Chapter 14
Plants

What would it take for plants from Earth to survive in outer space? Travel and life in space is stressful to plants. There are extreme temperatures, drought conditions, radiation, and varying gravity, to name several issues. Scientists from North Carolina State University are looking deep in the ocean for help in redesigning plants for life in outer space. They are studying a microorganism that can grow in underwater sea volcanoes where temperatures exceed the boiling point of water. Scientists are trying to take a helpful gene from this microbe and insert it into a simple plant. Perhaps the adaptability of the microbe can be transferred to the plant, allowing it to grow and thrive in outer space. Read this chapter to learn more about plants. Perhaps in your lifetime, scientists will be growing plants in space!

Key Questions

1. ***What are some main characteristics that all plants have?***
2. ***Do all plants have seeds?***
3. ***How do plants manage to live just about anywhere, from the desert to the Arctic tundra?***

14.1 What Are Plants?

You have many reasons to be thankful for plants. Your breakfast came from plants. In fact, most of your food comes from plants or from animals that eat plants. The paper in this book contains wood pulp from plants. Some of the oxygen you breathe comes from plants. So the next time you see a plant, be sure to say thanks! In this section you will learn about the characteristics and types of plants.

Plant characteristics

Plants vary in size and shape

Plants come in all sizes, from the tiny duckweed which grows to only about 10 mm in length, to the giant redwood which grows to about 100 m in height. Plants also come in many different shapes like a feathery fern or a prickly cactus. Some examples of plants are shown in Figure 14.1.

Characteristics common to all plants

Despite their great diversity, all plants share the following characteristics:

- **Plants are producers and use photosynthesis to make food.** Most plants are green. This is because they contain the pigment chlorophyll. As you read in Chapter 6, chlorophyll absorbs certain wavelengths of light and uses that energy to make carbohydrate molecules.
- **Plants have eukaryotic cells with cell walls.** Plant cells have a true nucleus and are surrounded by a cell wall. The cell wall surrounds the cell membrane, protecting the plant and providing a rigid structure.
- **Plants have a cuticle.** A **cuticle** is a waxy layer that covers the parts of a plant that are exposed to air like leaves and stems. The cuticle is an adaptation for living on land that keeps plants from drying out.

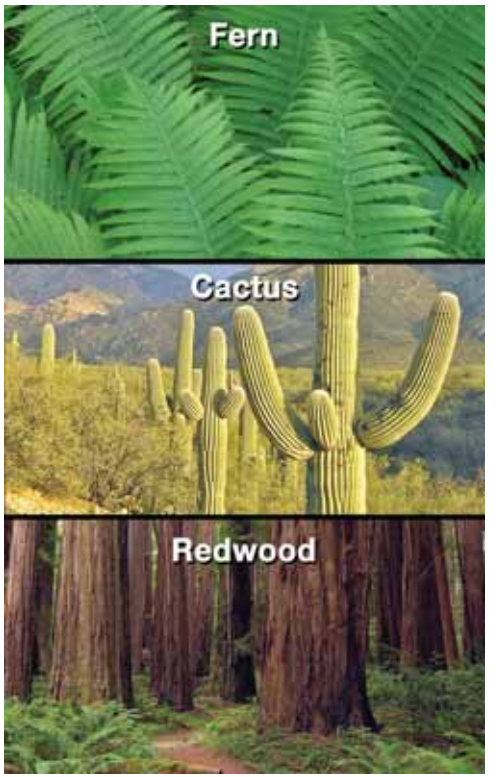

Figure 14.1: *Some representative plants.*

VOCABULARY

cuticle - a waxy layer that covers the parts of a plant that are exposed to air like leaves and stems.

Plant classification

Vascular and non-vascular plants

Classification in the Kingdom Plantae is based on the presence or absence of vascular tissues. **Vascular tissues** are made of cells organized into tube-like structures that transport water, minerals, and food throughout a plant.

Non-vascular plants

Non-vascular plants do not have any tissues to transport water and nutrients. Instead, they depend on the processes of diffusion and osmosis to supply their cells with nutrients. Because these processes are slow, non-vascular plants cannot grow very tall. Mosses and liverworts are examples of non-vascular plants.

Vascular plants

Vascular plants have tissues made of cells that transport water and nutrients throughout the plant. Like your veins and arteries, vascular tissues can transport materials over a distance. The evolution of vascular tissues is one of the adaptations that allowed plants to move onto land. **Vascular plants are divided into two groups—those that produce seeds and those that do not.** Plants that do not produce seeds include ferns, club mosses, and horsetails. Plants that produce seeds are divided into *gymnosperms* and *angiosperms,* which you'll learn more about later.

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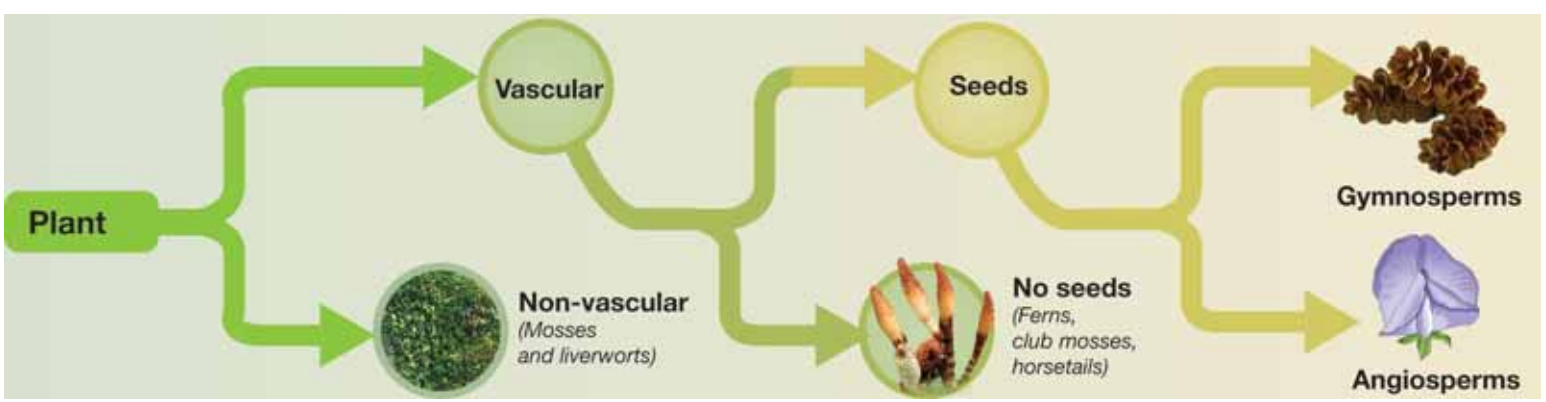
vascular tissues - cells organized into tube-like structures that transport water, minerals, and food throughout a plant.

non-vascular plants - do not have any tissues to transport water and nutrients.

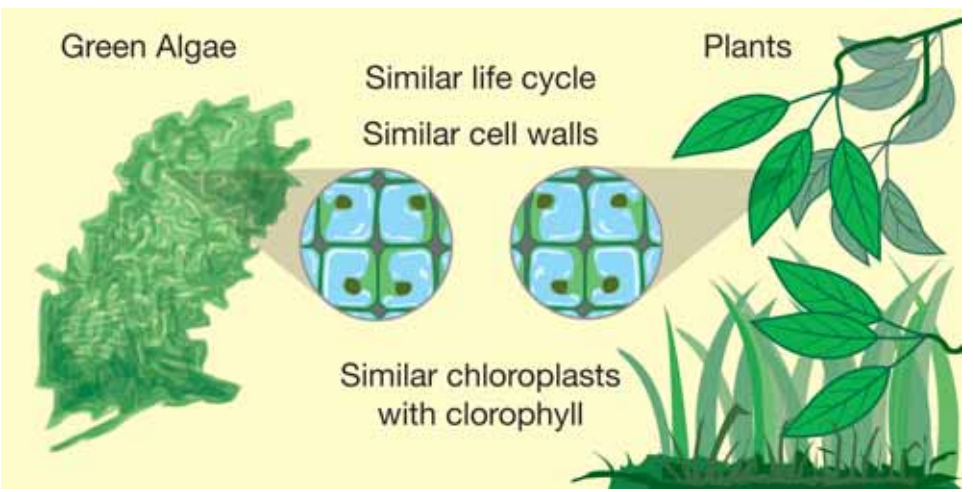
vascular plants - have tissues made of cells that transport water and nutrients throughout the plant.



Plant evolution

Plants and green algae

Because plants are similar in many ways to green algae, scientists think that both may have originated from an ancient species of green algae. Algae and green plants both have a life cycle that involves alternation of generations. Both contain the same type of chlorophyll and make the same type of starch. Also, both have similar cell walls.



A brief evolutionary history

The first ancestors of plants show up in the fossil record during the late Ordovician Period—about 450 million years ago. Plants started out living in water, an ideal environment that supported cells and transported nutrients. As Earth's environments changed, plants had to adapt to life on land. They evolved adaptations for support, protection, and to prevent them from drying out. They also evolved vascular tissues for transporting water and nutrients throughout their bodies. Figure 14.2 shows the evolutionary relationships among plant groups.

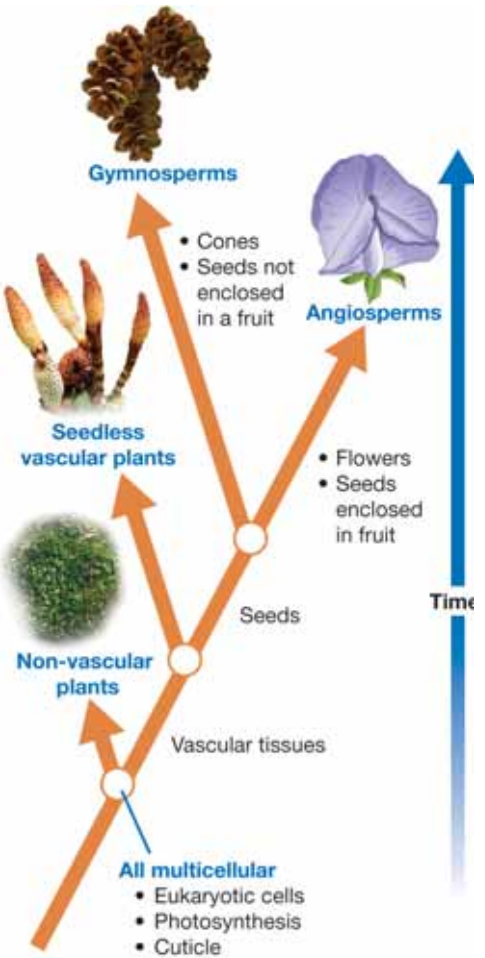


Figure 14.2: *A cladogram that shows evolutionary relationships among major plant groups.*

Non-vascular plants

Characteristics of non-vascular plants

The non-vascular plants include the mosses and liverworts. These are small, simple plants usually found in moist locations. Because they lack vascular tissues, each cell in the plant must absorb water and nutrients through osmosis and diffusion. Thus, mosses and liverworts do not grow very tall. Mosses and liverworts need water to carry the sperm to the eggs for fertilization. The life cycle of non-vascular plants shows an alternation of generations. It includes a *sporophyte* stage that produces spores and a *gametophyte* stage that produces sex cells.

Liverworts

You may have seen liverworts growing on wet rocks and soil in shady places (Figure 14.3). The sporophyte stage of a liverwort looks like a tiny palm tree. The body of the gametophyte stage is leafy and flattened. **Rhizoids** are root-like growths that extend from beneath the body and anchor the plant. They are not considered roots because they do not have vascular tissues.

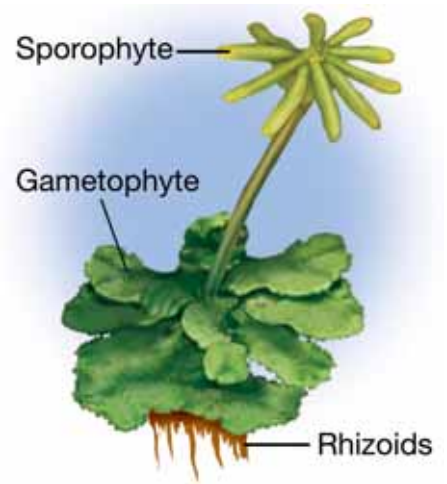


Figure 14.3: *Liverworts.*

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rhizoids - root-like growths on mosses and liverworts that anchor the plant to a surface and do not have vascular tissues.

Mosses

Mosses usually grow together in large colonies and cover an area like a carpet (Figure 14.4). Each moss plant consists of a leafy stalk with rhizoids at the base to anchor the plant. The sporophyte stage of a moss has a *capsule* on top that contains the spores.

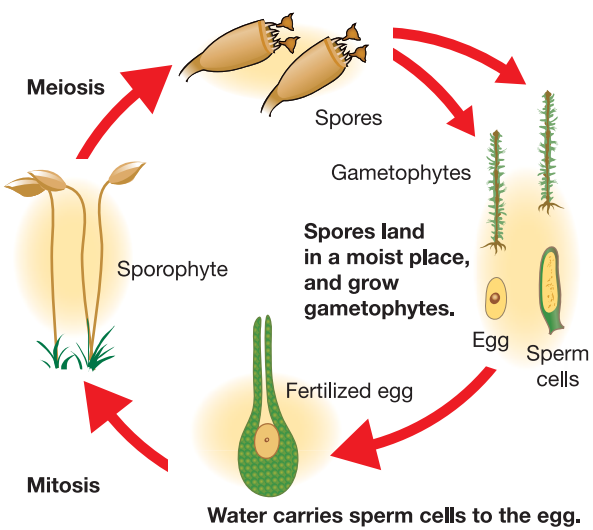


Figure 14.4: *A carpet of moss.*

Seedless vascular plants

What are seedless vascular plants?

The seedless vascular plants include ferns, club mosses, and horsetails (Figure 14.5). Because they have vascular tissues, these plants can grow taller than mosses and liverworts. A typical fern can reach heights of a meter or taller. Tropical tree ferns can reach a height of about 20 m. Ancestors of seedless vascular plants were even taller than their modern descendents. The first forests contained club mosses that grew to around 40 m tall! Modern club mosses are less than a meter tall.

Ferns

You can find ferns in tropical forests, temperate forests, and even in the Arctic. The form of a fern you will notice is the sporophyte. Figure 14.6 shows the structures of a fern. The leafy branch of the fern is called a *frond*. If you look underneath a fern frond, you may see small patches that contain the spores. Not every frond has spores under it. Ferns have an underground stem called a *rhizome* from which the fronds unfurl. Young fronds are tightly coiled and are called *fiddleheads*. The fern gametophyte is heart-shaped and about half the size of a pea. It has female parts that produce eggs and male parts that produce sperm. Like non-vascular plants, ferns need water to transport sperm cells to egg cells.

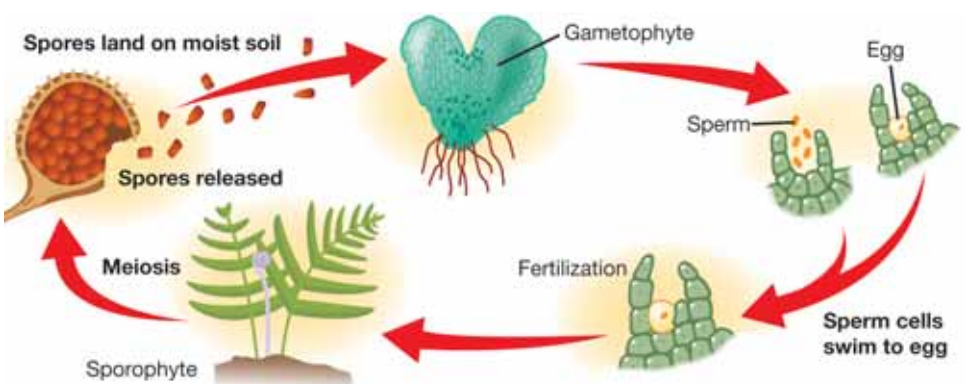


Figure 14.5: *Seedless vascular plants.*

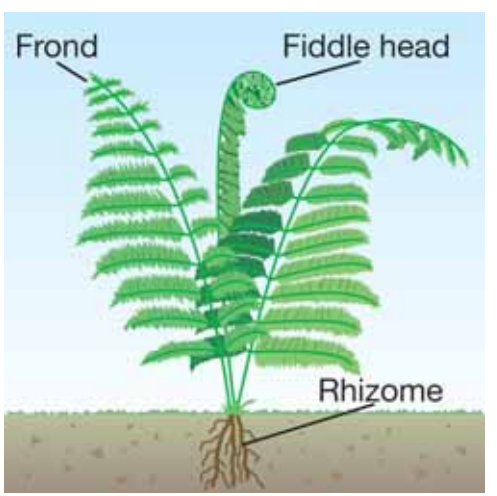


Figure 14.6: *The structures of a typical fern.*

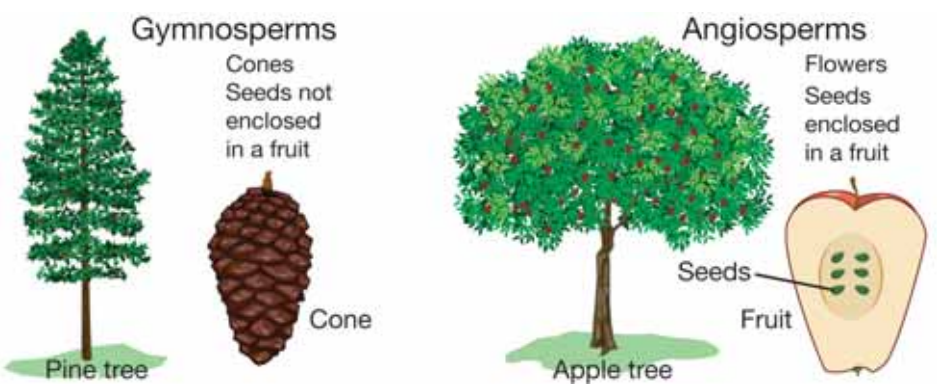
Vascular plants with seeds

What are seeds?

The types of plants you are probably most familiar with are trees, grasses, and flowers. These familiar plants are very different from mosses and ferns. They have the ability to produce *seeds*. A **seed** is a structure that contains a plant embryo and a supply of food inside a protective covering. A seed forms after fertilization and is made up of a plant embryo, stored food, and a tough covering. The three parts of a seed are shown in Figure 14.7.

Gymnosperms and angiosperms

Gymnosperms are a group of vascular plants whose seeds are not surrounded by a fruit. The seeds of many gymnosperms are housed in cones. Most gymnosperms are trees such as pine, fir, and spruce. **Angiosperms**, also known as flowering plants, produce seeds within a fruit. They are the most diverse of all plant groups and include fruit trees, roses, corn, grass, and oak trees.



Adaptations for life on land

Seed plants have many adaptations for living on land. Seeds are more resistant to drying out than spores. Unlike spores, seeds contain stored food to nourish the embryo and help it sprout and grow. Also, seed plants do not require water for reproduction. Recall that mosses and ferns need water for fertilization to occur. Finally, seed plants have well-developed vascular systems for transporting water and nutrients throughout their bodies.

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seed - a structure that contains a plant embryo and a supply of food inside a protective covering.

gymnosperms - vascular, seed-producing plants whose seeds are not enclosed in a fruit.

angiosperms - vascular, seed-producing plants whose seeds are enclosed in a fruit.

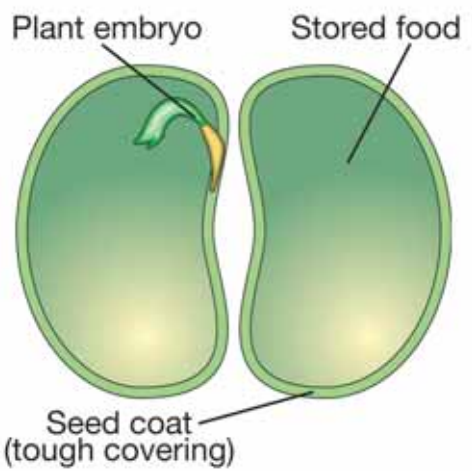

Figure 14.7: *The three parts of a seed.*

More about seed plants

Gymnosperms

Gymnosperms do not produce flowers and their seeds are not enclosed in a fruit. Gymnosperms include conifers, cycads, and gingkoes. A gymnosperm called the bristlecone pine is the oldest living organism on Earth (Figure 14.8). One bristlecone pine is believed to be almost 5,000 years old!

Conifers are a group of gymnosperms

The *conifers*, including pines and firs, are a group of gymnosperms that have cones. There are male and female cones on the same plant (Figure 14.9). Male cones produce male gametophytes called *pollen*. Pollen are dust-like particles that produce sperm. The female cone produces the eggs. Wind carries pollen to the female cone on the same or different plants. Sperm are released and fertilize the eggs. The seeds develop inside of the female cone.

Angiosperms

Angiosperms are flowering plants that produce seeds enclosed in a fruit. Angiosperms are divided into two classes—*monocots* and *dicots*. The two classes have different numbers of cotyledons in their seeds. A **cotyledon** is an embryonic leaf found inside of a seed. Monocots (*mono* = 1) have one cotyledon and dicots (*di* = two) have two. In monocots, bundles of vascular tissue are scattered while in dicots, the bundles form a ring.

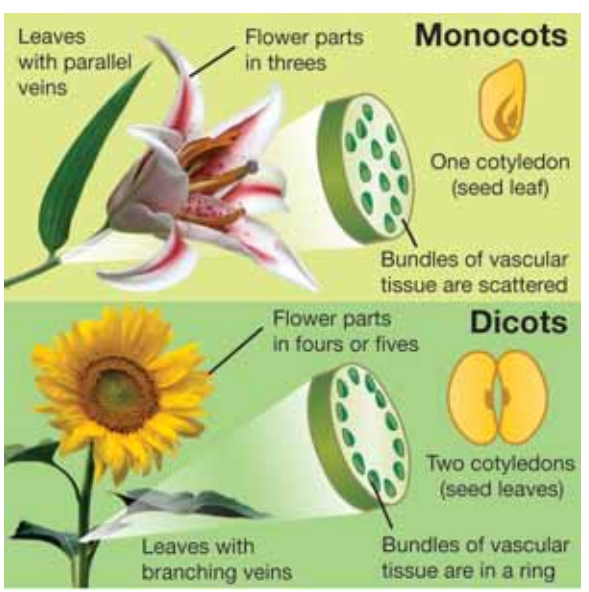

Figure 14.8: *The bristlecone pine is the oldest living thing on Earth.*

Figure 14.9: *Male and female cones on a pine tree.*

14.1 Section Review

1. All of the following are true of plants except:
   a. They have prokaryotic cells.
   b. They have a cell wall.
   c. They use photosynthesis to make their own food.
   d. They have a cuticle.
2. Define the following and give one example of each:
   a. non-vascular plant
   b. vascular plant
   c. seedless vascular plant
3. List two adaptations of plants for living on land.
4. What is the evidence that green plants evolved from green algae?
5. Why are some vascular plants tall while non-vascular plants are always short?
6. What are rhizoids? How are they similar and different than roots?
7. Which is true of the gametophyte generation of a fern?
   a. It produces spores which grow into a new plant.
   b. It produces sex cells.
   c. It is the dominant form of the plant you can see.
   d. It is diploid.
8. What are seeds?
9. List three reason why seed plants are more common than non-vascular or vascular plants with no seeds.
10. Give two examples of a gymnosperm and two examples of an angiosperm.

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(from previous page)

cotyledon - an embryonic leaf found inside of a seed.

CHALLENGE

Plant cells have a cuticle while green algae do not. Explain why plant cells need a cuticle but algae do not.

MY JOURNAL

Although mosses and liverworts are small in size, they play an important role in the environment. Research mosses and liverworts to find out why they are important. Write a few paragraphs about their importance.

14.2 Roots, Stems, and Leaves

Death Valley, in California, is one of the hottest and driest places on Earth. It reaches temperatures well over 50 °C and the average yearly rainfall is less than 5 cm! Yet over 1,000 species of plants flourish there, such as the Joshua tree, shown at the left. Twenty-three of those species are found nowhere else in the world. Seed plants are found in all land environments from mountaintops to the Arctic tundra. How do plants manage to live just about anywhere? The best way to answer this question is to study their structure and function. In this section you will learn about the structure and function of roots, stems, and leaves.

The structure of a plant

Parts of a plant The body of a plant is made up of three distinct regions known as roots, stems, and leaves. *Roots* anchor the plant and take in water and nutrients. Together, all of a plant's roots make up the *root system*. *Stems* support the body of the plant and carry water and nutrients from the roots to other parts of the plant. *Leaves* are the organs of photosynthesis. Recall that photosynthesis is the process of using sunlight to make food. The stems and leaves of a plant make up the *shoot system*.

Vascular tissues Seed plants contain vascular tissues that carry water and nutrients from one end of the plant to the other. There are two types of vascular tissues. **Xylem** is a vascular tissue that carries water. **Phloem** is a vascular tissue that carries sugars and other foods throughout the plant. Figure 14.10 shows the parts and tissues of a plant.

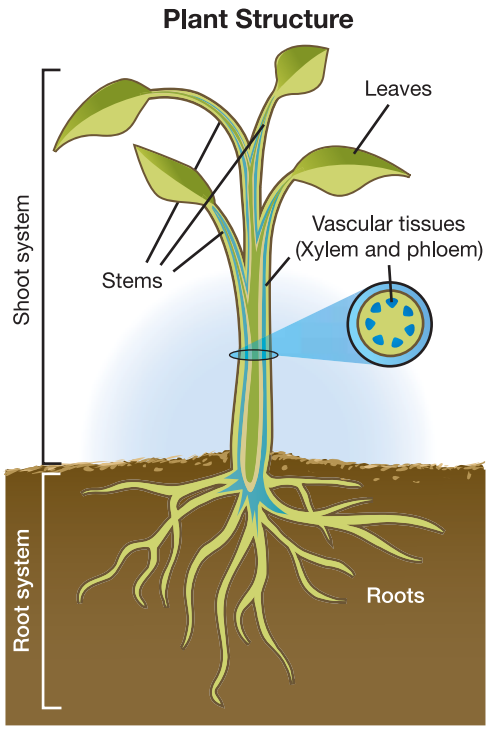

Figure 14.10: *The structure of a plant.*

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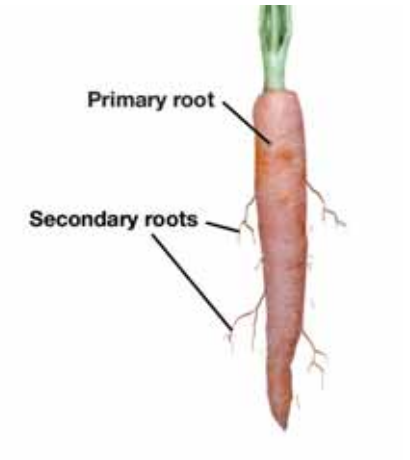
xylem - a vascular tissue that carries water throughout a plant.

phloem - a vascular tissue that carries sugars and other foods throughout a plant.

The root system

Functions of the root system

The main functions of the root system are to collect minerals and water from the soil and to anchor the plant. Roots also help support the part of the plant that is above ground. In addition, some roots store food produced from photosynthesis. The root system consists of a larger *primary root* and thinner *secondary roots* that branch off of the primary root. The photo (right) shows the root system of a carrot plant. The primary root of the carrot stores food.



Structure of roots

The layer of cells that covers the surface of roots is called the **epidermis**. Some epidermal cells grow outward into *root hairs*. Root hairs increase the surface area and maximize the amount of substances a plant can absorb. A plant's root system may contain billions of root hairs! Once absorbed, water and minerals diffuse through a layer of cells called the *cortex* and into the center of the root which contains the vascular tissues (xylem and phloem). The vascular tissues transport water and minerals to the rest of the plant. Figure 14.11 shows a cutaway and a cross section of a root.

Roots and osmosis

Plants use osmosis to take in water. When there is plenty of water in the soil, osmosis rapidly draws water into the root hairs. This happens because the concentration of water is greater on the outside of the root than on the inside. From there, water passes into the vascular tissues through osmosis. If the concentration of water is less outside the root than inside, the plant may lose water.

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epidermis - the layer of cells that covers the surface of roots.

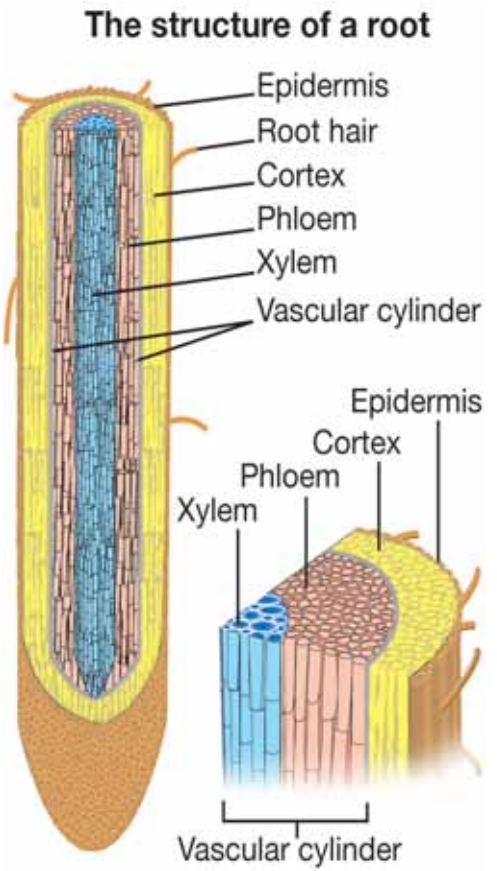


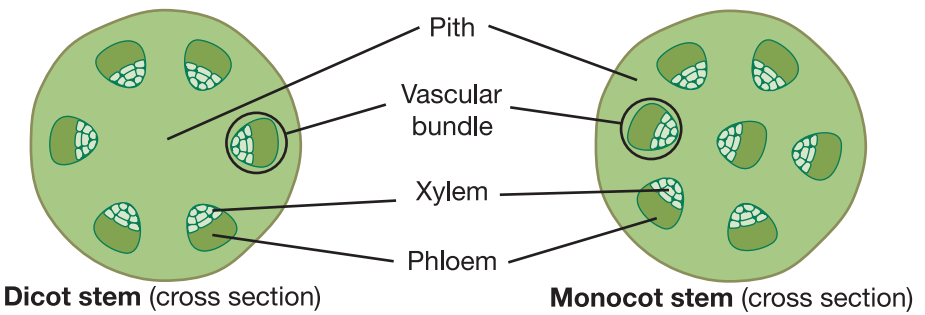
Figure 14.11: *The structure of a root.*

Stems

What are stems? Stems are part of the *shoot system* which also includes leaves and flowers. Flowers are discussed in Section 14.3. **Stems connect the roots that gather water and nutrients to the leaves that carry out photosynthesis.** Stems are usually located above ground, although some plants have underground stems. The white potato is an underground stem that stores starch. Stems come in many forms. The thickened stems of a cactus are adapted for storing water (Figure 14.12).

Figure 14.12: *The stems of a cactus are adapted for storing water.*

Stem structure Like roots, stems are covered in a layer of epidermal cells. They also contain vascular tissues. But those tissues are arranged differently in stems than they are in roots. In monocots, the bundles of xylem and phloem are scattered throughout the stem. In dicots and many gymnosperms, those bundles are arranged in a ring. The tissue inside the ring is called *pith*. The tissue outside the ring is called the *cortex*.



Types of stems Some plants have thin and flexible stems called *herbaceous stems*. Trees and shrubs have *woody stems* and produce a tough material called *wood*. At the beginning of the growing season, the plant produces thicker xylem cells. As fall approaches, the plant produces smaller xylem cells. When the growing season ends, the plant stops producing cells. This process produces the growth rings you see in a cross section of a tree trunk (Figure 14.13).

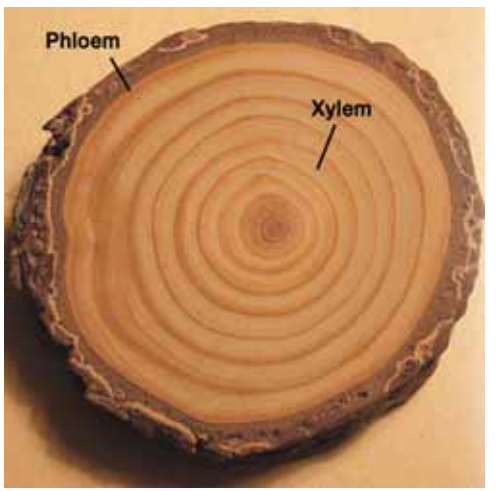


Figure 14.13: *The growth rings of a tree. Scientists analyze growth rings to study past weather patterns.*

Leaves

The function of leaves

The main function of leaves is to use sunlight to make food during the process of photosynthesis. Leaves take in carbon dioxide from the air and absorb sunlight. During photosynthesis, cells in leaves produce carbohydrates and oxygen. Oxygen is released into the air through the leaves. Carbohydrates are transported to other parts of the plant for later use.

The structure of a leaf

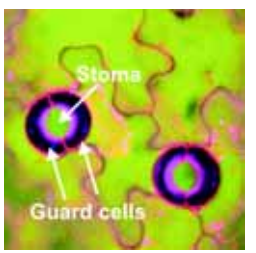
The structure of leaves is related to their function. Many leaves are broad and flat so they can absorb the maximum amount of sunlight. The diagram in Figure 14.14 shows a cutaway view of a leaf. As you can see, a leaf consists of many layers of tissue. The outer surface of the leaf is covered by the *cuticle* which protects the leaf. Next, is a single layer of cells called the *epidermis*. Light can easily pass through the epidermis and into the palisade and spongy layers where photosynthesis happens.

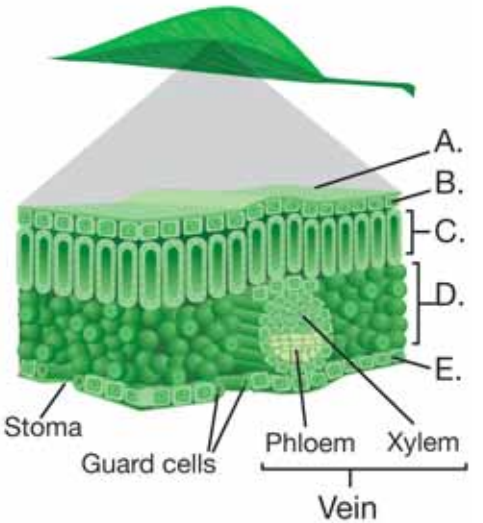
The palisade and spongy layers

The *palisade layer* is made up of elongated cells. Palisade cells contain many chloroplasts, the organelles where photosynthesis occurs. Cells in the *spongy layer* are spaced further apart. The air spaces between the cells allow carbon dioxide to diffuse throughout the leaf. The *veins* of the leaf contain xylem and phloem. Xylem carries water and minerals throughout the leaf. Phloem carries the carbohydrates made during photosynthesis to the rest of the plant.

Stomata

The *lower epidermis* contains tiny pores called stomata (singular, *stoma*). **Stomata** allow carbon dioxide to enter the leaf and oxygen and water vapor to exit. Each stoma is opened and closed by *guard cells*. The picture (right) shows two open stomata and their guard cells.





A. Cuticle

B. Upper epidermis

C. Palisade layer

D. Spongy layer

E. Lower epidermis

Figure 14.14: *A cutaway view of a leaf showing its structures.*

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stomata - tiny pores that allow carbon dioxide to enter a leaf and oxygen and water vapor to exit.

Movement of fluids in plants

The vascular system of plants

The vascular tissues form a network of tubes that carries water and nutrients throughout the plant. The vascular system of a plant is a bit like your circulatory system which carries fluids throughout your body. But plants don't have a heart to pump fluids throughout their bodies. Water enters the plant through the roots by osmosis. But osmosis cannot push water throughout the rest of the plant. In vascular plants, xylem cells are joined to form continuous tubes. Water moves through the xylem by two forces—capillary action and transpiration (Figure 14.15).

Water moves through the xylem by capillary action and transpiration.

Capillary action

If a thin tube is placed in a cup of water, the water will rise up the tube in a process called *capillary action*. Water molecules are strongly attracted to each other and attracted to surfaces. Those attractive forces act together to pull water molecules up a thin tube—like the tubes formed by the xylem of a plant.

Transpiration

A stronger force is produced by a process known as transpiration. **Transpiration** is the loss of water through the stomata. When the stomata are open, the plant is able to obtain carbon dioxide for photosynthesis. Oxygen produced during photosynthesis exits through the open stomata, along with water vapor. As water exits the stomata, it draws more water out of the xylem. The strong attraction of water molecules to each other creates a pull of water molecules throughout the xylem, similar to a train engine pulling cars along. When the stomata are closed, transpiration stops. About 10 percent of the water vapor in Earth's atmosphere comes from plants through transpiration.

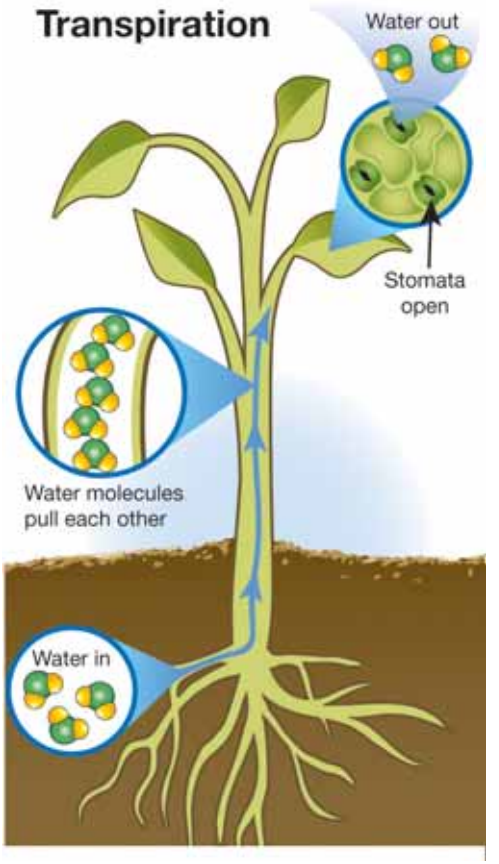

Figure 14.15: *Xylem tissues carry water from roots to leaves through capillary action and transpiration.*

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transpiration - the loss of water through the stomata.

Plant responses

Stimulus and response

Have you ever gone from the dark to a brightly lit room? How does your body respond? First, you quickly squint your eyes. Then, your pupils get smaller to let less light pass in so you can stop squinting. Recall that a reaction to a *stimulus* (like light) is called a *response*. Responding to stimuli is a characteristic of all living things. So it shouldn't surprise you that plants also respond to stimuli.

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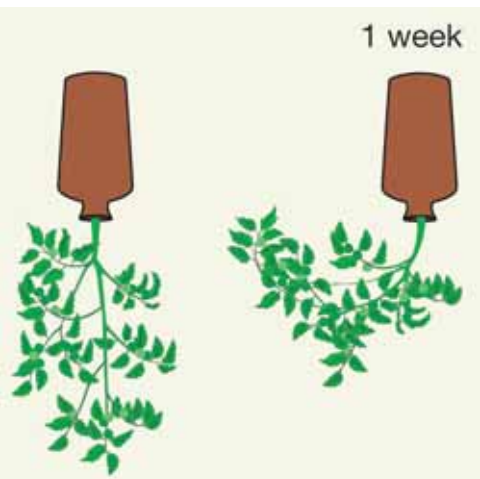
tropism - growth in response to a stimulus.

Tropism



Plants respond to a stimulus by growing either away or toward the stimulus. Growth in response to a stimulus is called a **tropism**. In a positive tropism, a plant grows toward a stimulus. In a negative tropism, a plant grows away from a stimulus. Have you ever noticed that some houseplants appear to turn their leaves to face a window? A change in the growth of a plant due to light is called *phototropism*. When a plant grows toward a light source, the cells on one side of the stem grow longer than the cells on the other side (Figure 14.16). Plants also grow in response to gravity (*gravitropism*). If a plant is turned upside down, it will grow away from the pull of gravity and turn upward, as shown to the left.

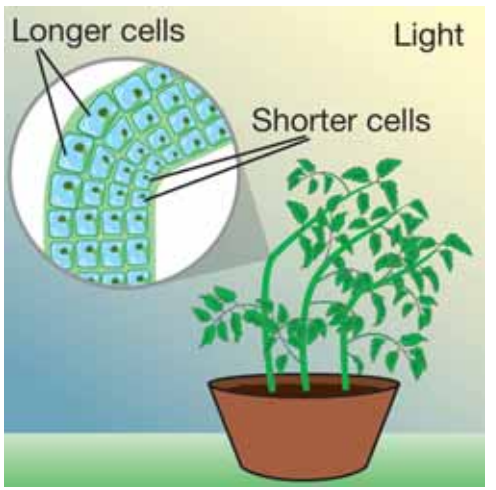


Figure 14.16: *Plant cells on one side of the stem grow longer than on the other side, causing the plant to grow towards a light source.*

Amount of daylight

Plants also grow in response to changes in seasons. As seasons change, so does the amount of light a plant is exposed to each day. In winter, there is less daylight than in summer. Changes in the amount of light each day is a stimulus to many plants. For example, some plants produce flowers in early Spring when the daylight is short. Other plants flower only in late summer when the daylight is long.

14.2 Section Review

1. Describe the major function of each region of a plant:
   a. roots
   b. stems
   c. leaves
2. What are the two major systems in a plant?
3. Explain the function of each vascular tissue:
   a. xylem
   b. phloem
4. What are root hairs? What is their function?
5. How are vascular tissues arranged in a monocot stem? A dicot stem?
6. Name the function of each leaf structure:
   a. stomata
   b. upper epidermis
   c. palisade layer
   d. spongy layer
   e. cuticle
   f. guard cells
7. Explain how transpiration pulls water throughout a plant.
8. Describe how a plant might respond to each situation:
   a. A potted plant is place in a window and receives light from only one direction.
   b. A plant is held in the position shown in Figure 14.17.

SOLVE IT!

For each situation below, tell whether water would move into the roots or out of the roots. Explain your reasoning for each answer.

1. Water is added to the soil of a potted plant that was dry.
2. Salt water is added to a potted plant.

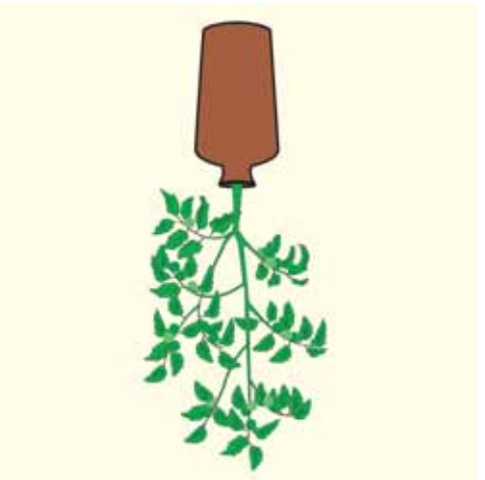


Figure 14.17: *Use this picture to answer question 8b.*

14.3 Reproduction in Flowering Plants

Normally, we associate flowers with a nice smell. But one type of flower, called a *carrion flower*, smells like rotting flesh (Figure 14.18). The smell of the carrion flower attracts flies. When flies crawl into the stinking flower looking for a meal, they brush up against the *anthers* of the flower which contain pollen. The flies fly out, carrying the pollen with them. When they land on another carrion flower, they brush up against the *stigma* and leave pollen behind! Flowers come in an amazing variety of smells, shapes, colors, and sizes. But they all have the same function—sexual reproduction. In this section, you will learn about reproduction in flowering plants.

Figure 14.18: *A carrion flower smells like rotting flesh. It even looks like flesh!*

Evolution of flowering plants

Angiosperms evolved from gymnosperms

It's hard to imagine a world without flowers. Angiosperms—the flowering plants, were the last of the seed plants to evolve. They appeared around 100 million years ago during the age of the dinosaurs and probably descended from a gymnosperm ancestor. Figure 14.19 is a photo of a *magnolia*, a primitive angiosperm. Can you see the resemblance of its fruit to the cone of a gymnosperm?

What are flowers?

A **flower** is the reproductive organ of angiosperms. Flowering plants reproduce by **pollination**, the transfer of pollen, containing sperm, to the female part of the flower. Since plants cannot move, they have evolved adaptations to ensure successful pollination. In many plants, the sperm from one plant must fertilize the egg of another plant. This ensures genetic variation. Over millions of years, a variety of flowers have evolved, many with unique adaptions for pollination. Some involve insects or birds while others involve wind, gravity, and other factors. Today, there are about 250 million species of flowering plants—more than any other group of plants.

VOCABULARY

flower - the reproductive organ of angiosperms.

pollination - the transfer of pollen, containing sperm, to the female part of the flower.

Figure 14.19: *The fruit of the magnolia resembles the cone of a gymnosperm.*

Flower structure and function

The function of flowers

Many flowers are beautiful and are used to celebrate important events. But as far as plants are concerned, flowers are used for one purpose: sexual reproduction. Figure 14.20 shows just a few types of flowers. Despite their diversity, most flowers have the parts shown in the diagram below.

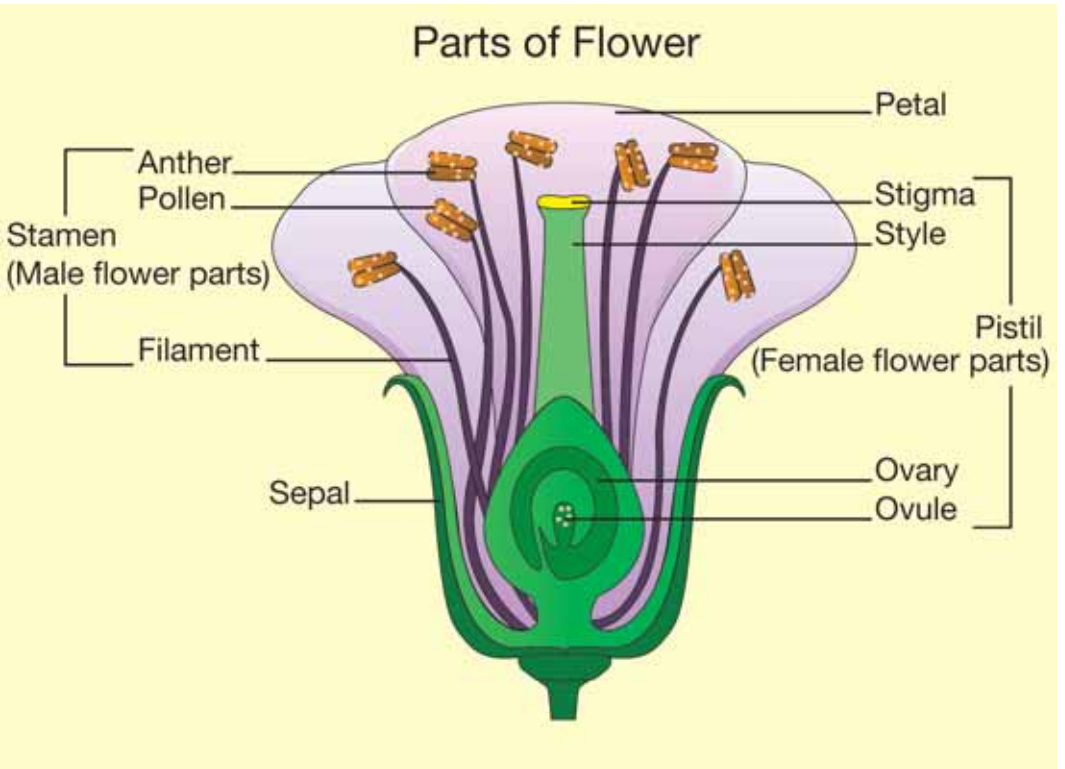


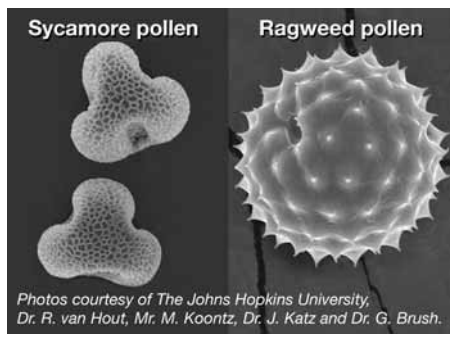
Figure 14.20: *A few types of flowers.*

Arrangement of flower parts

The flower parts are usually arranged in a ring around the female parts of the flower, called the pistil. *Sepals* make up the bottom ring of flower parts and are modified leaves. *Petals* are the colorful part of the flower (sepals are sometimes colorful too). Petals often help the plant reproduce by attracting insects or birds. The petals of the carrion flower are red and spotted and resemble rotting flesh!

Male flower parts

The male part of the flower is called the **stamen**. The stamen consists of the anther, pollen, and filament. The *filament* is a thin stalk that holds an anther. Each *anther* produces grains of pollen. **Pollen** is the reproductive spore that contains sperm cells. The picture (right) shows magnified pollen grains from sycamore and ragweed plants.



Female flower parts

The female part of the flower is called the **pistil**. The pistil consists of the stigma, style, ovary, and ovules (Figure 14.21). A flower may have one or more pistils. They are usually in the center of the flower. The tip of the pistil is called the stigma. The **stigma** attracts and holds grains of pollen. Stigmas are often sticky or feathery. Below the stigma is the *style*. The style connects the stigma to the ovary. The **ovary** is located at the base of the pistil and contains one or more ovules. Each **ovule** contains one egg cell. If fertilization occurs, each ovule develops into a seed and each ovary develops into a fruit.

If fertilization occurs, each ovule develops into a seed and each ovary develops into a fruit.

VOCABULARY

stamen - the male part of the flower.

pollen - the reproductive spore that contains sperm cells.

pistil - the female part of the flower.

stigma - part of the flower that attracts and holds pollen.

ovary - part of the flower that holds one or more ovules.

ovule - part of the flower that holds one egg cell.

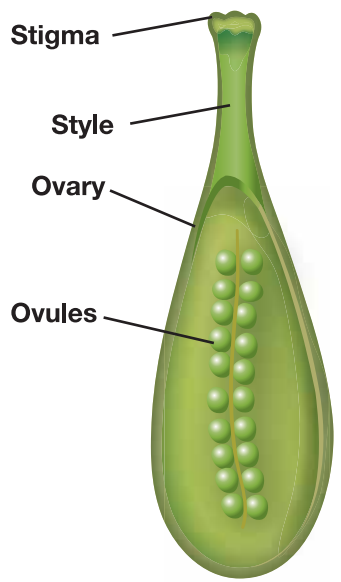


Figure 14.21: *A cross section of a pistil.*

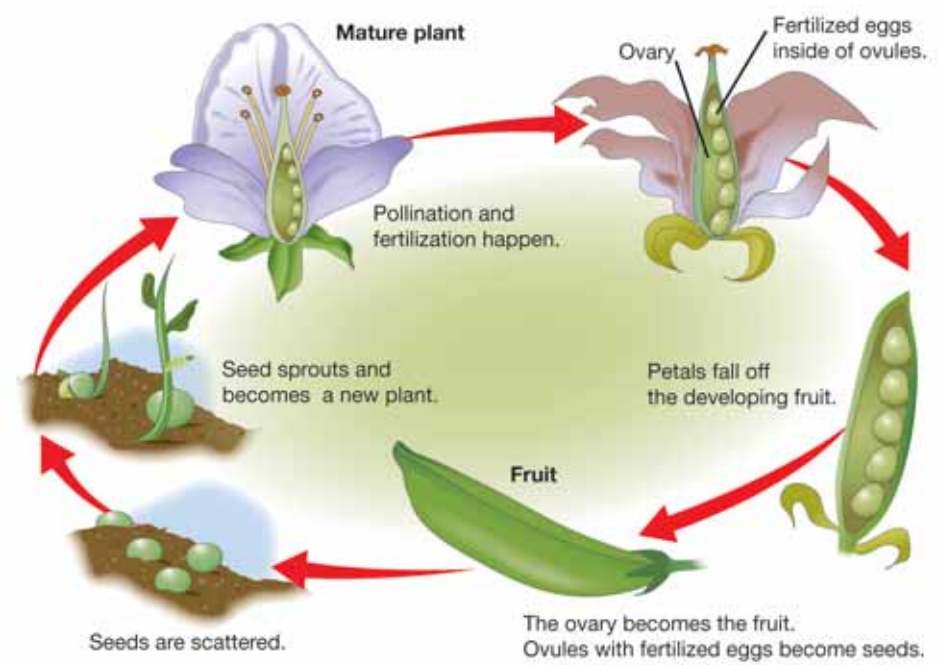
Reproduction in flowering plants

Fertilization

Fertilization in flowering plants happens through a process called pollination. Pollination occurs when pollen grains from the anther land on a stigma. After pollen grains land on the stigma, a *pollen tube* grows from the pollen grain, through the style, and into the ovary. Sperm cells inside the pollen grain travel down the pollen tube and into the ovary which contains the ovules. Fertilization occurs when one of the sperm cells fuses with the egg inside of an ovule (Figure 14.22).

Development of fruits and seeds

After fertilization occurs, each ovule develops into a seed. Each seed contains a tiny, undeveloped plant called an embryo. The ovary surrounding the ovules develops into a fruit that contains one or more seeds.



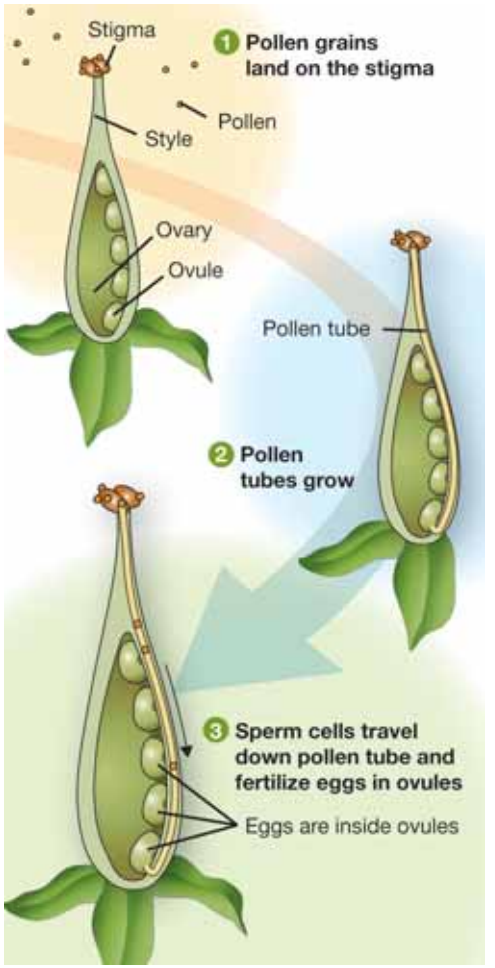


Figure 14.22: *Sperm cells travel from the pollen, through the pollen tube, and into the ovary where fertilization occurs.*

Fruits

What is a fruit?

Can you name a fruit? When you think of fruit, you may first think of oranges, grapes, and strawberries. But there are other examples you may not associate with being fruits. For example, a green bean is the fruit of the green bean plant. Figure 14.23 shows the fruit of a milkweed plant. A **fruit** is defined as a ripened ovary that contains angiosperm seeds. The ovary develops into a fruit at the same time the ovules develop into seeds. As the fruit develops, it swells and ripens. The function of a fruit is to hold and protect the seeds.

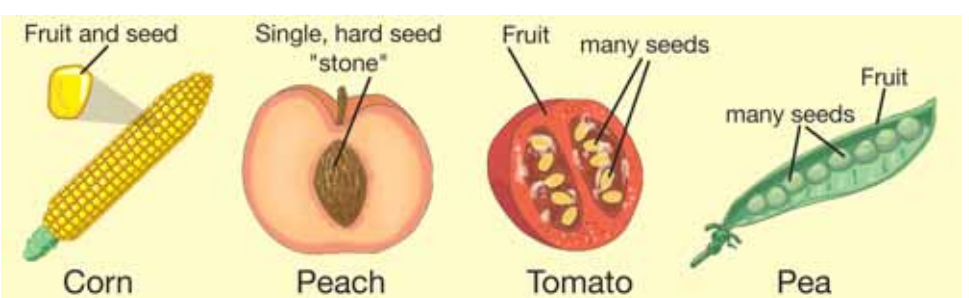
Figure 14.23: *The fruit of a milkweed plant.*

VOCABULARY

fruit - a ripened ovary that contains angiosperm seeds.

The amazing variety of fruits

The simplest fruits consist of a single seed enclosed in a single ovary. Grains like corn and wheat fit this description. In many grains, the ovary walls are so thin that they fuse with the seed. Each kernel of corn on a cob is actually an individual fruit! In nuts like acorns and chestnuts, the ovary hardens into a protective shell. In fruits like peaches and cherries, the fruits are soft and fleshy and contain a single, stony seed. Ovaries that contain many ovules produce a single fruit with many seeds. Grapes with seeds and tomatoes are examples. Legumes like beans and peas produce a fruit called a pod that contains many seeds. Most of the "fruit" of an apple is actually formed by the stem surrounding the ovary. If you slice an apple in half, you can see the boundary between the ovary wall and the stem (Figure 14.24).



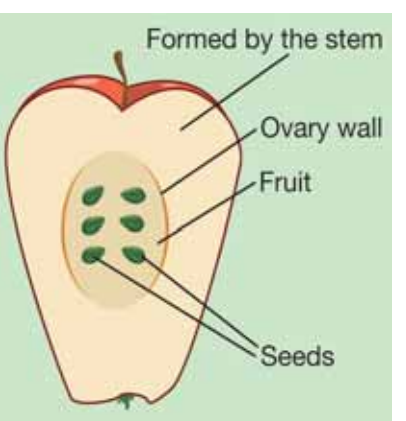


Figure 14.24: *The fruit of an apple begins in the core.*

Seeds and seed dispersal

Germination

Once the fruit and seeds are fully developed, the plant embryo inside of the seed goes into a *dormant* (inactive) state. Dormant seeds can often survive various harsh conditions like freezing temperatures and drought. Some seeds require extreme conditions to break their dormancy. Forest fires for example, burn the seed coats of some plant species and allow them to *germinate*. **Germination** is the process of a seed sprouting and its growth into a young plant (Figure 14.25).

Seed dispersal

Seed dispersal—the scattering of seeds, is an important part of a seed plant's life cycle. In order to germinate, a seed needs to be dropped into an environment with suitable conditions. Because plants cannot move, they depend on other forces to help seeds find the right conditions. These forces may include wind, water, or animals. **Fruits have evolved many ways to aid in seed dispersal.**

Examples of seed dispersal

Many seeds are dispersed directly into the air and rely on the wind to carry them. Maple trees have winged fruits that carry their seeds from the parent plant. Milkweed seeds have a tiny "umbrella" that allows them to drift over long distances. Coconuts are encased in a leathery fruit that floats over great distances on the ocean. Fruits like grapes, strawberries, and raspberries have sweet, fleshy fruits that are eaten by animals. The seeds pass, unharmed, through the animal's digestive system and are deposited in a new location.

VOCABULARY

germination - the process of a seed sprouting and its growth into a young plant.

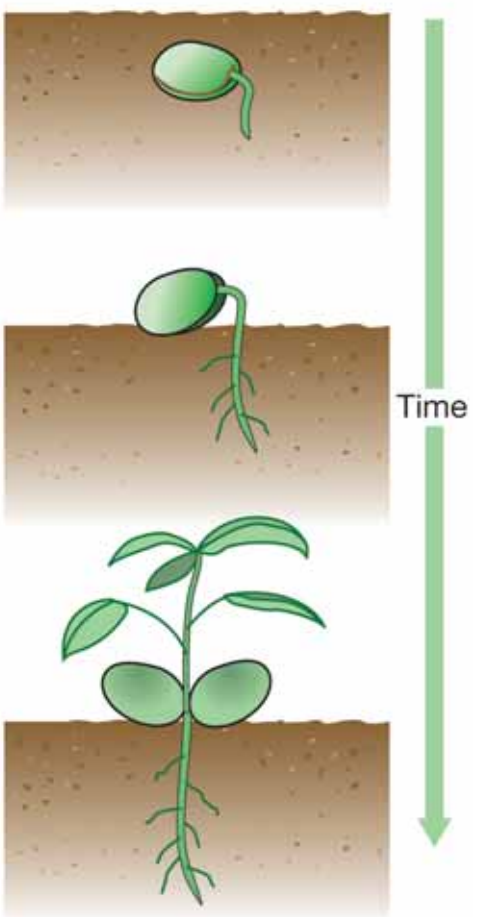


Figure 14.25: *The germination of a clover seed.*

14.3 Section Review

1. What is the main function of flowers?
2. How is a carrion flower adapted for pollination?
3. Match the structures below with their location on the diagram in Figure 14.26.

   stigma

   ovary

   ovule

   anther

   style

4. Name the function of each part in question 4.
5. List the steps to fertilization in flowering plants.
6. Why do seed plants need to evolve ways of dispersing their seeds?
7. Explain how each fruit is adapted to disperse seeds (wind, water, or animals).

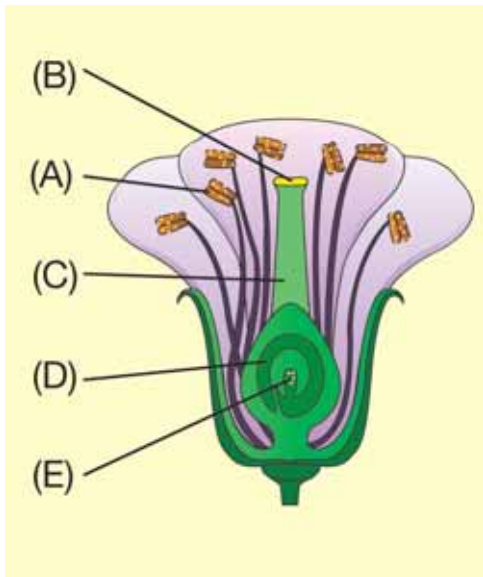
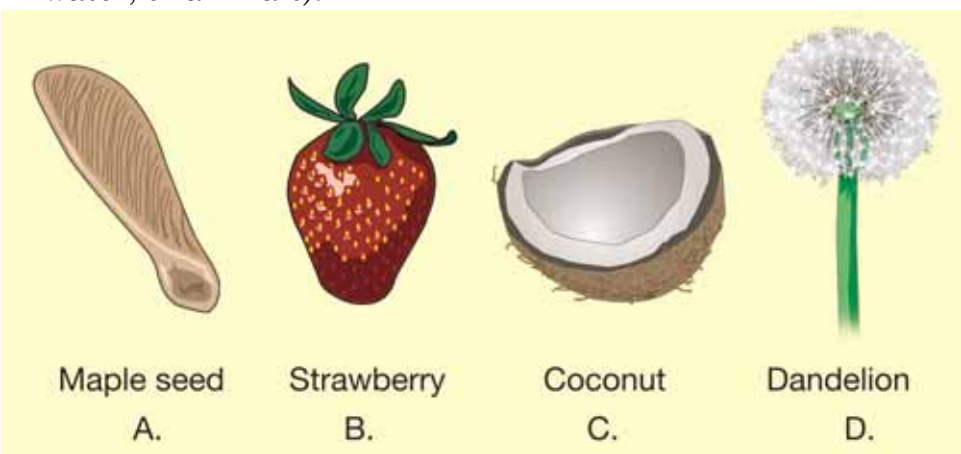


Figure 14.26: *Use the diagram to answer question 3.*



BIOLOGY CONNECTION

The Buds and the Bees

Lauren smiles as she dips her finger into the bucket of honey. She knows this golden liquid is deliciously sweet. Soon, it will be poured into jars and labeled and sold.

This is a common scene at Lauren's house because her father is an apiarist. That's another word for "beekeeper" (*apis* is Latin for bee), and there are an estimated 211,600 apiarists in the United States.

The honeybee colony

Honeybees are social insects that live in colonies. A typical colony will have one queen bee and thousands of worker bees and drones. The queen is the largest bee in the colony. Her job is to lay eggs, and a healthy queen can lay 3,000 eggs in one day. The workers are the smallest bees and there can be 50,000 of them in a colony. They, too, are females, and their jobs include collecting nectar and pollen, producing wax cells, making honey, tending the young, guarding the hive, and caring for the queen and the drones. Needless to say, they are the original "busy bees." Their age determines their job: Younger workers clean, build cells, and make honey; older workers gather nectar, pollen, and water. All worker bees defend the colony with their stingers. Most honeybees die shortly after they sting an intruder.

Male honeybees are called drones. They are larger than the workers and their job is to mate with the queen. There are usually only a few thousand drones in a colony. Drones do not have the body parts to collect nectar and pollen, nor do they have stingers.

The hive

Bee colonies make their homes in hives. Wild bees usually build their hives in trees. Beekeepers like Lauren's father build wooden hives for their bees. These wooden structures are usually boxlike, with removable frames lined up inside them. A single beehive can house an average of 50,000 bees.

The flower and pollination

Did you ever wonder why flowers are shaped and colored the way they are? A flower's color, scent, and structure are all important when it comes to attracting honeybees. Bees tend to like flowers that are blue, purple, and yellow. Bees have a strong sense of smell and are attracted to sweet-smelling flowers. Why is it important for bees to be attracted to flowers? It's a matter of "give and take": Honeybees gather the sweet nectar and pollen from the flowers - and as they flit from flower to flower, the bees pollinate the plants.

The transfer of pollen from one plant to another is called pollination. A large part of our diet comes from plants that have been pollinated by the honeybee. In fact, they are responsible for pollinating about 130 different agriculture crops such as fruits, berries, nuts, and vegetables. Large commercial farmers will rent colonies of honeybees to pollinate their crops.

They make honey in combs

How does the nectar of a flower become honey inside a honeycomb? The worker bees drink the nectar from the flowers and store it in honey sacs. Back at the hive, they transfer the honey into cells inside the wax combs. A cell is a hexagonal-shaped wax chamber used to store honey. All of these cells together make up the honeycomb. The workers must collect nectar from about 2 million flowers in order to produce about 1 pound of honey.

Beekeepers and their hives

Beekeepers like Lauren's father use smokers to calm their bees before opening the hive.

Honeybees have an alarm system that goes off when they smell smoke. They fear their hive is burning and they act to save the honey. They gorge themselves on honey and afterward are less likely to sting an intruder. The beekeepers can open the hive boxes and remove the individual frames. After careful inspection, the honey can be extracted from the comb and processed.

Questions:

1. What would happen to a honeybee colony if there were no worker bees?
2. Why are honeybees called "social insects"?
3. Explain the importance of honeybee pollination.
4. How do flowers and honeybees benefit each other?

CHAPTER ACTIVITY Design Your Own Pollinator

With the exception of plants that self-pollinate, all plants need pollinators. *Pollinators* like bees, birds, and butterflies, are responsible for carrying the pollen from one flower to another. Many flowering plants depend on pollinators to reproduce. As a result, many flowers have evolved certain adaptations to attract pollinators. Such adaptations increase a plants' chances reproduction. In this activity, you will create an imaginary flower with certain characteristics to attract and an imaginary pollinator that you will also design. For the activity, you will need drawing paper and colored pencils.

What you will do

1. Choose an organism to be the pollinator of your flower. You may choose a real organism or make up your own imaginary species.
2. Describe your pollinator. In neat writing, answer the following questions:

- What is your pollinator's (animal's) favorite food?
- What is your pollinator's (animal's) favorite shape?
- What is your pollinator's (animal's) favorite color?
- What is your pollinator's (animal's) favorite smell?

3. Draw and name your pollinator.
4. Label the part of pollinator's body that would pick up the pollen.
5. Using the qualities your pollinator likes, draw and name an imaginary flower that would attract your pollinator. Be creative!
6. Remember, the pollinator wants the food. Be sure to place the food in an area where the pollinator will be able to pick up the pollen while trying to get the food.
7. Label where the pollen is located on the flower.
8. Label where the pollen is deposited on the flower.
9. Be neat and creative!

Applying your knowledge

a. At the bottom of your picture, write a few paragraphs explaining the adaptations your pollinator has to the flower it pollinates.
b. Describe how the pollen is transferred from the pollinator to the flower. Use complete sentences and write neatly.
c. Describe the adaptations your flower has to the pollinator.

Chapter 14 Assessment

Vocabulary

Select the correct term to complete the sentences.

angiosperm	cotyledon	cuticle
germination	flower	fruit
ovary	gymnosperm	non-vascular plants
pistil	ovule	phloem
vascular plants	pollen	pollination
epidermis	seed	stamen
stigma	rhizoids	transpiration
tropism	stomata	vascular tissues
xylem		

Section 14.1

1. Angiosperms and gymnosperms are the two types of _____ that produce seeds.
2. The _____ is an important adaptation that allows plants to live on land without drying out.
3. Roots are more complex than _____ because they have vascular tissue.
4. All angiosperms either have one or two _____s inside their seeds.
5. Cells organized into tube like structures to transport water, minerals, and food make up _____.
6. Conifers, cycads, and ginkgoes are three groups of _____.
7. _____ usually grow in moist locations so that their cells can directly absorb water and nutrients through osmosis and diffusion.
8. The most diverse group of plants are the _____s, also known as flowering plants.
9. The three parts of a _____ are: a plant embryo, a food supply, and a protective covering.

Section 14.2

10. Carbon dioxide enters and oxygen and water vapor exit through the _____.
11. _____ produces 10% of the water vapor found in the Earth's atmosphere.
12. The way that plants respond to a stimuli, such as light or gravity, is called a _____.
13. Some of the cells of the _____ of roots grow out into root hairs to maximize the amount of substances that a plant can absorb.
14. The vascular tissue that carries water is called _____, while the vascular tissue that carries food is called _____.

Section 14.3

15. The _____ is the male part of the flower consisting of the anther, filament, and pollen.
16. Over time, _____s have developed amazing adaptations for _____.
17. _____ occurs when the seed sprouts and begins to develop into a whole new plant.
18. The _____ develops into the seed, while the _____ develops into the fruit.
19. _____ must be transferred from the anther to the _____ for pollination to occur.
20. The _____, which is the female part of the flower, is usually found in the center.
21. The function of the _____ is to hold and protect the seeds.

Concepts

Section 14.1

1. List three reasons why plants are important.
2. Identify two ways that plants are different from animals in terms of cell structure.
3. How are plants different from bacteria?
   a. Plants are eukaryotic, while bacteria are prokaryotic.
   b. Plants are multicellular, while bacteria are unicellular.
   c. Plants have a cell wall, while bacteria don't.
   d. both a and b
4. Why do cacti have a thick cuticle?
5. Would you expect a tall desert plant to be vascular or nonvascular? Explain your answer.
6. Why do seedless vascular plants still need to grow where it is moist if they have vascular tissue to move materials?
7. Explain what the difference is between each pair of terms:
   a. rhizoid, root
   b. spore, seed
   c. cone, fruit
   d. gametophyte, sporophyte
   e. vascular, non-vascular
   f. angiosperm, gymnosperm
   g. monocot, dicot
8. Match each plant with the group to which it belongs:

a. cycads	1. nonvascular plants
b. club mosses	2. gymnosperms
c. liverworts	3. seedless, vascular plants
d. grasses	4. angiosperms

Section 14.2

9. Draw and label your own example of a plant with these words: root system, roots, shoot system, stems. and leaves.
10. List five plants that you would put into a salad. Identify the part of the plant that you eat.
11. Desert plants often have shallow root systems that extend very far from the plant. Explain how this root adaptation is helpful.
12. What cell process do roots use to take in water?
    a. diffusion
    b. transpiration
    c. osmosis
    d. photosynthesis
13. Explain why rainforest plants often have large flat leaves, while desert plants usually have small, spiky leaves.
14. Why are the cuticle and epidermis transparent?
15. What part of the leaves are chloroplasts found in?
    a. spongy layer
    b. palisade layer
    c. cuticled
    d. epidermis
16. Would you expect plants to absorb more carbon dioxide during the day or at night? Why?
17. You look down on a plant growing in a shady area and notice something about the leaf arrangement. Each leave is spaced out so that it is not covering the leaf below it. Why is this a useful adaptation for the plant?
18. The two forces that move water through the xylem are _____ and _____.

Section 14.3

19. Why are flowers that are pollinated by the wind usually lacking bright, colorful petals? Why don't pine cones smell pretty? Explain how flowers and pine cones are specially adapted to fit their means of pollination.
20. Identify these flower parts as male or female: filament, ovule, pollen, ovary, anther, pistil, stigma, stamen, style.
21. In some flowers, the stamen extends beyond the petals. Is this helpful or harmful for the flower? Why?
22. Imperfect flowers have either male or female parts. Can these flowers self pollinate? From your understanding of genetics and angiosperm reproduction, is this arrangement advantageous? Explain your answer.
23. Ginkgoes have separate male and female plants. The fruit of ginkgo trees smells unpleasant. For this reason, only male trees are planted near houses. Explain why this practice makes sense.
24. Explain the advantage of dormancy for seeds.
25. What conditions would you predict are required for seed germination in most species of plants?
26. Explain how the seeds in the picture below are dispersed.

27. Describe what three challenges might be for a seedling that germinates right next to the parent plant.

Math and Writing Skills

Section 14.1

1. After science class one day, your friend tells you that he thinks plants are dumb. Write a persuasive paragraph to convince your friend that plants are really important in your daily life.
2. You are involved in writing a script for a new documentary about the challenges that plants face living on land. Choose a plant (moss, fern, gymnosperm, or angiosperm) and write an imaginary interview describing their adaptations for life out of water.
3. Your friend lives in Costa Rica and has a beautiful fern garden in her backyard. She is about to move to Arizona and is making plans for her garden at her new home. She is planning on trying another fern garden. What advice would you give your friend about her landscape plans?
4. Create a pie graph to show the comparative numbers of species of seedless vascular plants: 12,000 ferns, 1,000 club mosses, and 15 horsetails.
5. Which offers better protection for a seed - a cone or a fruit? Design an advertisement to show off the special features of your choice.
6. Monocots have petals in multiples of threes. Dicots have petals in multiples of fours and fives. Identify each of these flowers as monocot or dicot:
   a. 9 petals
   b. 16 petals
   c. 20 petals
   d. 21 petals

Section 14.2

7. Plants have adapted to all the diverse habitats of the Earth. Select three different habitats and describe the challenges that plants face there. Explain what special features that plants have for dealing with these challenges.
8. A tree trunk has a radius of 55 centimeters.
   a. What is the diameter?
   b. What is the circumference?
   c. If the tree grows at a rate of 10 mm a year, how old is the tree?
9. Design an experiment to show how water that is pulled in through the roots of plants is lost through the leaves.

Section 14.3

10. Many people don't realize that tomatoes are fruit. Now that you know the scientific definition of a fruit, make a list of ten other vegetables that may not be properly known as fruit.
11. Franny works in the produce department of a local grocery store. Her manager tells her to mark down all the fruit by 25% for an upcoming sale. She needs your help to determine which items are fruit. Calculate the new prices for the fruit in the chart below. Prices are listed per pound.

Butternut squash:	1.29	Potatoes:	0.40
Lettuce:	0.99	Onion:	0.20
Tomatoes:	2.99	Carrots:	0.25
Asparagus:	1.99	Green peppers:	2.99
Green beans:	1.19	Cabbage:	0.20
Cucumbers:	1.39	Spinach:	1.49
Oranges:	0.69	Bananas:	0.79

12. A seed package label claims that the seeds are 95% viable. If you plant 30 seeds, how many plants can you expect to grow?

Chapter Project

Carnivorous plants

Did you know that some plants can attract, capture, kill, and digest insects and other animal life? Carnivorous plants have been around for thousands of years. For this project you will choose a carnivorous plant and a method for sharing information about the plant with the rest of the class.

1. Choose one of these carnivorous plants

- Venus Fly Trap
- Cobra Lily
- Australian Pitcher Plant
- Tropical Pitcher Plant Vine
- Sundew

2. Choose a method for sharing information

- Tri-fold brochure
- Diorama that shows habitat, plant, and prey
- Working model of carnivorous plant

3. List four sources of information to accompany your project. Only two of the sources can be websites.
4. Make sure your project shows the following:
   a. Common name and scientific name of carnivorous plant
   b. Examples of plant's prey
   c. Explanation of plant's attraction, capture, and killing processes
   d. Information about plant's habitat