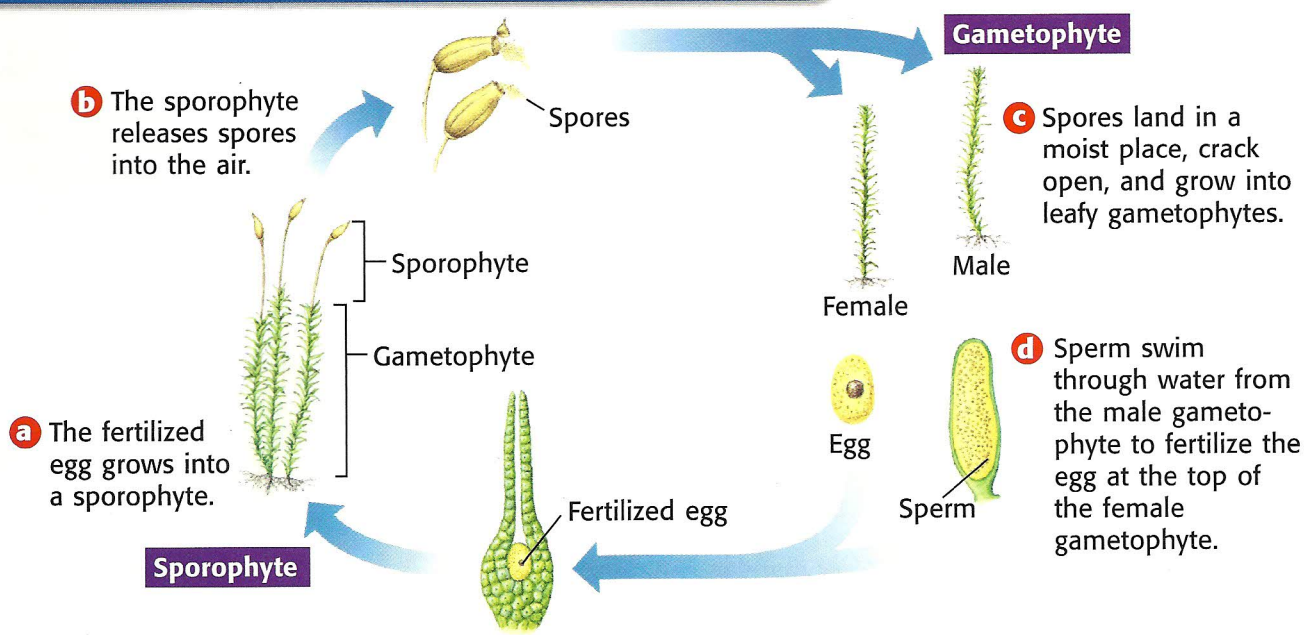
Mosses, liverworts, and hornworts don't have true stems, roots, or leaves. They do, however, have structures that carry out the activities of stems, roots, and leaves.

Mosses

Mosses often live together in large groups. They cover soil or rocks with a mat of tiny green plants. Mosses have leafy stalks and rhizoids (RIE ZOYDZ). A **rhizoid** is a rootlike structure that holds nonvascular plants in place. Rhizoids help the plants get water and nutrients. As you can see in **Figure 1,** mosses have two stages in their life cycle.

rhizoid a rootlike structure in nonvascular plants that holds the plants in place and helps plants get water and nutrients

Figure 1 Moss Life Cycle



Liverworts and Hornworts

Like mosses, liverworts and hornworts are small, nonvascular plants that usually live in damp places. The life cycles of liverworts and hornworts are similar to the life cycle of mosses. The gametophytes of liverworts can be leafy and mosslike or broad and flattened. Hornworts also have broad, flattened gametophytes. Both liverworts and hornworts have rhizoids.

The Importance of Nonvascular Plants

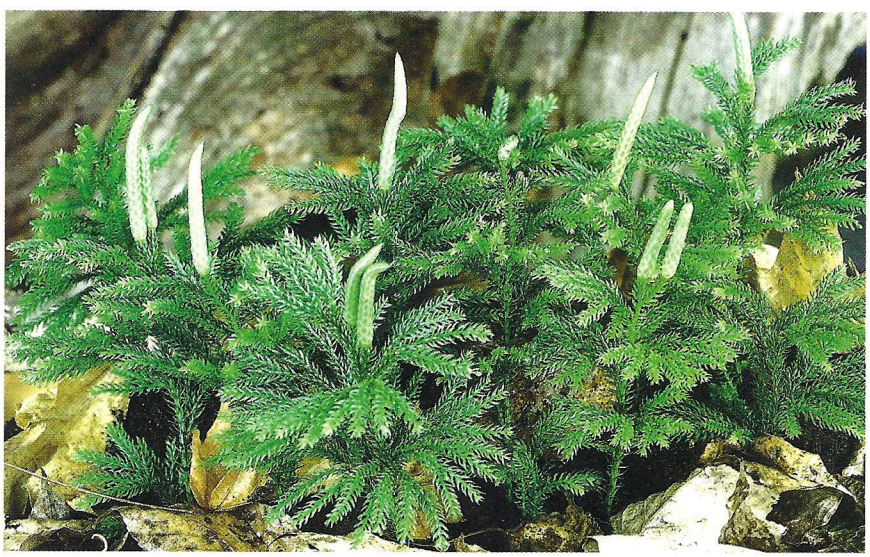
Nonvascular plants have an important role in the environment. They are usually the first plants to live in a new environment, such as newly exposed rock. When these nonvascular plants die, they form a thin layer of soil. New plants can grow in this soil. More nonvascular plants may grow and hold the soil in place. This reduces soil erosion. Some animals eat nonvascular plants. Other animals use these plants for nesting material.

Peat mosses are important to humans. Peat mosses grow in bogs and other wet places. In some places, dead peat mosses have built up over time. This peat can be dried and burned as a fuel. Peat mosses are also used in potting soil.

Reading Check **How are nonvascular plants important to the environment?** (*See the Appendix for answers to Reading Checks.*)

Seedless Vascular Plants

Ancient ferns, horsetails, and club mosses grew very tall. Club mosses grew to 40 m in ancient forests. Horsetails once grew to 18 m tall. Some ferns grew to 8 m tall. Today, ferns, horsetails, and club mosses are usually much smaller. But because they have vascular tissue, they are often larger than nonvascular plants. **Figure 2** shows club mosses and horsetails.



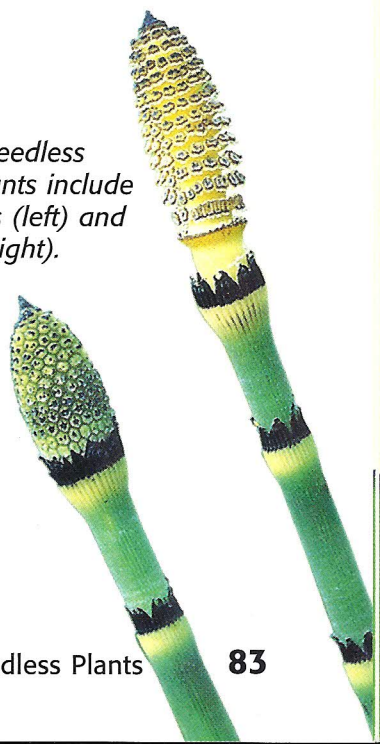


Figure 2 *Seedless vascular plants include club mosses (left) and horsetails (right).*

QUICK LAB

Moss Mass

1. Determine the mass of a small sample of **dry sphagnum moss.**
2. Observe what happens when you put a small piece of the moss in **water.** Predict what will happen if you put the entire sample in water.
3. Place the moss sample in a **large beaker of water** for 10 to 15 minutes.
4. Remove the wet moss from the beaker, and determine the mass of the moss.
5. How much mass did the moss gain? Compare your result with your prediction.
6. What could this plant be used for?

rhizome a horizontal, underground stem that produces new leaves, shoots, and roots

Ferns

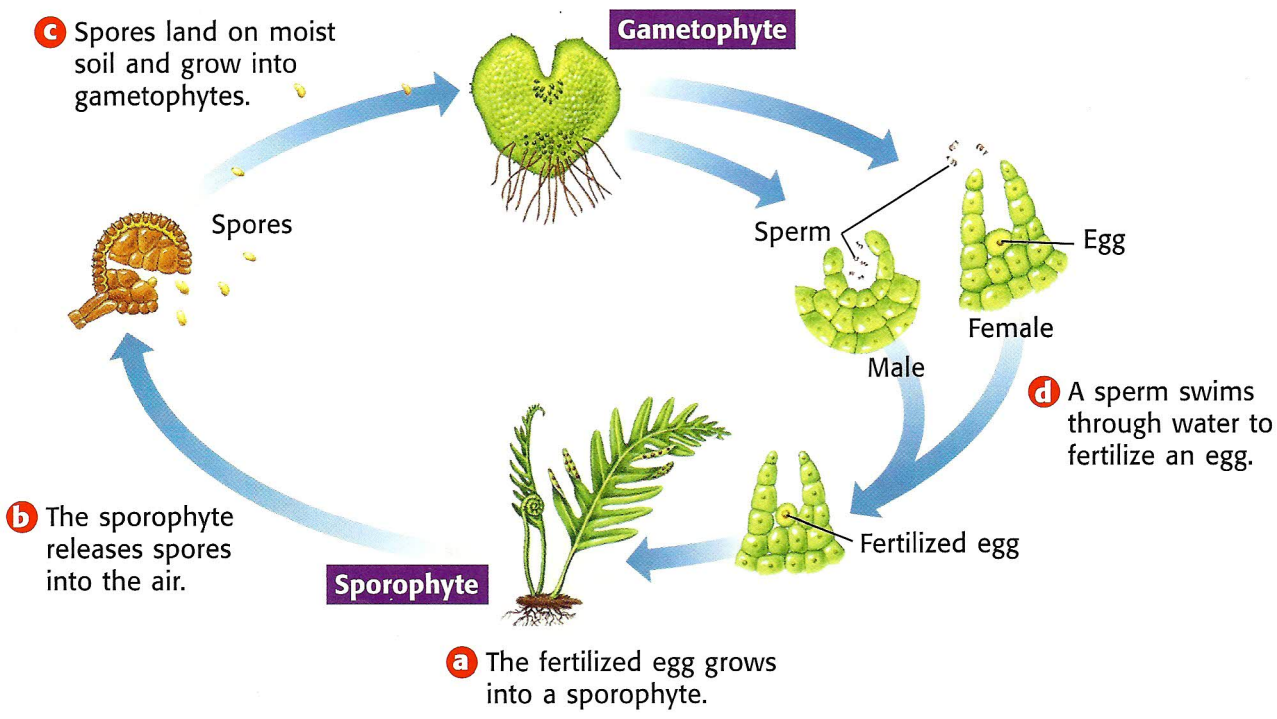
Ferns grow in many places, from the cold Arctic to warm, humid tropical forests. Many ferns are small plants. But some tropical tree ferns grow as tall as 24 m. Most ferns have a rhizome. A **rhizome** is an underground stem from which new leaves and roots grow. At first, fern leaves, or fronds, are tightly coiled. These fronds look like the end of a violin, or fiddle. So, they are called *fiddleheads*. You are probably most familiar with the leafy fern sporophyte. The fern gametophyte is a tiny plant about half the size of one of your fingernails. The fern gametophyte is green and flat. It is usually shaped like a tiny heart. The life cycle of ferns is shown in **Figure 3.**

Horsetails and Club Mosses

Modern horsetails can be as tall as 8 m. But many horsetails are smaller. They usually grow in wet, marshy places. Their stems are hollow and contain silica. The silica gives horsetails a gritty texture. In fact, early American pioneers referred to horsetails as *scouring rushes*. They used horsetails to scrub pots and pans. Horsetails and ferns have similar life cycles.

Club mosses are often about 20 cm tall. They grow in woodlands. Club mosses are not actually mosses. Unlike mosses, club mosses have vascular tissue. The life cycle of club mosses is similar to the fern life cycle.

Figure 3 **Fern Life Cycle**



The Importance of Seedless Vascular Plants

Seedless vascular plants play important roles in the environment. Ferns, horsetails, and club mosses help form soil. They also help prevent soil erosion. In rocky areas, ferns can play a role in the formation of communities. After lichens and mosses create a layer of soil, ferns may take over. Ferns add to soil depth, which allows other plants to grow.

Ferns and some club mosses are popular houseplants. The fiddleheads of some ferns can be cooked and eaten. Young horsetail shoots and their roots are also edible. Horsetails are used in some dietary supplements, shampoos, and skin-care products.

Seedless vascular plants that lived and died about 300 million years ago are among the most important to humans. The remains of these ancient ferns, horsetails, and club mosses formed coal. Coal is a fossil fuel that humans mine from the Earth's crust. Humans rely on coal for energy.

Reading Check **How are seedless vascular plants important to the environment?**

CONNECTION TO Language Arts

WRITING SKILL **Selling Plants** Imagine that you work for an advertising agency. Your next assignment is to promote seedless vascular plants. Write an advertisement describing seedless vascular plants and ways people benefit from them. Your advertisement should be exciting and persuasive.

SECTION Review

Summary

- Nonvascular plants include mosses, liverworts, and hornworts.
- Seedless vascular plants include ferns, horsetails, and club mosses.
- The rhizoids and rhizomes of seedless plants prevent erosion by holding soil in place.
- The remains of seedless vascular plants that lived and died about 300 million years ago formed coal. Humans rely on coal for energy.

Using Key Terms

1. Use each of the following terms in a separate sentence: *rhizoid* and *rhizome*.

Understanding Key Ideas

2. Seedless plants
   - **a.** help form communities.
   - **b.** reduce soil erosion.
   - **c.** add to soil depth.
   - **d.** All of the above
3. Describe six kinds of seedless plants.
4. What is the relationship between coal and seedless vascular plants?

Math Skills

5. Club mosses once grew as tall as 40 m. Now, they grow no taller than 20 cm. What is the difference in height between ancient and modern club mosses?

Critical Thinking

6. **Making Inferences** Imagine a very damp area. Mosses cover the rocks and trees in this area. Liverworts and hornworts are also very abundant. What might happen if the area dries out? Explain your answer.
7. **Applying Concepts** Modern ferns, horsetails, and club mosses are smaller than they were millions of years ago. Why might these plants be smaller?

SCILINKS NSTA
Developed and maintained by the National Science Teachers Association

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

Topic: Seedless Plants
SciLinks code: HSM1368

SECTION 3

Seed Plants

Think about the seed plants that you use during the day. You likely use dozens of seed plants, from the food you eat to the paper you write on.

The two groups of vascular plants that produce seeds are gymnosperms and angiosperms. Gymnosperms are trees and shrubs that do not have flowers or fruit. Angiosperms have flowers and seeds that are protected by fruit.

READING WARM-UP

Objectives

- Describe three ways that seed plants differ from seedless plants.
- Describe the structure of seeds.
- Compare angiosperms and gymnosperms.
- Explain the economic and environmental importance of gymnosperms and angiosperms.

Terms to Learn

pollen
pollination

READING STRATEGY

Reading Organizer As you read this section, make a table comparing angiosperms and gymnosperms.

Characteristics of Seed Plants

As with seedless plants, the life cycle of seed plants alternates between two stages. But seed plants, such as the plant in **Figure 1,** differ from seedless plants in the following ways:

- Seed plants produce seeds. Seeds nourish and protect young sporophytes.
- Unlike the gametophytes of seedless plants, the gametophytes of seed plants do not live independently of the sporophyte. The gametophytes of seed plants are tiny. The gametophytes form within the reproductive structures of the sporophyte.
- The sperm of seedless plants need water to swim to the eggs of female gametophytes. The sperm of seed plants do not need water to reach an egg. Sperm form inside tiny structures called **pollen.** Pollen can be transported by wind or by animals.

pollen the tiny granules that contain the male gametophyte of seed plants

These three characteristics of seed plants allow them to live just about anywhere. For this reason, seed plants are the most common plants on Earth today.

Reading Check **List three characteristics of seed plants.** (*See the Appendix for answers to Reading Checks.*)

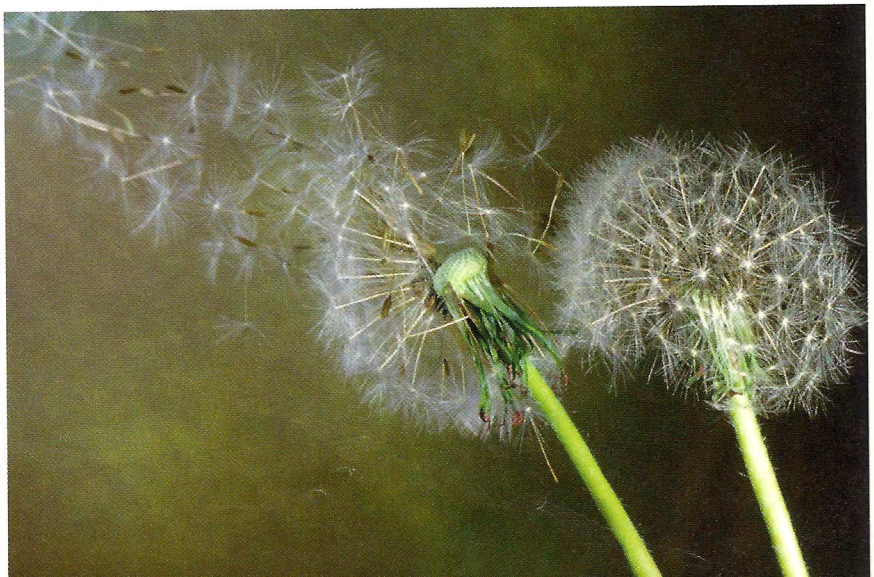


Figure 1 *Dandelion fruits, which each contain a seed, are spread by wind.*

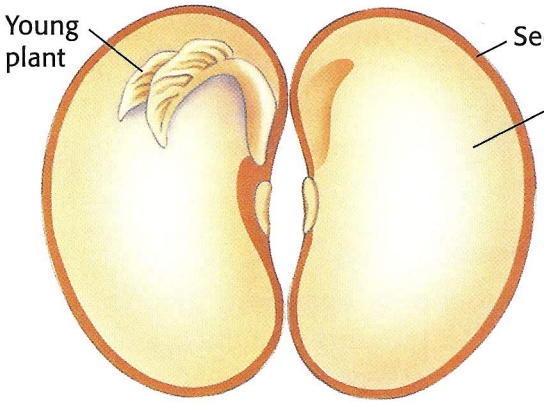


Figure 2 *A seed contains stored food and a young plant, or sporophyte. A seed is surrounded and protected by a seed coat.*

The Structure of Seeds

A seed forms after fertilization, when sperm and eggs are joined. A seed is made up of three parts, as shown in **Figure 2.** The first part is a young plant, or the sporophyte. The second part is stored food. It is often found in the cotyledons (KAHT uh LEED uhnz), or the seed leaves of the young plant. Finally, a seed coat surrounds and protects the young plant.

Seed plants have some advantages over seedless plants. For example, when a seed begins to grow, the young plant uses the food stored in the seed. The spores of seedless plants don't have stored food to help a new plant grow. Another advantage of seed plants is that seeds can be spread by animals. The spores of seedless plants are usually spread by wind. Animals spread seeds more efficiently than the wind spreads spores.

Reading Check **Describe two advantages that seed plants have over seedless plants.**

CONNECTION TO Environmental Science

WRITING SKILL **Animals That Help Plants** Animals need plants to live, but some plants benefit from animals, too. These plants produce seeds with tough seed coats. An animal's digestive system can wear down these seed coats and speed the growth of a seed. Identify a plant that animals help in this way. Then, find out how being eaten by animals makes it possible for seeds to grow. Write about your findings in your **science journal.**

QUICK LAB

Dissecting Seeds

1. Soak a **lima bean seed** in **water** overnight. Draw the seed before placing it in the water.
2. Remove the seed from the water. Draw what you see.
3. The seed will likely look wrinkly. This is the seed coat. Use a **toothpick** to gently remove the seed coat from the lima bean seed.
4. Gently separate the halves of the lima bean seed. Draw what you see.
5. What did you see after you split the lima bean seed in half?
6. *What part of the seed do you think provides the lima bean plant with the energy to grow?*

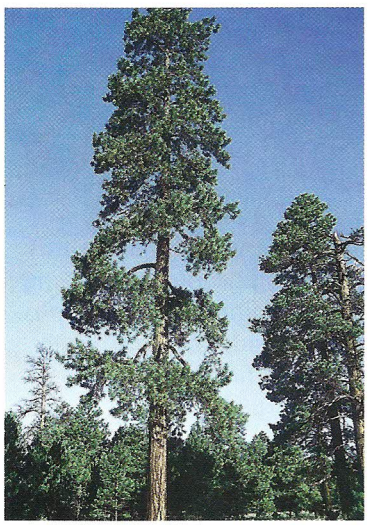
Gymnosperms

Seed plants that do not have flowers or fruit are called *gymnosperms*. Gymnosperm seeds are usually protected by a cone. The four groups of gymnosperms are conifers, ginkgoes, cycads, and gnetophytes (NEE toh FIETS). You can see some gymnosperms in **Figure 3.**

The Importance of Gymnosperms

Conifers are the most economically important gymnosperms. People use conifer wood for building materials and paper products. Pine trees produce a sticky fluid called *resin*. Resin is used to make soap, turpentine, paint, and ink. Some conifers produce an important anticancer drug. Some gnetophytes produce anti-allergy drugs. Conifers, cycads, and ginkgoes are popular in gardens and parks.

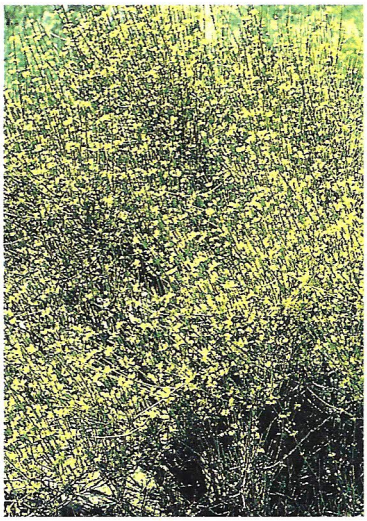
Figure 3 **Examples of Gymnosperms**



Conifers The conifers, such as this ponderosa pine, are the largest group of gymnosperms. There are about 550 species of conifers. Most conifers are evergreens that keep their needle-shaped leaves all year. Conifer seeds develop in cones.

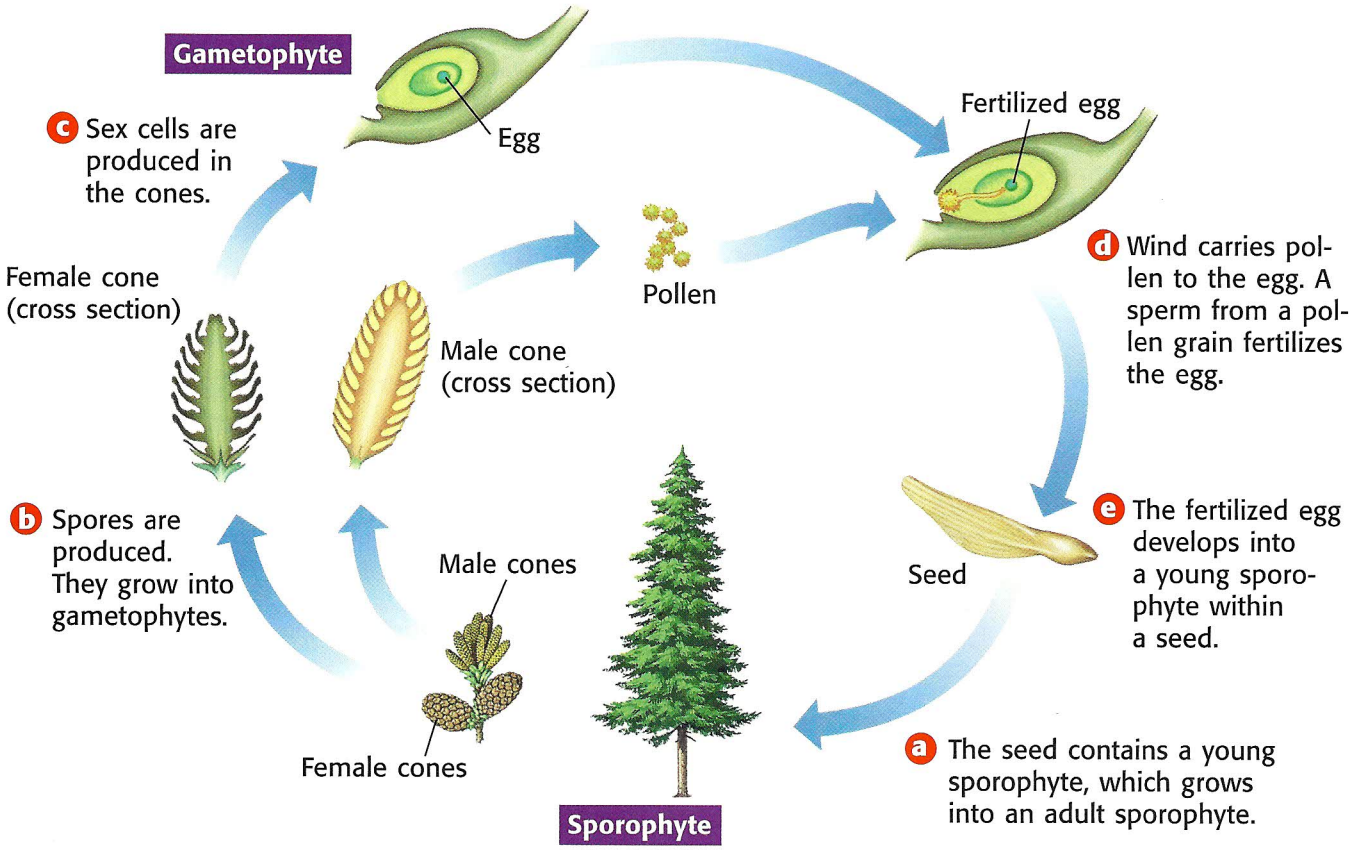
Ginkgoes Today, there is only one living species of ginkgo, the ginkgo tree. Ginkgo seeds are not produced in cones. The seeds have fleshy seed coats and are attached directly to the branches of the tree.

Cycads The cycads were more common millions of years ago. Today, there are only about 140 species of cycads. These plants grow in the Tropics. Like conifer seeds, cycad seeds develop in cones.



Gnetophytes About 70 species of gnetophytes, such as this joint fir, exist today. Many gnetophytes are shrubs that grow in dry areas. The seeds of most gnetophytes develop in cones.

Figure 4 Pine Life Cycle



Gymnosperm Life Cycle

The gymnosperms that are most familiar to you are probably the conifers. The word *conifer* comes from two words that mean "cone-bearing." Conifers have two kinds of cones—male cones and female cones. The spores of each kind of cone become tiny gametophytes.

The male gametophytes of gymnosperms are found in pollen. Pollen contain sperm. The female gametophytes produce eggs. Wind carries pollen from the male cones to the female cones. This transfer of pollen from the male cones to the female cones is called **pollination.** The female cones can be on the same plant. Or, they can be on a different plant of the same species.

pollination the transfer of pollen from the male reproductive structures to the female structures of seed plants

Sperm from pollen fertilize the eggs of the female cone. A fertilized egg develops into a young sporophyte within the female cone. The sporophyte is surrounded by a seed. Eventually, the seed is released. Some cones release seeds right away. Other cones release seeds under special circumstances, such as after forest fires. If conditions are right, the seed will grow. The life cycle of a pine tree is shown in **Figure 4.**

Reading Check **Describe the gymnosperm life cycle.**

Angiosperms

Vascular plants that produce flowers and fruits are called *angiosperms*. Angiosperms are the most abundant plants today. There are at least 235,000 species of angiosperms. Angiosperms can be found in almost every land ecosystem.

Figure 5 *This bee is on its way to another squash flower, where it will leave some of the pollen it is carrying.*

Angiosperm Reproduction

Flowers help angiosperms reproduce. Some angiosperms depend on the wind for pollination. But others have flowers that attract animals. As shown in **Figure 5,** when animals visit different flowers, the animals may carry pollen from flower to flower.

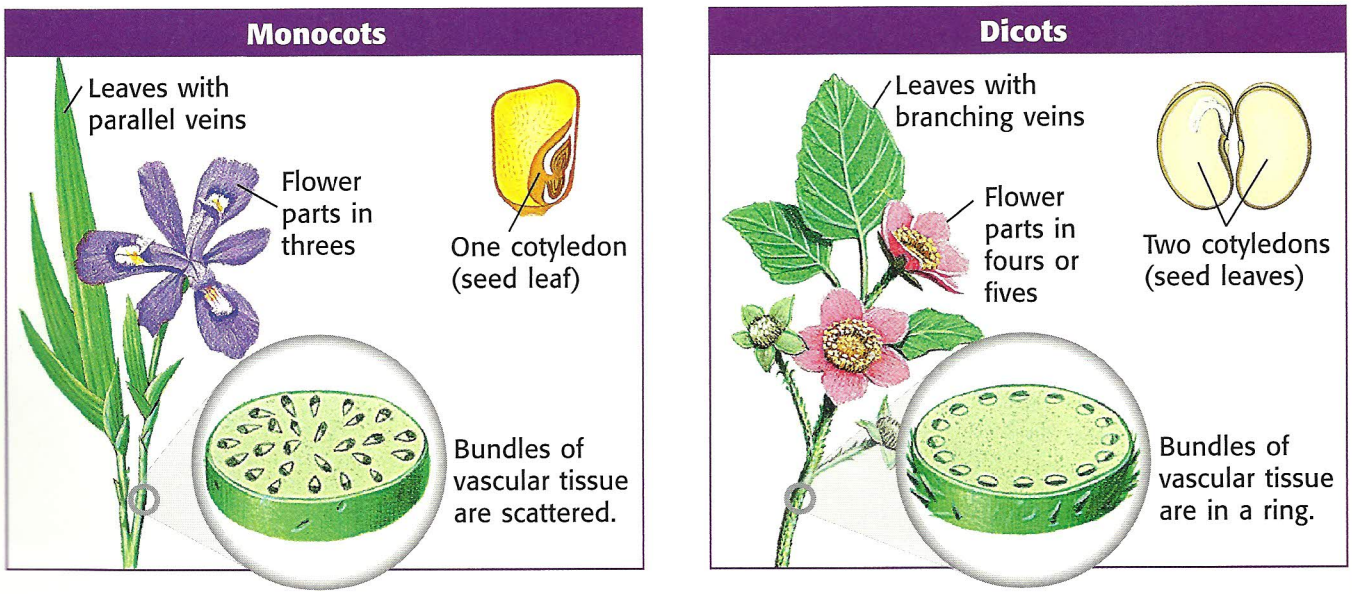
Fruits surround and protect seeds. Some fruits and seeds have structures that help the wind carry them short or long distances. Other fruits attract animals that eat the fruits. The animals discard the seeds away from the plant. Some fruits, such as burrs, are carried from place to place by sticking to the fur of animals.

Reading Check **Why do angiosperms have flowers and fruits?**

Two Kinds of Angiosperms

Angiosperms are divided into two classes—monocots and dicots. The two classes differ in the number of cotyledons, or seed leaves, their seeds have. Monocot seeds have one cotyledon. Grasses, orchids, onions, lilies, and palms are monocots. Dicot seeds have two cotyledons. Dicots include roses, cactuses, sunflowers, peanuts, and peas. Other differences between monocots and dicots are shown in **Figure 6.**

Figure 6 **Two Classes of Angiosperms**



The Importance of Angiosperms

Flowering plants provide many land animals with the food they need to survive. A field mouse that eats seeds and berries is using flowering plants directly as food. An owl that eats a field mouse is using flowering plants indirectly as food.

People use flowering plants in many ways. Major food crops, such as corn, wheat, and rice, are flowering plants. Some flowering plants, such as oak trees, are used for building materials. Flowering plants, such as cotton and flax, are used to make clothing and rope. Flowering plants are also used to make medicines, rubber, and perfume oils.

Reading Check How are flowering plants important to humans?

INTERNET ACTIVITY

For another activity related to this chapter, go to **go.hrw.com** and type in the keyword **HL5PL1W.**

SECTION Review

Summary

- Seeds nourish the young sporophyte of seed plants. Seed plant gametophytes rely on the sporophyte. Also, they do not need water for fertilization.
- Seeds nourish a young plant until it can make food by photosynthesis.
- Gymnosperms do not have flowers or fruits. Gymnosperm seeds are usually protected by cones. Gymnosperms are used for building materials, paper, resin, and medicines.
- Angiosperms have flowers and fruits. Angiosperms are used for food, medicines, fibers for clothing, rubber, and building materials.

Using Key Terms

1. In your own words, write a definition for each of the following terms: *pollen* and *pollination*.

Understanding Key Ideas

2. One advantage of seed plants is that
   - **a.** seed plants grow in few places.
   - **b.** they can begin photosynthesis as soon as they begin to grow.
   - **c.** they need water for fertilization.
   - **d.** young plants are nourished by food stored in the seed.
3. The gametophytes of seed plants
   - **a.** live independently of the sporophytes.
   - **b.** are very large.
   - **c.** are protected in the reproductive structures of the sporophyte.
   - **d.** None of the above
4. Describe the structure of seeds.
5. Briefly describe the four groups of gymnosperms. Which group is the largest and most economically important?
6. Compare angiosperms and gymnosperms.

Math Skills

7. More than 265,000 species of plants have been discovered. Approximately 235,000 of those species are angiosperms. What percentage of plants are NOT angiosperms?

Critical Thinking

8. **Making Inferences** In what ways are flowers and fruits adaptations that help angiosperms reproduce?
9. **Applying Concepts** An angiosperm lives in a dense rainforest, close to the ground. It receives little wind. Several herbivores live in this area of the rainforest. What are some ways the plant can ensure its seeds are carried throughout the forest?

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Topic: Plants with Seeds
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SECTION 4

Structures of Seed Plants

You have different body systems that carry out many functions. Plants have systems too—a root system, a shoot system, and a reproductive system.

READING WARM-UP

Objectives

- List three functions of roots and three functions of stems.
- Describe the structure of a leaf.
- Identify the parts of a flower and their functions.

Terms to Learn

xylem
phloem
sepal
petal
stamen
pistil
ovary

READING STRATEGY

Mnemonics As you read this section, create a mnemonic device to help you remember the parts of a plant.

A plant's root system and shoot system supply the plant with what it needs to survive. The root system is made up of roots. The shoot system includes stems and leaves.

The vascular tissues of the root and shoot systems are connected. There are two kinds of vascular tissue—xylem (ZIE luhm) and phloem (FLOH EM). **Xylem** is vascular tissue that transports water and minerals through the plant. Xylem moves materials from the roots to the shoots. **Phloem** is vascular tissue that transports food molecules to all parts of a plant. Xylem and phloem are found in all parts of vascular plants.

xylem the type of tissue in vascular plants that provides support and conducts water and nutrients from the roots

phloem the tissue that conducts food in vascular plants

Roots

Most roots are underground, as shown in **Figure 1.** So, many people do not realize how extensive root systems can be. For example, a corn plant that is 2.5 m tall can have roots that grow 2.5 m deep and 1.2 m out and away from the stem!

Root Functions

The following are the three main functions of roots:

- Roots supply plants with water and dissolved minerals. These materials are absorbed from the soil. The water and minerals are transported to the shoots in the xylem.
- Roots hold plants securely in the soil.
- Roots store surplus food made during photosynthesis. The food is produced in the leaves. Then, it is transported in the phloem to the roots. In the roots, the surplus food is usually stored as sugar or starch.

Onion Dandelion Carrots

Figure 1 *The roots of these plants provide the plants with water and minerals.*

Root Structure

The structures of a root are shown in **Figure 2.** The layer of cells that covers the surface of roots is called the *epidermis*. Some cells of the epidermis extend from the root. These cells, or root hairs, increase the surface area of the root. This surface area helps the root absorb water and minerals. After water and minerals are absorbed by the epidermis, they diffuse into the center of the root, where the vascular tissue is located.

Roots grow longer at their tips. A group of cells called the *root cap* protects the tip of a root. The root cap produces a slimy substance. This substance makes it easier for the root to push through soil as it grows.

Root Systems

There are two kinds of root systems—taproot systems and fibrous root systems. A taproot system has one main root, or a taproot. The taproot grows downward. Many smaller roots branch from the taproot. Taproots can reach water deep underground. Dicots and gymnosperms usually have taproot systems.

A fibrous root system has several roots that spread out from the base of a plant's stem. The roots are usually the same size. Fibrous roots usually get water from close to the soil surface. Monocots usually have fibrous roots.

Reading Check **What are two types of root systems?** (*See the Appendix for answers to Reading Checks.*)

MATH PRACTICE

Practice with Percentages

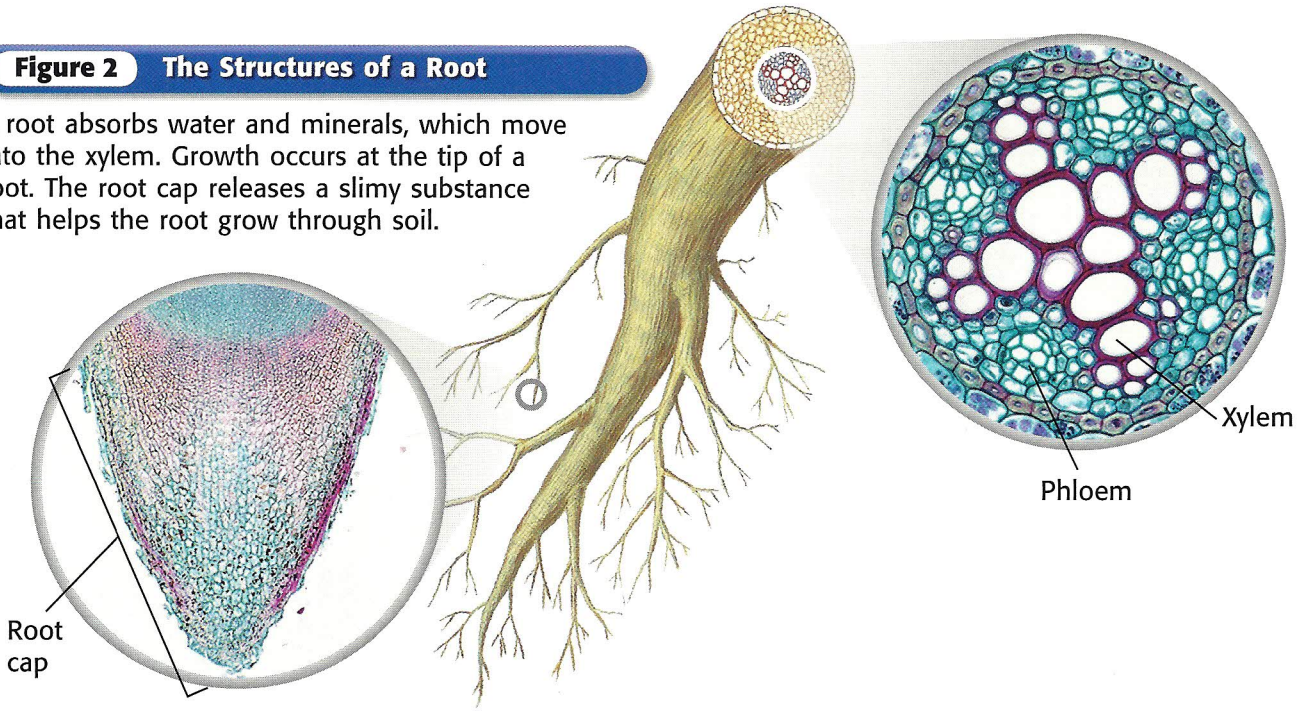
The following table gives an estimate of the number of species in each plant group.

Plant Species	
Plant group	**Number of species**
Mosses, liverworts, and hornworts	15,600
Ferns, horsetails, and club mosses	12,000
Gymnosperms	760
Angiosperms	235,000

What percentage of plants do not produce seeds?

Figure 2 **The Structures of a Root**

A root absorbs water and minerals, which move into the xylem. Growth occurs at the tip of a root. The root cap releases a slimy substance that helps the root grow through soil.



Stems

Stems vary greatly in shape and size. Stems are usually located above ground. However, many plants have underground stems. The trunk of the valley oak in **Figure 3** is a stem.

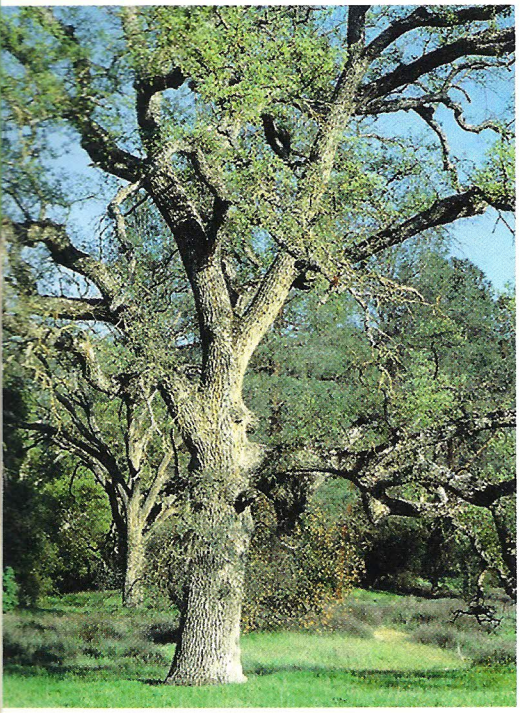


Figure 3 *The stem, or trunk, of this valley oak keeps the tree upright, which helps leaves get sunlight for photosynthesis.*

Stem Functions

A stem connects a plant's roots to its leaves and flowers. A stem also has the following functions:

- Stems support the plant body. Leaves are arranged along stems or on the ends of stems. This arrangement helps leaves get sunlight for photosynthesis. Stems hold up flowers, which helps pollinators, such as bees, see the flowers.
- Stems transport materials between the root system and the shoot system. Xylem carries water and dissolved minerals from the roots to the leaves and other shoot parts. Phloem carries the food made during photosynthesis to roots and other parts of the plant.
- Some stems store materials. For example, the stems of cactuses and some trees are adapted for water storage.

Herbaceous Stems

Many plants have stems that are soft, thin, and flexible. These stems are called *herbaceous stems* (huhr BAY shuhs STEMZ). Examples of plants that have herbaceous stems include wildflowers, such as clovers and poppies. Many crops, such as beans, tomatoes, and corn, have herbaceous stems. A cross section of an herbaceous stem is shown in **Figure 4.**

Reading Check **What are herbaceous stems? Give an example of a plant that has an herbaceous stem.**

Figure 4 **Cross Section of an Herbaceous Stem**

Buttercups are just one plant that has herbaceous stems. Wildflowers and many vegetables have soft, thin, and flexible stems.

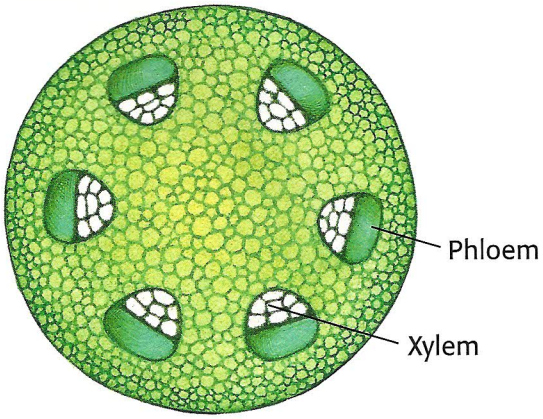
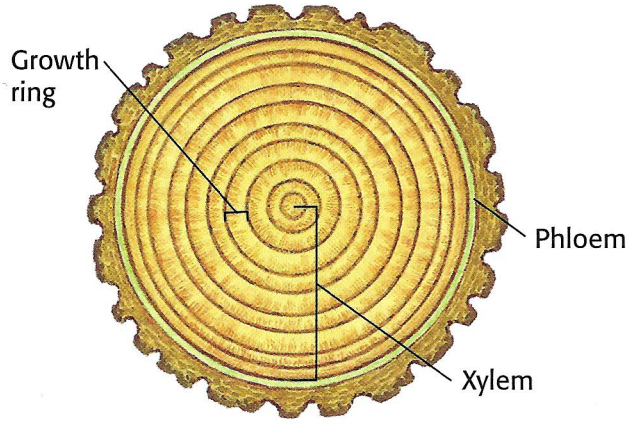


Figure 5 Cross Section of a Woody Stem

Some plants, such as these trees, have woody stems. Plants that have woody stems usually live for many years. People can use growth rings to estimate the age of a plant.



Woody Stems

Trees and shrubs have rigid stems made of wood and bark. These stems are called *woody stems*. **Figure 5** shows a cross section of a woody stem. Trees or shrubs that live in areas with cold winters have a growing period during the spring and summer. These plants have a dormant period during the winter. At the beginning of each growing period, large xylem cells are produced. As fall approaches, the plants produce smaller xylem cells, which appear darker. In the fall and winter, the plants stop producing new cells. The cycle begins again the next spring. A ring of dark cells surrounding a ring of light cells makes up a growth ring.

Leaves

Leaves vary greatly in shape. They may be round, narrow, heart-shaped, or fan-shaped. Leaves also vary in size. The raffia palm has leaves that may be six times longer than you are tall. The leaves of duckweed, a tiny aquatic plant, are so small that several of the leaves can fit on your fingernail. **Figure 6** shows a poison ivy leaf.

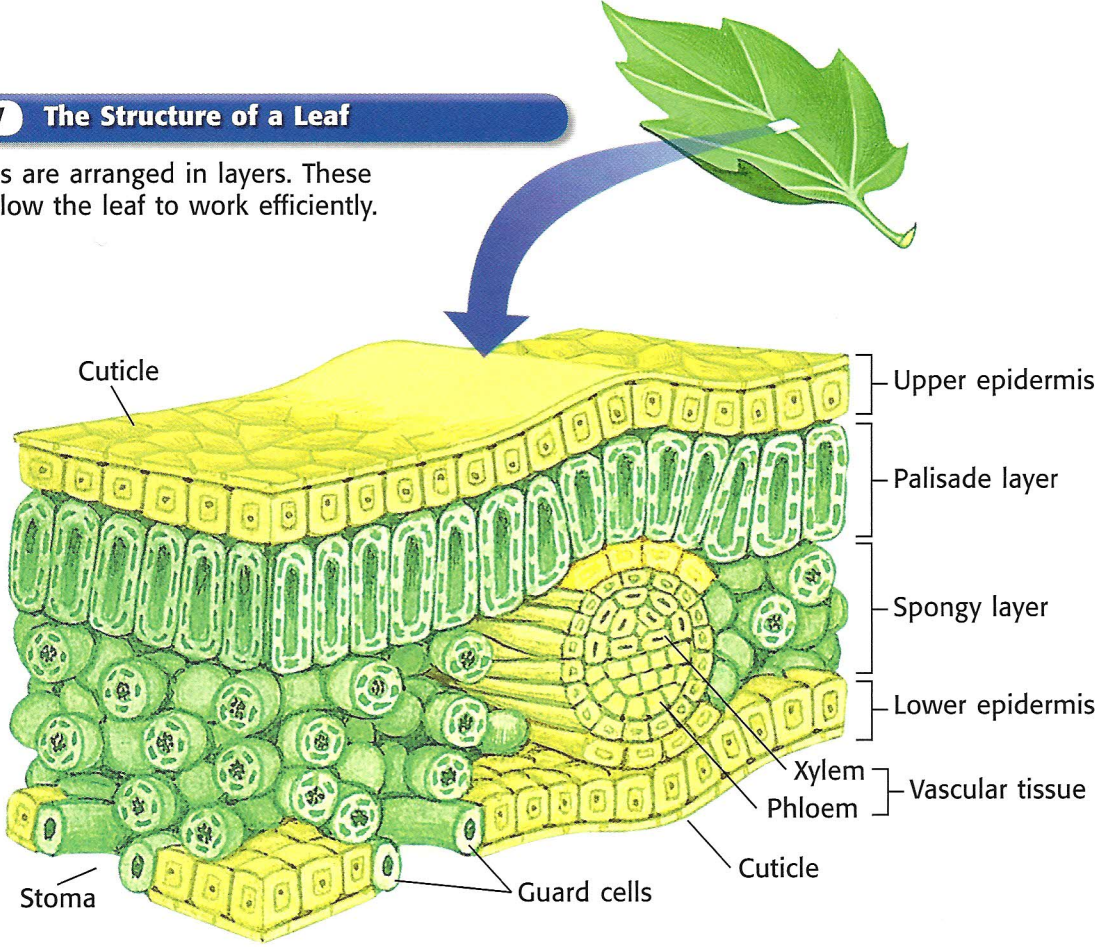
Leaf Functions

The main function of leaves is to make food for the plant. Chloroplasts in the cells of leaves capture energy from sunlight. The leaves also absorb carbon dioxide from the air. The leaves use the captured energy to make food, or sugar, from carbon dioxide and water.

Figure 6 *The leaves of poison ivy are very distinctive. They make food to help the plant survive.*

Figure 7 The Structure of a Leaf

Leaf cells are arranged in layers. These layers allow the leaf to work efficiently.



Leaf Structure

The structure of leaves, shown in **Figure 7,** is related to their main function—photosynthesis. The outer surfaces of a leaf are covered by a cuticle. The cuticle prevents water loss from the leaf. A single layer of cells, the epidermis, lies beneath the cuticle. Light passes through the epidermis. Tiny openings in the epidermis, called *stomata* (singular, *stoma*), let carbon dioxide enter the leaf. Guard cells open and close the stomata.

Most photosynthesis takes place in the middle of a leaf. This part of a leaf often has two layers. Cells in the upper layer, the palisade layer, contain many chloroplasts. Photosynthesis takes place in the chloroplasts. Carbon dioxide moves freely in the space between the cells of the second layer, the spongy layer. Xylem and phloem are also found in the spongy layer.

Reading Check **What are the cell layers of a leaf?**

Leaf Adaptations

Some leaves have functions other than photosynthesis. For example, the leaves of many cactuses are modified as spines. These spines keep animals from eating the cactuses. The leaves of another plant, the sundew, are modified to catch insects. Sundews grow in soil that does not contain enough nitrogen to meet the plants' needs. By catching and digesting insects, a sundew is able to get enough nitrogen.

SCHOOL to HOME

Looking at Leaves

Leaves are many shapes and sizes. They are also arranged on a stem in many ways. Walk around your home. In your **science journal,** sketch the leaves of the plants you see. Notice how the leaves are arranged on the stem, the shapes of the leaves, and the veins in the leaves. Use a ruler to measure the size of the leaves.

ACTIVITY

Flowers

Most people admire the beauty of flowers, such as the wildflowers in **Figure 8.** But why do plants have flowers? Flowers are adaptations for sexual reproduction.

Flowers come in many shapes, colors, and fragrances. Brightly colored and fragrant flowers usually rely on animals for pollination. For example, some flowers look and smell like rotting meat. These flowers attract flies. The flies pollinate the flowers. Plants that lack brightly colored flowers and fragrances, such as grasses, depend on the wind to spread pollen.

Many flowers also produce nectar. Nectar is a fluid that contains sugar. Nectar attracts birds and insects. These animals move from flower to flower and drink the nectar. As they do so, they often carry pollen to the flowers.

sepal in a flower, one of the outermost rings of modified leaves that protect the flower bud

petal one of the ring or rings of the usually brightly colored, leaf-shaped parts of a flower

Sepals and Petals

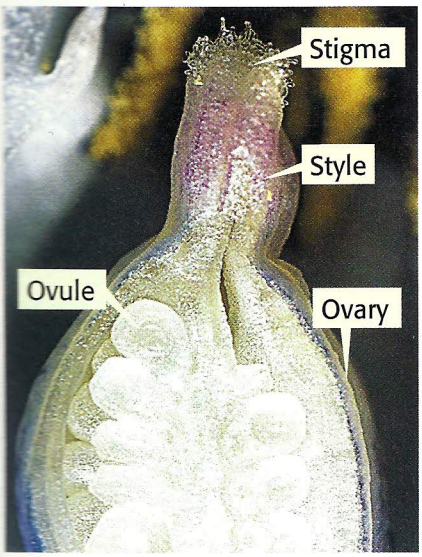
Flowers usually have the following basic parts: sepals, petals, stamens, and one or more pistils. The flower parts are usually arranged in rings around the central pistil.

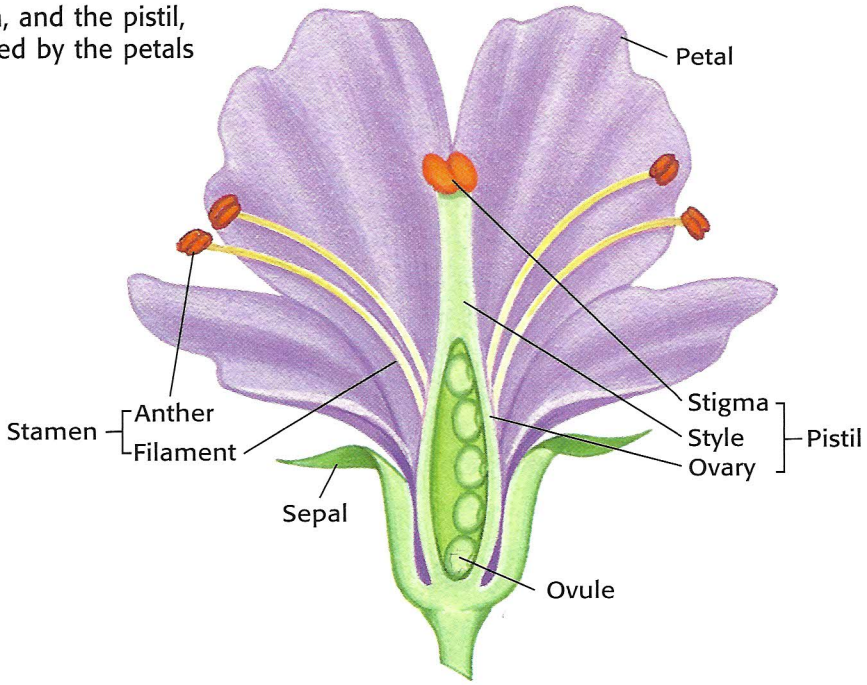
Sepals are modified leaves that make up the outermost ring of flower parts and protect the bud. Sepals are often green like other leaves. Sepals cover and protect the flower while it is a bud. As the blossom opens, the sepals fold back. Then, the petals can unfold and become visible. **Petals** are broad, flat, thin leaflike parts of a flower. Petals vary greatly in color and shape. Petals attract insects or other animals to the flower. These animals help plants reproduce by carrying pollen from flower to flower.

Figure 8 *Many flowers help the plants reproduce by attracting pollinators with bright petals and strong fragrances.*

Figure 9 **The Structure of a Flower**

The stamens, which produce pollen, and the pistil, which produces eggs, are surrounded by the petals and the sepals.





stamen the male reproductive structure of a flower that produces pollen and consists of an anther at the tip of a filament

pistil the female reproductive part of a flower that produces seeds and consists of an ovary, style, and stigma

ovary in flowering plants, the lower part of a pistil that produces eggs in ovules

Stamens and Pistils

As you can see in **Figure 9,** the stamens of flowers are usually found just above the petals. A **stamen** is a male reproductive structure of flowers. Each stamen has a thin stalk called a *filament*. The filament is topped by an anther. Anthers are saclike structures that produce pollen.

Found in the center of most flowers is one or more pistils. A **pistil** is the female reproductive structure of flowers. The tip of the pistil is called the *stigma*. Pollen grains collect on stigmas, which are often sticky or feathery. The long, slender part of the pistil is the style. The rounded base of a pistil that contains one or more ovules is called the **ovary.** Each ovule contains an egg. When the egg is fertilized, the ovule develops into a seed. The ovary develops into a fruit.

Reading Check **Describe stamens and pistils. Which are the female parts of a flower? the male parts of a flower?**

The Importance of Flowers

Flowers help plants reproduce. Humans also use flowers for many things. Roses and many other flowers are used for floral arrangements. Some flowers, such as artichokes, broccoli, and cauliflower, can be eaten. Other flowers, such as hibiscus and chamomile flowers, are used to make tea. Flowers used as spices include cloves and saffron. Flowers are also used in perfumes, lotions, and shampoos.