

Reproduction in Plants

Color-enhanced SEM Magnification: 1800X

What You'll Learn

- You will compare and contrast the life cycles of mosses, ferns, and conifers.
- You will sequence the life cycle of a flowering plant.
- You will describe the characteristics of flowers, seeds, and fruits.

Why It's Important

Much of life on Earth, including you, depends on plants. Humans eat plants and some people eat organisms that eat plants. If plants did not reproduce and continue their species, the food sources for much of life on Earth would disappear.

Understanding the Photo

Pollen grains of seed plants—coniferophytes and angiosperms—contain male reproductive cells. Botanists and paleobotanists can use the unique structures of pollen grains to identify living or extinct seed-plant species. This color-enhanced SEM photograph shows pollen grains from several species of living angiosperms.



Biology Online

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- study the entire chapter online
- access Web Links for more information and activities on reproduction in plants
- review content with the Interactive Tutor and self-check quizzes

Section 24.1

SECTION PREVIEW

Objectives

Review the steps of alternation of generations.

Survey and identify methods of reproduction and the life cycles of mosses, ferns, and conifers.

Review Vocabulary

gametophyte: haploid form of an organism in alternation of generations that produces gametes (p. 532)

New Vocabulary

vegetative reproduction
protonema
megaspore
microspore
micropyle

Life Cycles of Mosses, Ferns, and Conifers

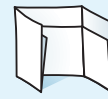
FOLDABLES Study Organizer

Life Cycles Make the following Foldable to help you organize events in the life cycles of mosses, ferns, and conifers.

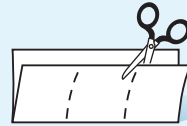
STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back part about 5 cm longer than the front part.



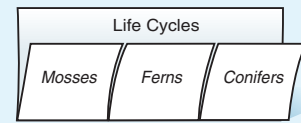
STEP 2 **Turn** the paper so the fold is on the bottom, then **fold** it into thirds.



STEP 3 **Unfold and cut** only the top layer along each fold to make three tabs.



STEP 4 **Label** the Foldable as shown.



Illustrate and Write As you read Chapter 24, illustrate and write about the life cycles of each group of plants behind the appropriate tab.

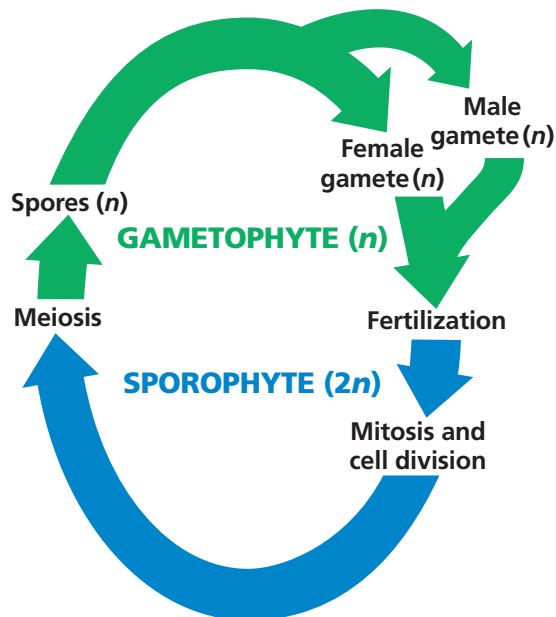


Figure 24.1

In an alternation of generations, the gametophyte (n) stage produces gametes, and the sporophyte ($2n$) produces spores.

Alternation of Generations

As you learned earlier, most plant life cycles include an alternation of generations. As shown in **Figure 24.1**, an alternation of generations consists of a sporophyte stage and a gametophyte stage.

All cells of a sporophyte are diploid. Certain cells of a sporophyte undergo meiosis, which produces haploid spores. These spores undergo cell divisions and form a multicellular, haploid gametophyte. Some cells of a gametophyte differentiate and form haploid gametes. The female gamete is an egg and the male gamete is a sperm. When a sperm fertilizes an egg, a diploid zygote forms. This is sexual reproduction. The zygote can undergo cell divisions and form an embryo sporophyte. If the embryo develops to maturity, the cycle can begin again.


This basic life cycle pattern is the same for most plants. However, there are many variations on this pattern within the plant kingdom. For instance, recall that in mosses the gametophyte is the familiar form, not the sporophyte.

In others, such as flowering plants, the gametophyte is microscopic. Most people have never even seen the female gametophyte of a flowering plant. Botanists usually refer to the bigger, more obvious plant as the dominant generation. The dominant

generation lives longer and can survive independently of the other generation. In most plant species the sporophyte is the dominant plant.

Asexual reproduction

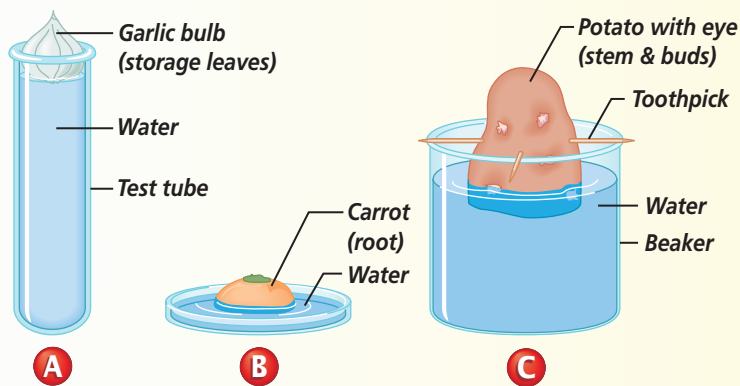
Most plants also can reproduce asexually by a process called **vegetative reproduction**. In this type of reproduction, new plants are produced from existing plant organs or parts of organs. The new plants have the same genetic makeup as the original plant. For example, some thallose liverwort gametophytes can produce cuplike structures, as shown in *Figure 24.2*. Inside, minute pieces of tissue called gemmae (JEH mee) develop. If gemmae fall from the cup, they can grow into other liverwort gametophytes that are genetically identical to the thallus. You can learn more about asexual reproduction in *MiniLab 24.1*.

 **Reading Check** Compare the genetic makeups of plants produced from one plant by asexual reproduction to each other and the original plant.

MiniLab 24.1

Experiment

Growing Plants Asexually Plants are capable of reproducing asexually. Reproductive cells such as egg or sperm are not needed in asexual reproduction. Plant organs such as roots, stems, and even leaves can produce new offspring.



Procedure

- 1 Prepare three different plant parts for study using diagrams A, B, and C as a guide.
- 2 Design a data table in which you can diagram your observations and list the number of days since the experiment began.
- 3 Diagram the plant parts and label them as *Day 1*.
- 4 Make and record observations every three days. Replace any lost water as needed.
- 5 Observe any changes that occur to your plants over the next two weeks.

Analysis

1. **Observe** What experimental evidence do you have that:
 - a. plants can use different structures for asexual reproduction?
 - b. asexual reproduction is a rapid process?
 - c. asexual reproduction requires only one parent?
2. **List** Describe advantages of asexual reproduction in plants.

Figure 24.2

Small cups filled with tiny gemmae have formed on the thallus of this liverwort.



Life Cycle of Mosses

The gametophyte stage is the dominant generation in mosses. A haploid moss spore can germinate and grow to form a **protonema** (proh tuh NEE muh). It is a small green filament of cells that can develop into the gametophyte. In some mosses, male and female reproductive structures form on separate gametophytes, but in others, male and female reproductive structures are on the same gametophyte. Recall that the egg-producing, female reproductive structure is an archegonium, and the sperm-producing, male reproductive structure is an antheridium.

Motile sperm from an antheridium swim in a continuous film of water to an egg in an archegonium. If fertilization occurs, a diploid zygote forms. The zygote undergoes cell divisions forming the sporophyte that consists of a stalk with a capsule at the top. The sporophyte remains attached to and dependent on the gametophyte. Cells in the capsule undergo meiosis, producing haploid spores. When the capsule matures, it bursts open and releases spores. If the spores land in a favorable environment, they can germinate and the cycle repeats, as shown in *Figure 24.3*.

Figure 24.3 The moss gametophyte produces gametes that join to form a zygote. The zygote develops into the sporophyte that produces spores. Spores can germinate and grow into a gametophyte, completing the moss's life cycle.

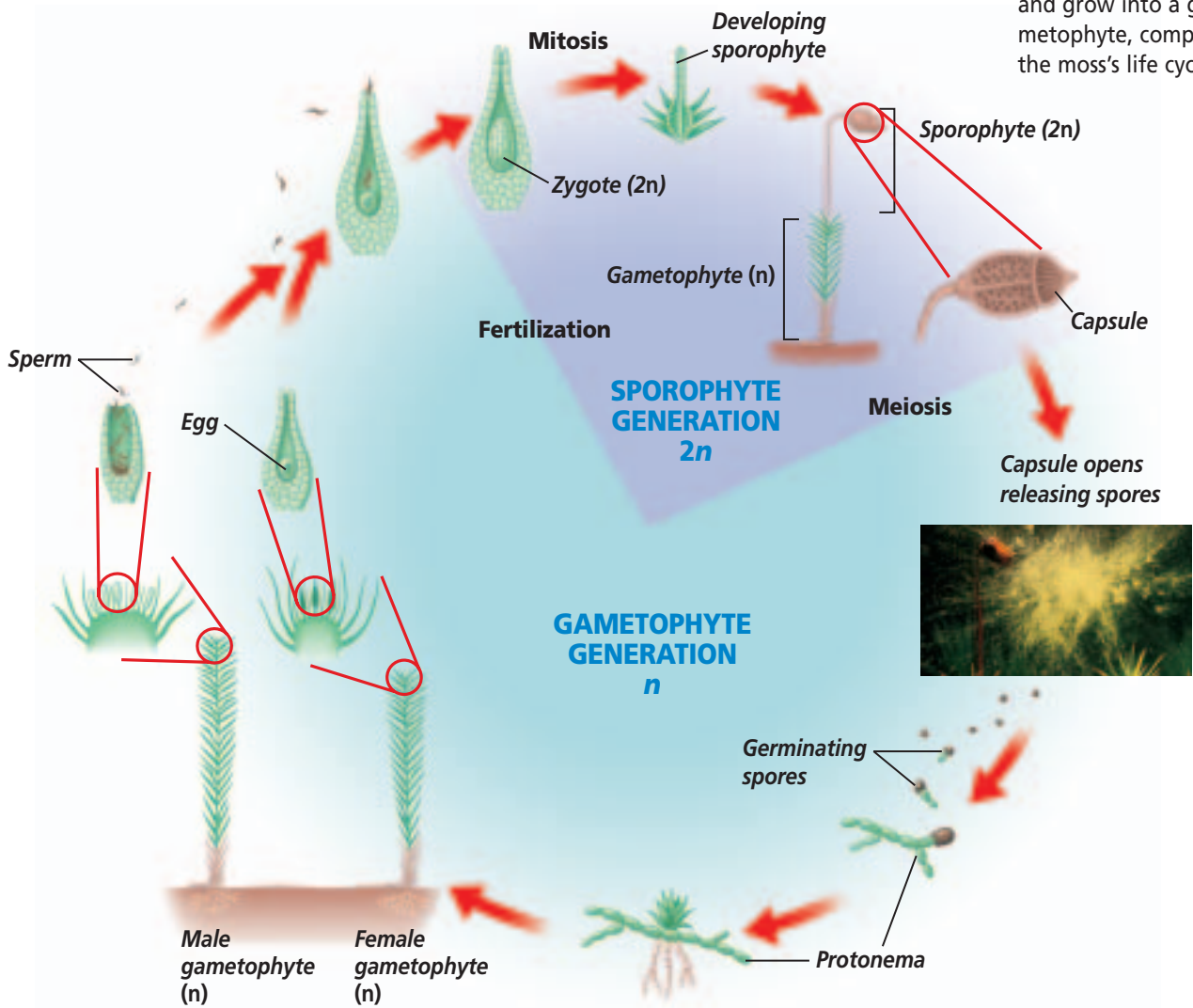
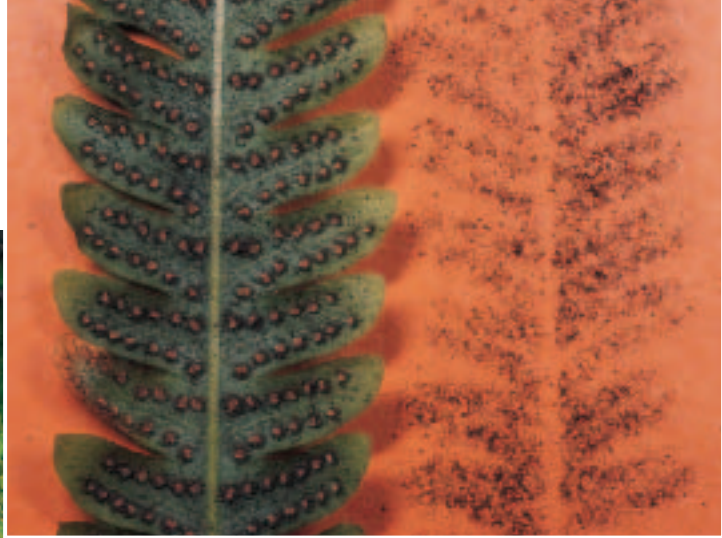


Figure 24.4

Fern sporophytes are common in a forest. However, a fern gametophyte is rarely seen.



A Most fern sporophytes can grow 25 cm or taller. Differentiate **How is a fern's method of growth different from a moss's?**



B Each round cluster of sporangia on the underside of a fern frond is called a sorus. Each sporangium contains spores that are released, sometimes in dramatic fashion.



C The heart-shaped fern gametophyte is usually 5 mm–6 mm across.

Stained LM Magnification: 25x

Some moss gametophytes also reproduce by vegetative reproduction. They can break into pieces when dry and brittle then, when moisture returns, each piece can grow and form a protonema then a gametophyte.

Life Cycle of Ferns

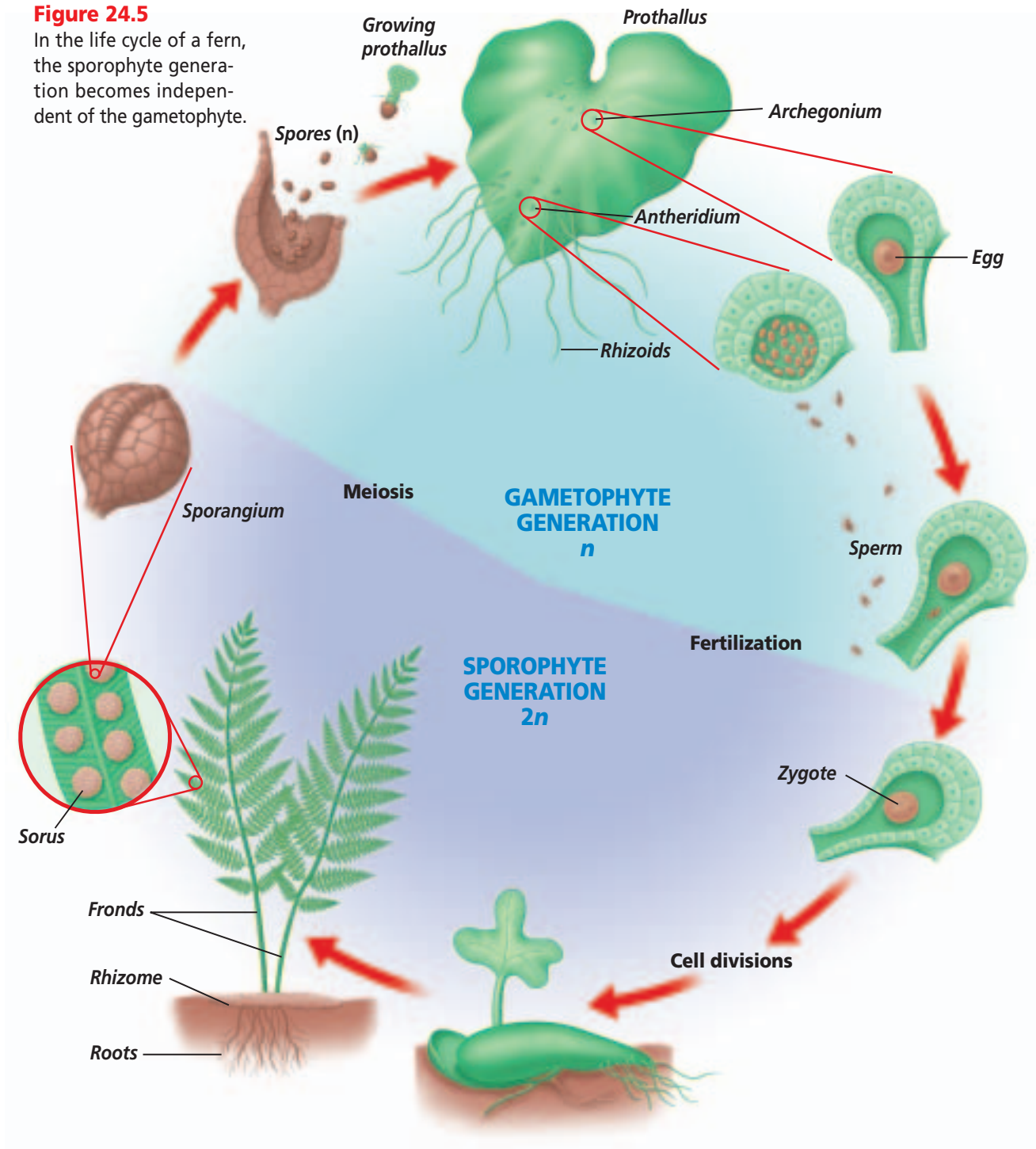
Unlike mosses, the dominant stage of the fern life cycle is the sporophyte stage. The fern sporophyte includes the familiar fronds you see in *Figure 24.4A*. Fern fronds grow from a rhizome, which is an underground stem. On the underside of some fronds are sori, which are clusters of sporangia. Meiosis occurs within the sporangia,

producing haploid spores. When environmental conditions are right, the sporangia open and release haploid spores, as shown in *Figure 24.4B*.

A spore can germinate to form a heart-shaped gametophyte called a prothallus, as shown in *Figure 24.4C*. The prothallus produces both archegonia and antheridia on its surface. The flagellated sperm released by antheridia swim through a film of water to eggs in archegonia. If fertilization occurs, the diploid zygote can develop into the sporophyte. Initially, this developing sporophyte depends upon the gametophyte for its nutrition. However, once the sporophyte produces green fronds, it can carry on

Figure 24.5

In the life cycle of a fern, the sporophyte generation becomes independent of the gametophyte.



photosynthesis and survive on its own. The prothallus dies and decomposes as the sporophyte matures. The mature fern sporophyte consists of a rhizome from which roots and fronds grow. If pieces of rhizome break away,

new fern plants can develop from them by vegetative reproduction. Sporangia can develop on the fronds, spores can be released, and the cycle can begin again. The life cycle of the fern is summarized in *Figure 24.5*.

The Life Cycle of Conifers

The dominant stage in conifers is the sporophyte generation. One of the more familiar conifer sporophytes is shown in *Figure 24.6A*. The adult conifer produces male and female cones on separate branches of one plant. Cones contain spore-producing structures, or sporangia, on their scales.

Female cones, which are larger than the male cones, develop two ovules on the upper surface of each cone scale. Each ovule contains a sporangium with a diploid cell that undergoes meiosis and produces four megaspores. A **megaspore** is a female spore that eventually can become the female gametophyte. One of the four megaspores survives and grows by cell divisions

into the female gametophyte. It consists of hundreds of cells and is dependent on the sporophyte for protection and nutrition. Within the female gametophyte are two or more archegonia, each containing an egg.

Male cones have sporangia that undergo meiosis to produce male spores called **microspores**. Each microspore can develop into a male gametophyte, or pollen grain. Each pollen grain, with its hard, water-resistant outer covering, is a male gametophyte. Examples of male and female conifer gametophytes are shown in *Figure 24.7*.

In conifers, pollination is the transfer of pollen grains from the male cone to the female cone. Pollination can occur when a wind-borne pollen grain falls near the opening in one of the

Word Origin

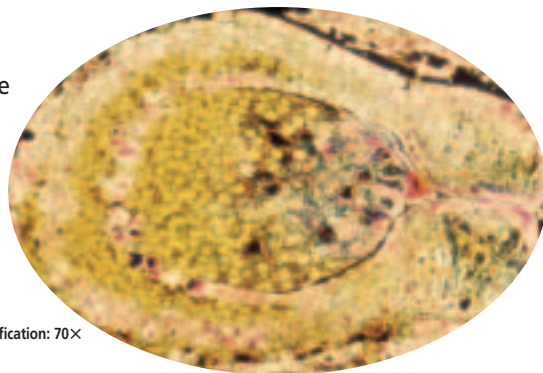
micropyle from the Greek words *mikros*, meaning "small," and *pyle*, meaning "gate"; The micropyle is the small opening at one end of the ovule.

Figure 24.6

In conifers, the sporophyte is immense compared with the microscopic gametophytes.

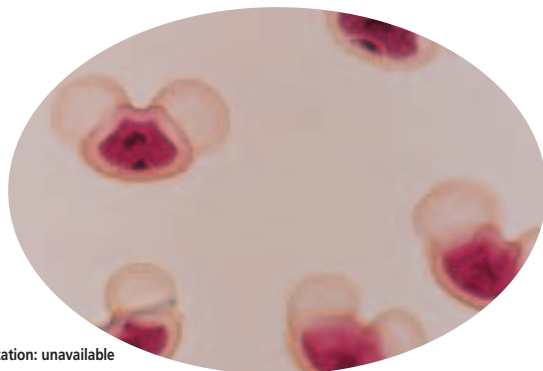
A This pine sporophyte can grow more than 25 m tall.

B The female gametophyte in this pine ovule is less than 0.01 mm long.



Stained LM Magnification: 70X

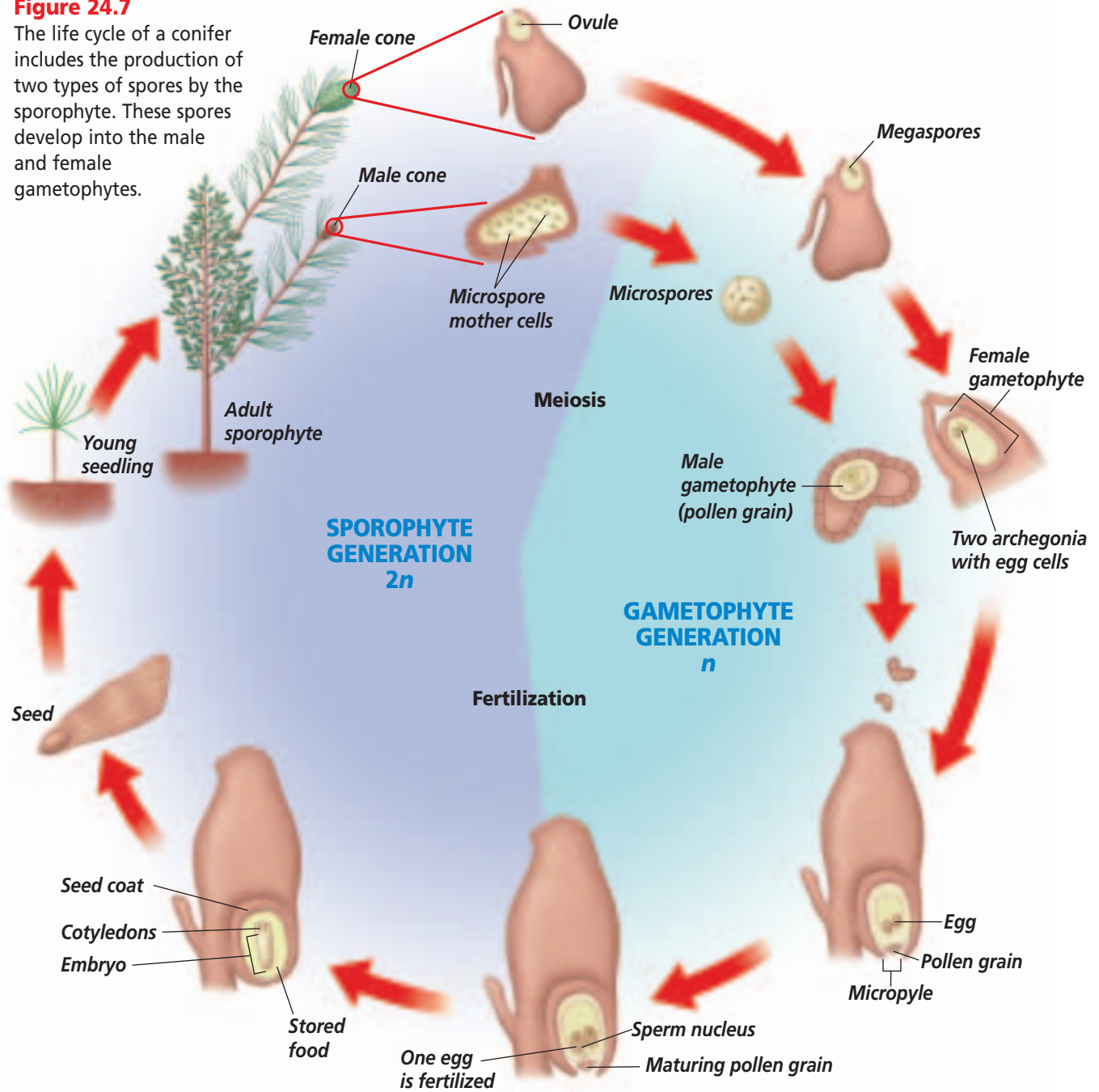
C A pollen grain is so small it can be carried by the wind.



Stained LM Magnification: unavailable

Figure 24.7

The life cycle of a conifer includes the production of two types of spores by the sporophyte. These spores develop into the male and female gametophytes.



ovules of the female cone. The opening of the ovule is called the **micropyle** (MI kruh pile). The pollen grain adheres to a sticky drop of fluid that covers the micropyle. As the fluid evaporates, the pollen grain is drawn closer to the micropyle. Although pollination has occurred, fertilization does not take place for at least a year. The pollen grain and the female gametophyte will mature during this time.

As the pollen grain matures, it produces a pollen tube that grows through the micropyle and into the ovule. A sperm nucleus from the male gametophyte moves through the pollen tube to the egg. If fertilization occurs, a zygote forms. It is nourished by the female gametophyte and can develop into an embryo with several cotyledons. The cotyledons will nourish the sporophyte after germination.

Problem-Solving Lab 24.1

Make and Use Tables

What characteristics do mosses, ferns, and conifers share?

It can help to organize information in a table, because characteristics, similarities, and differences are shown in a simple format.

Solve the Problem

Copy and complete the following data table using “yes” or “no.”

| Data Table | | | |
|--|------|------|---------|
| Trait | Moss | Fern | Conifer |
| Has alternation of generations | | | |
| Film of water needed for fertilization | | | |
| Dominant gametophyte | | | |
| Dominant sporophyte | | | |
| Sporophyte is photosynthetic | | | |
| Produces seeds | | | |
| Produces sperm | | | |
| Produces pollen grains | | | |
| Produces eggs | | | |

Thinking Critically

- Identify** Which two plant groups share the most characteristics? Which two share the fewest?
- Describe** While on a woodland trail, would you easily observe:
 - a pine gametophyte? Sporophyte? Explain.
 - a fern gametophyte? Sporophyte? Explain.
- Compare and Contrast** Using information from your table, compare and contrast reproduction among mosses, ferns, and conifers.

Figure 24.8

Conifer seeds germinate into new, young sporophytes such as the pine tree seedling shown here.



A seed coat forms around the ovule as the mature seed is produced. Mature seeds are released when the female cone opens.

When conditions are favorable, a released seed can germinate and grow into a new, young sporophyte, as shown in *Figure 24.8*. Review the stages of a conifer’s life cycle in *Figure 24.7*. Use the *Problem-Solving Lab* on this page to further explore the characteristics of the life cycles of mosses, ferns, and conifers.

Section Assessment

Understanding Main Ideas

- Explain how vegetative reproduction can produce a new plant. Provide an example.
- How is the sporophyte generation of a moss dependent on the gametophyte generation?
- Interpret the function of a plant’s reproductive system.
- Compare and contrast the life cycle of a fern and a conifer.

Thinking Critically

- Why is the term alternation of generations appropriate to describe the life cycle of a plant?

SKILL REVIEW

- Sequence** Make an events-chain concept map of the life cycle of a fern, beginning with the prothallus. For more help, refer to *Sequence* in the *Skill Handbook*.



Section 24.2

SECTION PREVIEW

Objectives

Identify the organs of a flower.

Examine how photoperiodism influences flowering.

Review Vocabulary

response: an organism's reaction to a change in its internal or external environment (p. 9)

New Vocabulary

petal
sepal
stamen
anther
pistil
ovary
photoperiodism
short-day plant
long-day plant
day-neutral plant

Flowers and Flowering

A Flower by Any Other Name

Using Prior Knowledge When you hear the word *flower*, what image comes to mind? Is it a fragrant rose, a yellow daisy, or a trumpet-shaped lily? These flowers have characteristics that are similar and others that are different. You may know that they all have petals, but what other parts are found in each of them? In this section you will read about a flower's organs, their functions, and how they vary from species to species. You also will learn how an external stimulus affects flowering times.

Assemble For one week, find images of flowers in magazines and other periodicals. With permission, cut them out and bring them to class. Try not to duplicate your selections. Create a class list of the name of each flower and assemble a classroom collage of the flower images.



Flowers display a variety of shapes and colors.

What is a flower?

The process of sexual reproduction in flowering plants takes place in a flower, which is a complex structure made up of several organs. Some organs of the flower are directly involved in fertilization and seed production. Other floral organs function in pollination. There are probably as many different shapes, sizes, colors, and configurations of flowers as there are species of flowering plants. In fact, flower characteristics are often used in plant identification.

The structure of a flower

Even though there is an almost limitless variation in flower shapes and colors, all flowers share a basic structure. A flower's structure is genetically determined and usually made up of four kinds of organs: sepals, petals, stamens, and pistils. The flower parts you are probably most familiar with are the petals. **Petals** are usually the colorful structures at the top of a flower stem. The flower stem is called the peduncle. **Sepals** are usually leaflike and encircle the peduncle below the petals.

Inside the petals are the stamens. A **stamen** is the male reproductive organ of a flower. At the tip of the stamen is the **anther**. The anther produces pollen that eventually contains sperm.

Identifying Organs of a Flower

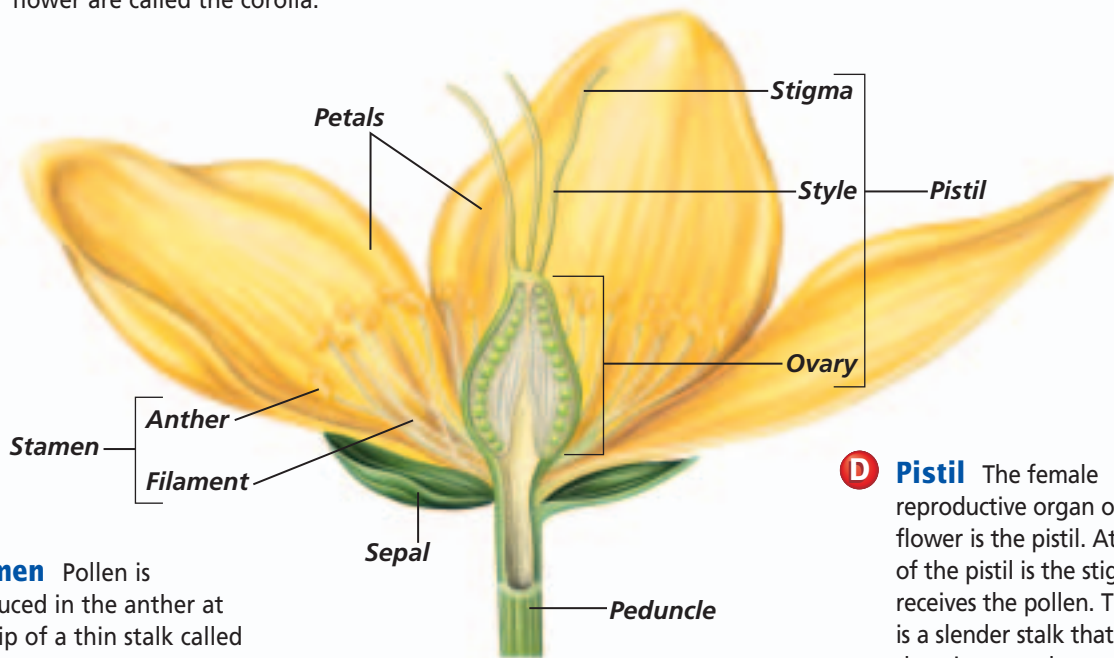
Figure 24.9

Of the four major organs of a flower, only two—the stamens and pistils—are reproductive organs directly involved in seed development. Sepals and petals support and protect the reproductive organs and help attract pollinators. The structure of a typical flower is illustrated here. **Critical Thinking** *How are different flower shapes important to a plant's survival?*



St.-John's-Wort

A Petals These are usually brightly colored and often have perfume or nectar at their bases to attract pollinators. In many flowers, the petal also provides a surface for insect pollinators to rest on while feeding. All of the petals of a flower are called the corolla.



B Stamen Pollen is produced in the anther at the tip of a thin stalk called a filament. Together, the anther and filament make up the stamen, the male reproductive organ. The number of stamens in flowers varies from none to many, like the flower shown here.

C Sepals A ring of sepals makes up the outermost portion of the flower. Sepals serve as a protective covering for the flower bud. They sometimes are colored and resemble petals. All of the sepals of a flower are called the calyx.

D Pistil The female reproductive organ of a flower is the pistil. At the top of the pistil is the stigma that receives the pollen. The style is a slender stalk that connects the stigma to the ovary in which ovules grow. Each ovule can produce an egg. If fertilization occurs, the ovule develops into the seed. The number of pistils in flowers varies from none to many.

At the center of the flower, attached to the top of the peduncle, is usually one or more pistils. The **pistil** is the female organ of the flower. The bottom portion of the pistil is the **ovary**, a structure with one or more ovules, each usually contains one egg. As you read in the previous section, the female gametophyte develops inside the ovule. You can learn more about floral structure and practice your lab skills in the *BioLab* at the end of this chapter.

Modifications in flower structure

A flower that has all four organs—sepals, petals, stamens, and pistils—is called a complete flower, as shown in *Figure 24.9*. The morning glory, shown in *Figure 24.10A*, is another example of a complete flower. A flower that lacks one or more organs is called an incomplete flower. For example, walnut trees have separate

male and female flowers. The male flowers, as shown in *Figure 24.10B*, have stamens but no pistils; the female flowers bear pistils but no stamens.

The flowers of plants such as sweet corn, as shown in *Figure 24.10C*, and grasses, have no petals and are adapted for pollination by wind rather than by animals. You can explore flower adaptations further in the *Problem-Solving Lab* on the next page.

Photoperiodism

The relative lengths of daylight and darkness each day have a significant effect on the rate of growth and the timing of flower production in many species of flowering plants. For example, some chrysanthemum plants produce flowers only during the fall, when the length of daylight is getting shorter and the length of darkness is getting longer daily.

Word Origin

photoperiodism from the Greek words *photos*, meaning “light,” and *periodos*, meaning “a period”; The flowering response of a plant to periods of dark and light is photoperiodism.

Figure 24.10

The diversity of flower forms is evidence of the success of flowering plants.

A The petals of the morning glory are fused together to form a bell shape.



B The male flowers of the walnut tree form long structures called catkins.

C The tassels at the top of a corn plant are male flowers.



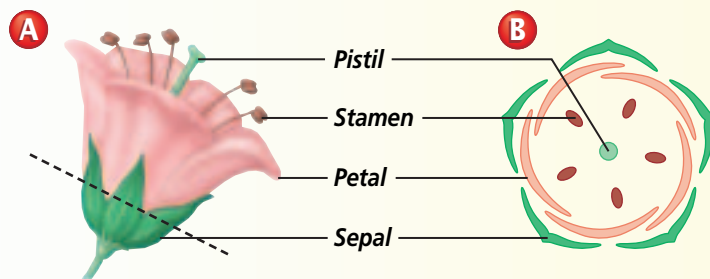
Problem-Solving Lab 24.2

Interpret Scientific Illustrations

How do flowers differ? There is great variation in flower shape. This variation occurs when certain flower parts are fused together, parts are rearranged, or when parts may be totally missing. Almost all dicot plants will have flower parts that are in multiples of four or five. For example, a plant having eight or ten petals would be a dicot. Almost all monocot plants have flower parts in multiples of three.

Solve the Problem

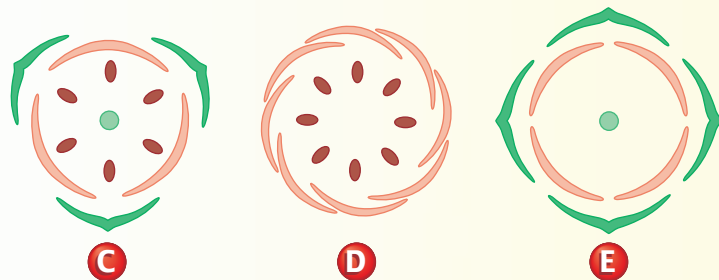
Diagram A shows a flower with its parts labeled. Imagine that the flower has been cut along the dashed line. Diagram B is an enlarged cross-section view of the bottom half. The flower is from a dicot plant because there are five sepals, petals, and stamens.



Thinking Critically

Use diagrams B, C, D, and E to answer the following questions.

- Determine** Diagrams C, D, and E also are diagrammatic cross-section views of flowers. Is diagram:
 - C a monocot or dicot? Explain.
 - D a monocot or dicot? Explain.
 - E a monocot or dicot? Explain.
- Infer** Which diagrams are complete flowers, and which are incomplete flowers?
- Predict** Which flowers might be capable of self-pollination? Explain.
- Predict** Which flowers require another flower for pollination? Explain.



A grower who wants to produce these chrysanthemum flowers during the middle of summer must artificially increase the length of darkness. The grower can do this by draping a black cloth over and around the chrysanthemum plants before sunset each day, and then removing it the following morning. The response of flowering plants to daily daylight-darkness conditions is called **photoperiodism**.

Plant biologists originally thought that the length of daylight controlled flowering. However, they now know that it is the length of darkness that controls flowering, and that the darkness must be uninterrupted. Each plant species has a critical period—specific daylight-darkness conditions that will initiate flowering. Plants can be placed in one of four categories depending on the daylight-darkness conditions that they require for flower production. Plants are short-day plants, long-day plants, day-neutral plants, or intermediate day plants.

A **short-day plant** flowers when the number of daylight hours is shorter than that of its critical period. Short-day plants usually flower sometime during late summer, fall, winter, or spring. Examples of short-day plants include asters, poinsettias, strawberries, ragweed, and pansies, as shown in *Figure 24.11A*.

Reading Check Explain why pansies stop flowering in midsummer.

A **long-day plant** flowers when the number of daylight hours is longer than that of its critical period. Long-day plants usually flower in summer, but also will flower if lighted continually. Carnations, petunias, potatoes, spinach, and wheat are long-day plants, as well as the lettuce shown in *Figure 24.11B*.

Figure 24.11

Photoperiodism refers to a plant's response to the changing length of night.

A Short-day plants include pansies (right) and goldenrod.



B Spinach and lettuce (left) are long-day plants that flower in midsummer.

C Many plants are day-neutral. Flowering in cucumbers (left), tomatoes, and corn is not influenced by a dark period.

As long as the proper growing conditions exist, some plants will flower over a range in the number of daylight hours. These plants are called **day-neutral plants**. This category includes many tropical plants, roses, cotton, dandelions and many other weeds, as well as the cucumbers shown in *Figure 24.11C*.

An intermediate-day plant will not flower if days are shorter or

longer than its critical period. Several grasses and sugarcane are in this category.

Photoperiodism is a physiological adaptation of all flowering plants that ensures the production of flowers at a time when there is an abundant population of pollinators. This is important because pollination is a critical event in the life cycles of all flowering plants.

Section Assessment

Understanding Main Ideas

1. Compare and contrast sepals and petals.
2. Describe the male and female reproductive organs of a flower.
3. Explain why walnut flowers are considered incomplete flowers.
4. Discuss how photoperiodism influences flowering.
5. Infer why a gardener's holly plant flowers every spring but never produces holly berries.

Thinking Critically

6. In the middle of the summer a florist receives a large shipment of short-day plants. Infer what the florist must do to induce flowering.

Skill Review

7. **Get the Big Picture** Explain why the structure of a wind-pollinated flower is often different from that of an insect pollinated flower. For more help, refer to *Get the Big Picture* in the **Skill Handbook**.



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Section 24.3

SECTION PREVIEW

Objectives

Survey and identify the methods of reproduction, growth, and development in flowering plants.

Outline the processes in which cells differentiate during the formation of seeds and fruits and during seed germination.

Review Vocabulary

pollination: transfer of pollen grains from male reproductive organs to female reproductive organs in plants; usually within the same species (p. 259)

New Vocabulary

polar nuclei
double fertilization
endosperm
dormancy
germination
radicle
hypocotyl

The Life Cycle of a Flowering Plant

“Tall oaks from little acorns grow.” —David Everett (1769–1813)

Finding Main Ideas On a piece of paper, construct an outline about the life cycle of a flowering plant, such as the bee orchid shown to the right. Use the red and blue titles in this section as a guideline. As you read the paragraphs that follow the titles, add important information and vocabulary words to your outline.

Example:

- I. The Life Cycle of an Anthophyte
 - A. Development of the female gametophyte
 1. Occurs in ovule
 2. Involves meiosis
 3. Polar nuclei formed

Use your outline to help you answer questions in the Section Assessment on page 657. For more help, refer to *Outline* in the **Skill Handbook**.



Bee orchid, *Ophrys speculum*

The Life Cycle of an Anthophyte

The life cycle of flowering plants is similar to that of conifers in many ways. In both coniferophytes and anthophytes, the gametophyte generation is contained within the sporophyte. Many of the reproductive structures are also similar. However, anthophytes are the only plants that produce flowers and fruits. *Figure 24.12* summarizes the life cycle of a flowering plant.

Development of the female gametophyte

In anthophytes, the female gametophyte is formed inside the ovule within the ovary. In the ovule, a cell undergoes meiosis and produces haploid megaspores. One of these megaspores can develop into the female gametophyte, but the other three spores usually die. In most flowering plants, the megaspore's nucleus undergoes mitosis three times, producing eight haploid nuclei. These eight nuclei make up the female gametophyte. Cell walls form around each of six nuclei, one of which is now called the egg cell.

Figure 24.12

In the life cycle of a flowering plant, the sporophyte generation nourishes and protects the developing gametophyte.

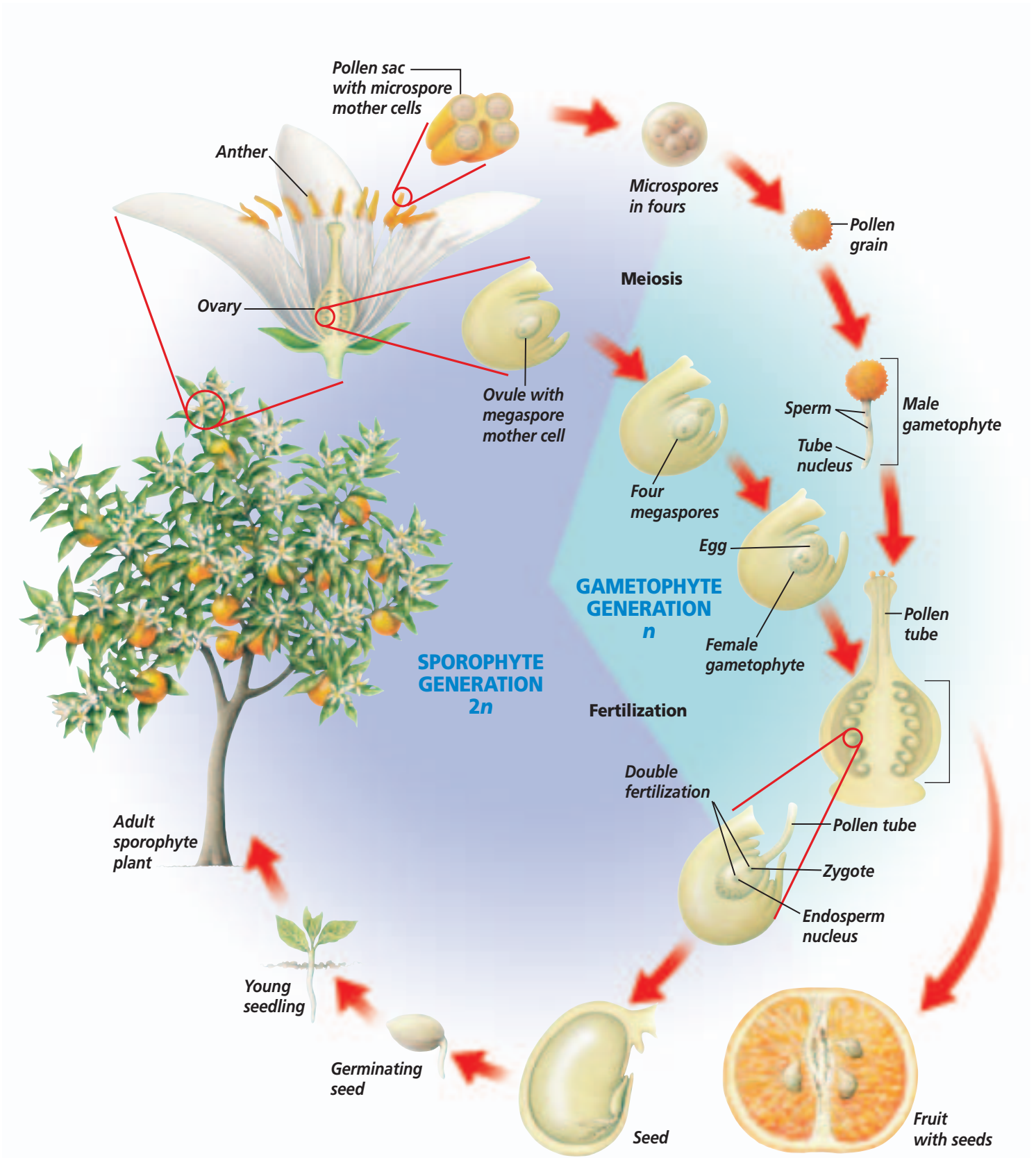
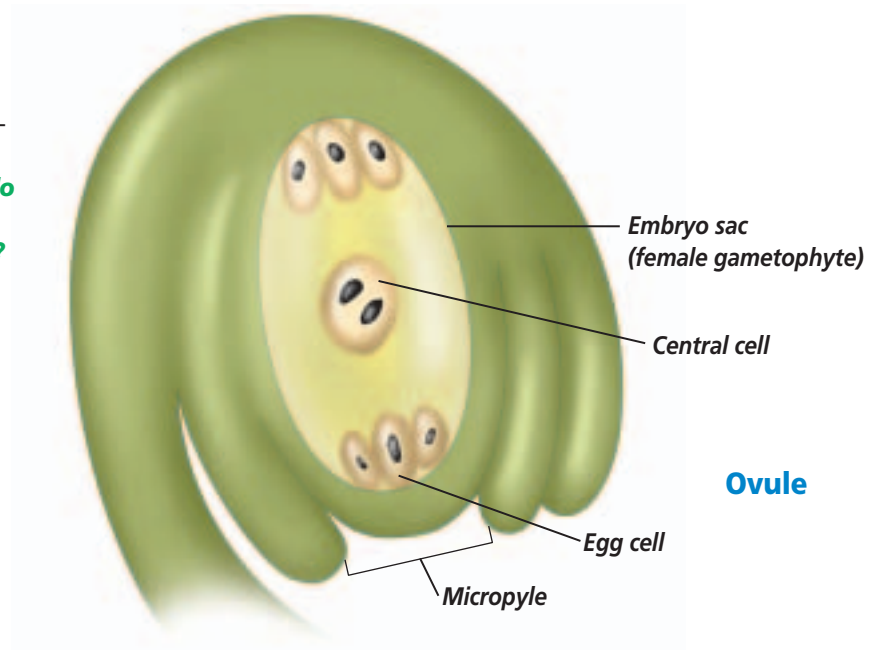


Figure 24.13

The eight nuclei produced by the megaspore form the female gametophyte inside an ovule of an angiosperm's flower. **Differentiate** *How do these nuclei differ from those in the leaf cells of this angiosperm?*



The two remaining nuclei, which are called **polar nuclei**, are enclosed in one cell. This cell, the central cell, is located at the center of the female gametophyte. The egg cell is near the micropyle, as shown in *Figure 24.13*. The other five cells eventually disintegrate.

Development of the male gametophyte

The formation of the male gametophyte begins in the anther, as

seen in *Figure 24.14*. Haploid microspores are produced by meiosis within the pollen sac. The nucleus of each microspore undergoes mitosis. A thick, protective wall surrounds these two nuclei. This structure is the immature male gametophyte, or pollen grain. The nuclei within the pollen grain are the tube nucleus and the generative nucleus. When the pollen grains mature, the anther usually splits open.

Figure 24.14

Meiotic division of each of many cells within the anther produces four microspores. These microspores develop into male gametophytes or pollen grains.

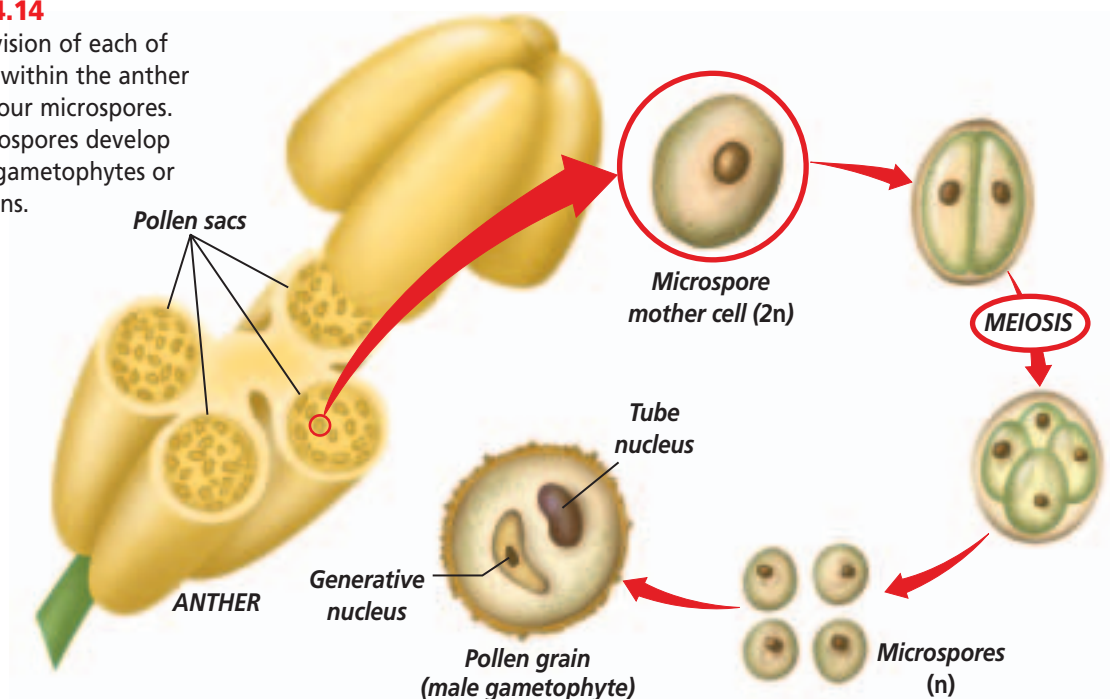


Figure 24.15

The shape, color, and size of a flower reflect its relationship with a pollinator.

A Ragweed's wind-pollinated flowers are small and green and lack structures that would block wind currents.



B A butterfly can be a pollinator when it visits a flower to sip nectar.



C Flowers pollinated by hummingbirds are often tubular and colored bright red or yellow but may have little scent.



D The ultraviolet markings of some flowers guide pollinating insects to a flower's nectar.



Pollination

In anthophytes, pollination is the transfer of the pollen grain from the anther to the stigma. Depending on the type of flower, the pollen can be carried to the stigma by wind, water, or animals. Plant reproduction is most successful when the pollination rate is high, which means that the pistil of a flower receives enough pollen of its own species to fertilize the egg in each ovule. Although it may seem wasteful for wind-pollinated plants to produce such large amounts of pollen, it does help ensure pollination. Many

anthophytes have elaborate mechanisms that help ensure that pollen grains are deposited in the right place at the right time. Some of these are shown in *Figure 24.15*.

Most anthophytes that are pollinated by animals produce nectar in their flowers. Nectar is a highly concentrated food sought by visitors to these flowers. It is a liquid made up of proteins and sugars and usually collects in the cuplike area at the base of petals. Animals, such as insects and birds, brush up against the anthers while trying to get to the nectar.

The pollen that attaches to them can be carried to another flower, resulting in pollination. Some insects also gather pollen to use as food. By producing nectar and attracting animal pollinators, animal-pollinated plants are able to promote pollination with lesser amounts of pollen.

Some nectar-feeding pollinators are attracted to a flower by its color or scent or both. Some of the bright, vivid flowers attract pollinators, such as butterflies and bees. Some of these flowers have markings that are invisible to the human eye but are easily seen by insects, as shown in *Figure 24.15D*. Flowers that are pollinated by beetles and flies have a strong scent but are often dull in color.

Many flowers have structural adaptations that favor cross-pollination—pollination between two plants of the same species. This results in greater genetic variation because a sperm from one plant fertilizes an egg from another. For example, the flowers of certain species of orchids resemble

female wasps. A male wasp visits the flower and attempts to mate with it and becomes covered with pollen, which is deposited on orchids it may visit in the future.

Fertilization

Once a pollen grain has reached the stigma of the pistil, several events take place before fertilization occurs. Inside each pollen grain are two haploid nuclei, the tube nucleus and the generative nucleus. The tube nucleus directs the growth of the pollen tube down through the pistil to the ovary, as shown in *Figure 24.16*. The generative nucleus divides by mitosis, producing two sperm nuclei. The sperm nuclei move through the pollen tube to a tiny opening in the ovule called the micropyle.

Within the ovule is the female gametophyte. One of the sperm unites with the egg forming a diploid zygote, which begins the new sporophyte generation. The other sperm nucleus fuses with the central cell, which

Figure 24.16

In flowering plants, part of the male gametophyte grows through the pistil to reach the female gametophyte. Double fertilization involves two sperm nuclei. A zygote ($2n$) and endosperm ($3n$) are formed.

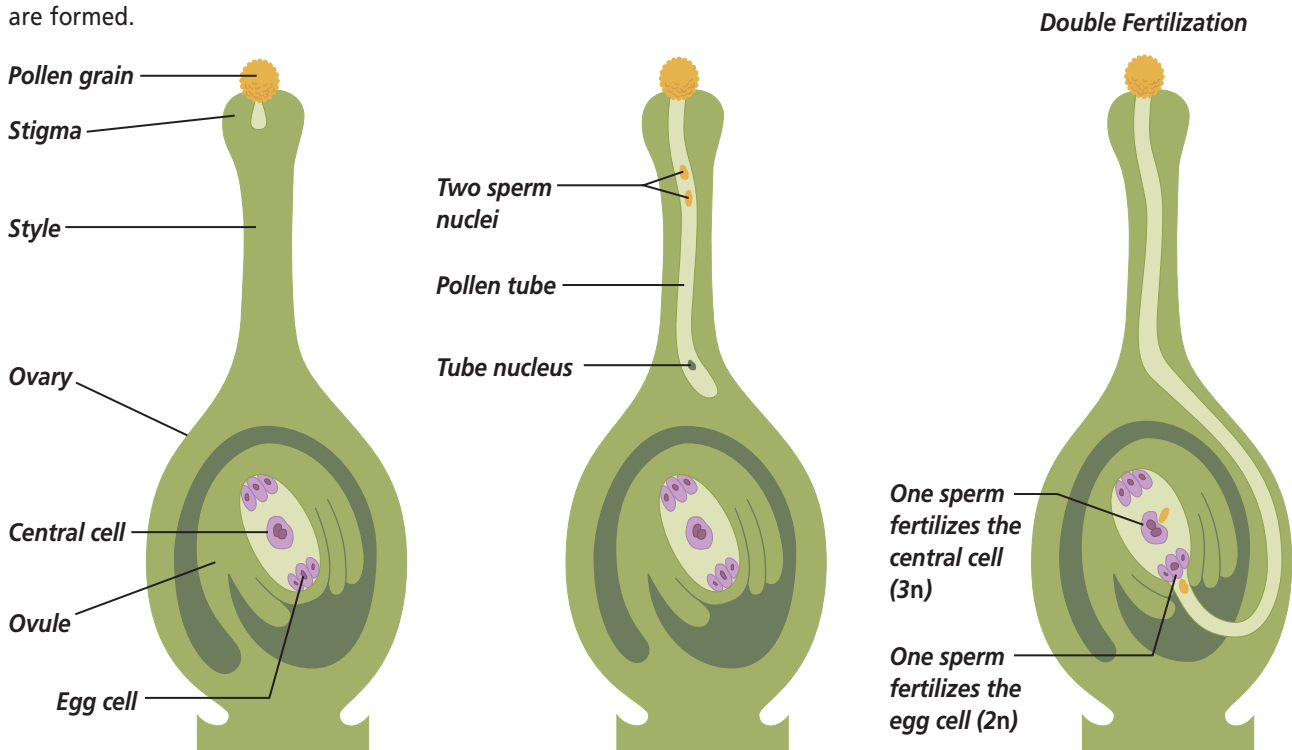
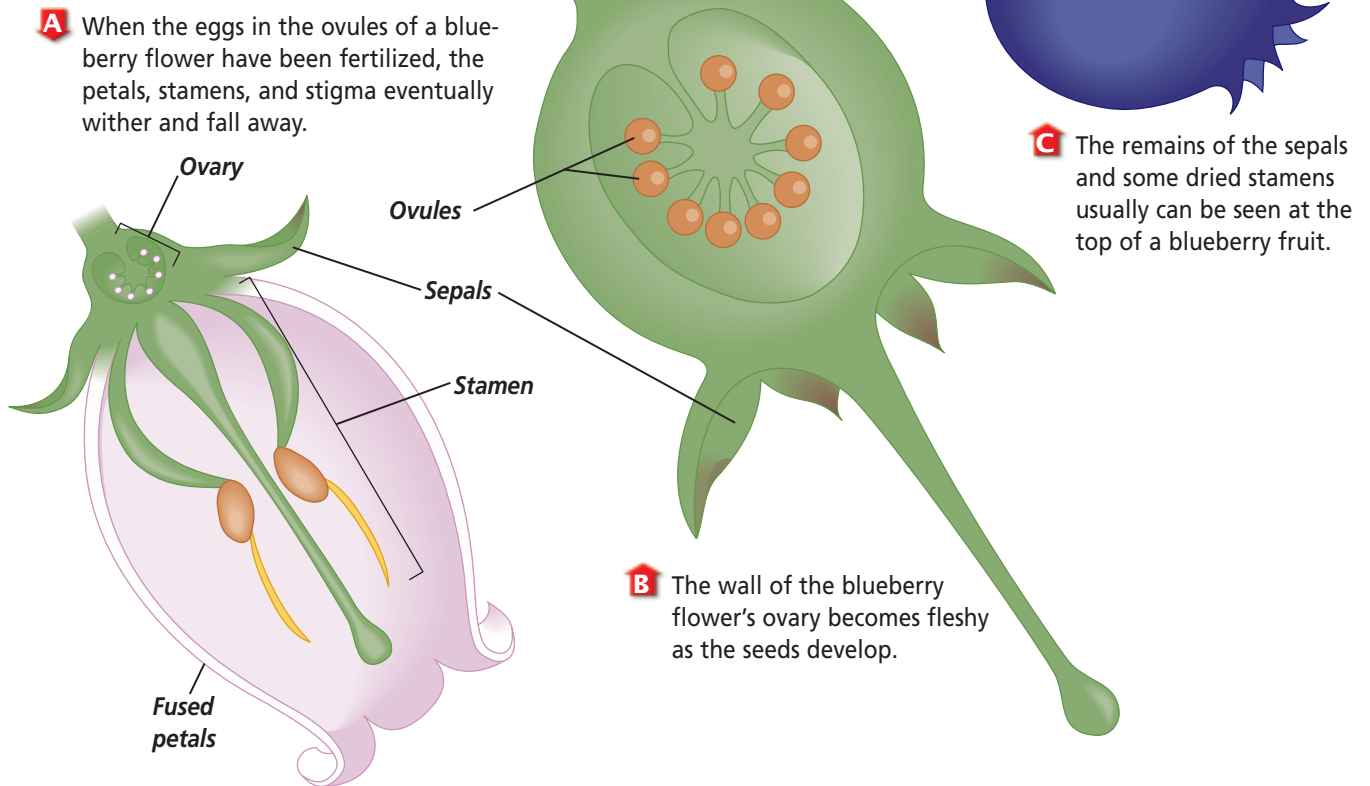


Figure 24.17

A fruit usually consists of seeds and the surrounding mature ovary of a flowering plant.



contains the polar nuclei, to form a cell with a triploid ($3n$) nucleus. This process, in which one sperm fertilizes the egg and the other sperm joins with the central cell, is called **double fertilization**. Double fertilization is unique to anthophytes and is illustrated in *Figure 24.16*. The triploid nucleus will divide many times, eventually forming the endosperm of the seed. The **endosperm** is food storage tissue that supports development of the embryo in anthophyte seeds.

Many flower ovaries contain more than one ovule. For each ovule to become a seed, at least one pollen grain must land on the stigma for each ovule contained in the ovary. In a watermelon plant, for example, hundreds of pollen grains are required to pollinate a

flower if each ovule is to be fertilized. You are probably familiar with the hundreds of seeds in a watermelon that are the result of this process.

Seeds and Fruits

The embryo contained within a seed is the next sporophyte generation. The formation of seeds and the fruits that enclose them, as shown in *Figure 24.17*, help ensure the survival of the next generation.

Seed formation

After fertilization takes place, seed development begins. Inside the ovule, the zygote divides and develops into the embryo plant. The triploid central cell develops into the seed's endosperm.

Word Origin

endosperm from the Greek words *endon*, meaning "within," and *sperma*, meaning "seed"; The endosperm is storage tissue found in the seeds of many anthophytes.

Greens Keeper

Do you like to work outside? Is golf your favorite sport? Then you already know the value of a well-manicured golf fairway. Maintaining golf fairways is one of the responsibilities of a greens keeper.



Skills for the Job

A greens keeper maintains both the playing quality and the beauty of a golf course. Beginning greens keepers usually learn on the job and spend their days mowing the greens. Greens keepers who want to manage large crews will need a two- or four-year degree in turf management and a certificate in grounds management. They must be thoroughly familiar with different types of grasses, the growing conditions that each require, and the pests, diseases, and environmental factors that can affect them. Greens keepers also must know what corrective measures to take when something affects the grasses so that fairways can be kept in excellent condition. Other careers in turf management include maintaining the grounds of shopping centers, schools, sports playing fields, cemeteries, office buildings, and other locations.



For more careers in related fields, visit bdol.glencoe.com/careers

The wall of the ovule becomes the seed coat, which can aid in seed dispersal and help protect the embryo until it begins growing.

Fruit formation

As the seeds develop, the surrounding ovary enlarges and becomes the fruit. Sometimes other flower organs become part of the fruit. A fruit is the structure that contains the seeds of an anthophyte.

A fruit is as unique to an anthophyte as is its flower, and many anthophytes can be identified by examining their fruit. You are familiar with plants that develop fleshy fruits, such as apples, grapes, melons, tomatoes, and cucumbers. Other plants develop dry fruits such as peanuts, sunflower “seeds,” and walnuts. In dry fruits, the ovary around the seeds hardens as the fruit matures. Some plant foods that we call vegetables or grains are actually fruits, as shown in *Figure 24.18*.

Figure 24.18

A fruit is usually the ripened ovary of a flower that can contain one or more seeds. The most familiar fruits are those we consume as food.



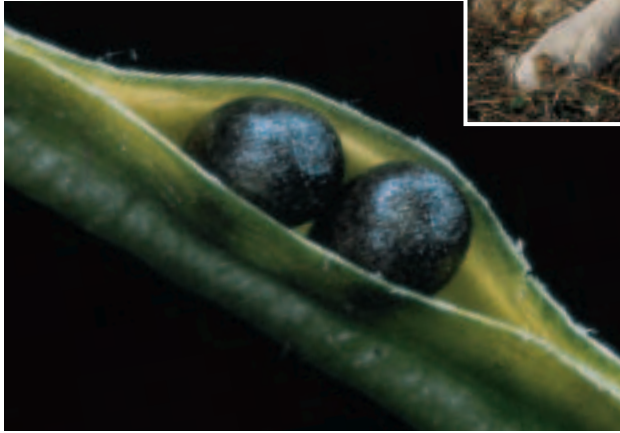
B Fleshy fruits are juicy and full of water and sugars.



A Dry fruits have dry fruit walls. The ovary wall may start out with a fleshy appearance, as in hickory nuts or bean pods, but when the fruit is fully matured, the ovary wall is dry.

Figure 24.19

A wide variety of seed-dispersal mechanisms have evolved among flowering plants.



A The ripe pods of violets snap open with a pop, which sends a shower of small seeds in all directions.



B Clinging fruits, like those of the cocklebur and burdock, are covered by hooks that stick to the hair, fur, or feathers of passing animals or the clothes of passing humans.



C Wind-dispersed seeds have structural adaptations that enable them to be held aloft while they drift away from their parent.

Can you think of any vegetables that are actually fruits? For example, green peppers are fleshy fruits that are often referred to as vegetables.

Seed dispersal

A fruit not only protects the seeds inside it, but also may aid in dispersing those seeds away from the parent plant and into new habitats. The dispersal of seeds, as shown in *Figure 24.19*, is important because it reduces competition for sunlight, soil, and water between the parent plant and its offspring. Animals such as raccoons, deer, bears, and birds help distribute many seeds by eating fruits. They can carry the fruit some distance away from the parent plant before consuming it and spitting out the seeds. Or they may eat the fruit, seeds and all. Seeds that are eaten usually pass through the digestive system undamaged and are deposited in the animal's wastes. Squirrels, birds, and other nut gatherers may drop and lose seeds they collect, or even bury them only

to forget where. These seeds can then germinate far from the parent plant.

Plants, such as water lilies and coconut palms that grow in or near water, produce fruits or seeds with air pockets in the walls that enable them to float and drift away from the parent plant. The ripened fruits of many plants split open to release seeds with structural adaptations for dispersal by wind or by clinging to animal fur. Orchid seeds are so tiny that they can become airborne. The fruit of the poppy flower forms a seed-filled capsule that bobs about in the wind and sprinkles its tiny seeds like a salt shaker. Tumbleweed seeds are scattered as the plant rolls along the ground.

Seed germination

At maturity, seeds are fully formed. The seed coat dries and hardens, enabling the seed to survive environmental conditions that are unfavorable to the parent plant. The seeds of some plant species must germinate within a short period of time or die.

Figure 24.20

Seeds can remain dormant for long periods of time. Lupine seeds like these can germinate after remaining dormant for decades.



However, the seeds of some plant species can remain in the soil until conditions are favorable for growth and development of the new plant. This period of inactivity in a mature seed is called **dormancy**. The length of time a seed remains dormant can vary from one species to another. Some seeds, such as willow, magnolia, and maple remain dormant for only a few weeks after they mature. These

seeds cannot survive harsh conditions for long periods of time. Other plants produce seeds, like those shown in **Figure 24.20**, that can remain dormant for remarkably long periods of time. Even under harsh conditions, the seeds of desert wildflowers and some conifers can survive dormant periods of 15 to 20 years. Scientists discovered ancient seeds of the East Indian Lotus, *Nelumbo nucifera*, in China, which they have radiocarbon dated to be more than a thousand years old. Imagine their amazement when these seeds germinated!

Requirements for germination

Dormancy ends when the seed is ready to germinate. **Germination** is the beginning of the development of the embryo into a new plant. The absorption of water and the presence of oxygen and favorable temperatures usually end dormancy, but there may be other requirements.

Water is important because it activates the embryo's metabolic system. Once metabolism has begun, the seed must continue to receive water or it will die. Just before the seed coat breaks open, the rate of respiration in the plant embryo increases rapidly.

Many seeds germinate best at temperatures between 25°C and 30°C. At temperatures below 0°C or above 45°C, most seeds won't germinate at all.

Some seeds have specific requirements for germination. For example, some germinate more readily after they have passed through the acid environment of an animal's digestive system. Others require a period of freezing temperatures, such as apple

Figure 24.21

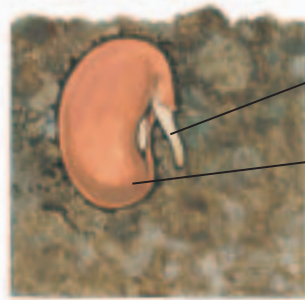
Many wildflower seeds require fire to germinate. This is especially true in prairie environments where fires are periodically set to induce the germination of prairie wildflower seeds.



Figure 24.22

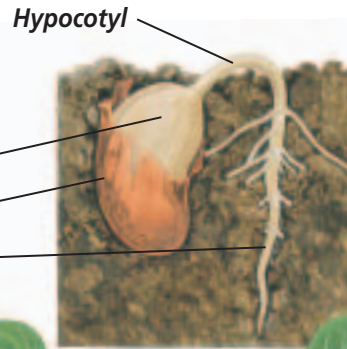
Germination of a bean seed is stimulated by warm temperatures and water, which softens the seed coat.

A The radicle will become the primary root.



Radicle
Cotyledon
Seed coat
Primary root

B The hypocotyl is the first part of the stem to appear.



Cotyledon

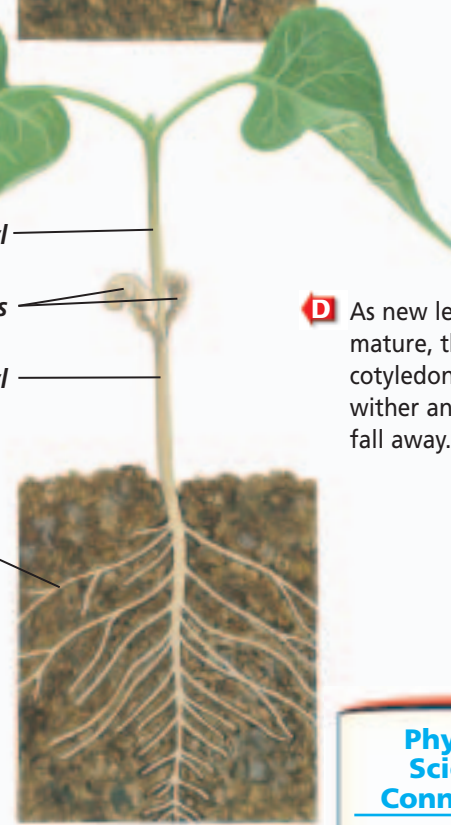
C As the hypocotyl straightens, the plant's first leaves are exposed to sunlight.



Epicotyl
Withered cotyledons
Hypocotyl

D As new leaves mature, the cotyledons wither and fall away.

Secondary roots



Physical Science Connection

Forces exerted by seedlings

When a seedling emerges from a seed, its stem pushes upward through the soil. This push or force results from water pressure inside the seedling's cells. Also, the number of cells within the seedling increases as it grows. Therefore, the total force exerted on the soil by the seedling increases as the seedling grows.

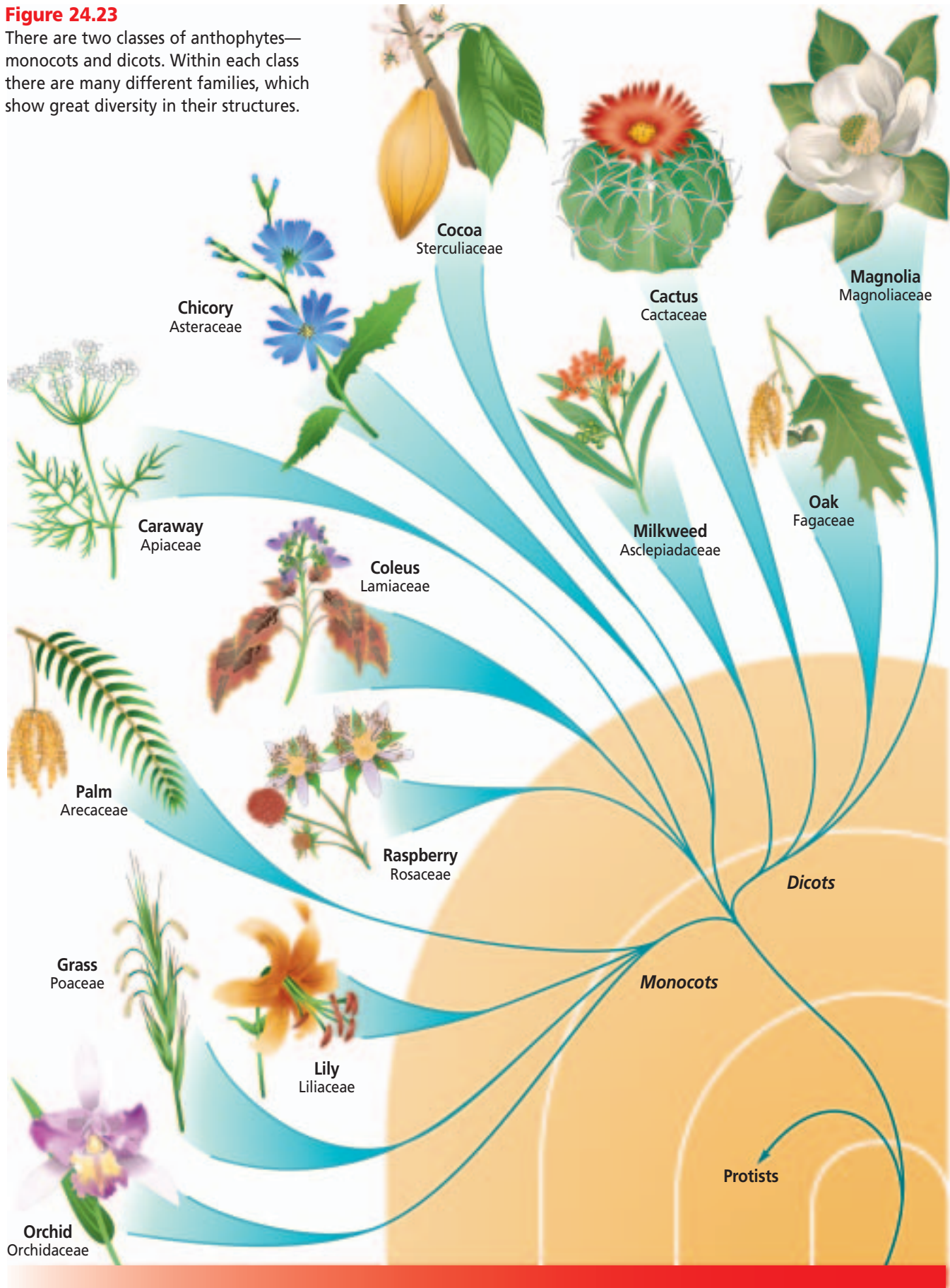
seeds, extensive soaking in saltwater, such as coconut seeds, or certain day lengths. The seeds of some conifers will not germinate unless they have been exposed to fire. The same is true of certain wildflower species, including lupines and gentians, as shown in *Figure 24.21*.

The germination of a typical dicot embryo is shown in *Figure 24.22*. Once the seed coat has been softened by water, the embryo starts to emerge from the seed. The first part of the embryo to appear is the embryonic root called the **radicle** (RA dih kul). The radicle grows down into the soil

and develops into a root. The portion of the stem nearest the seed is called the **hypocotyl** (HI poh kah tul). In some plants, the first part of the stem to push above ground is an arched portion of the hypocotyl. As the hypocotyl continues growing, it straightens, bringing with it the cotyledons and the plant's first leaves. In monocots, the cotyledon remains below the soil's surface. As growth continues, the leaves turn green, and the plant produces its own food through photosynthesis. To learn more about germinating seeds, try the *MiniLab* on page 657.

Figure 24.23

There are two classes of anthophytes—monocots and dicots. Within each class there are many different families, which show great diversity in their structures.



Vegetative reproduction

The roots, stems, and leaves of plants are called vegetative structures. When these structures produce a new plant, it is called vegetative reproduction. Vegetative reproduction is common among anthophytes. Some modified stems of anthophytes, such as potato tubers, can produce a new plant from each “eye” or bud. Farmers make use of this feature when they cut potato tubers into pieces and plant them.

Although cloning animals is a relatively new phenomenon, for years gardeners have relied on cloning to reproduce plants. Using vegetative reproduction to grow numerous plants from one plant is frequently referred to as vegetative propagation. Some plants, such as begonias, can be propagated by planting cuttings, which are pieces of the stem or a leaf that has been cut off another begonia. Even smaller pieces of plants can be used to grow plants by tissue culture. Minute pieces of plant tissue are placed on nutrient agar in test tubes or petri dishes. The plants grown from cuttings and tissue cultures have the same genetic makeup as the plants from which they came and are botanical clones.

There is great diversity in the flowers, seeds, fruits, and vegetative structures of anthophytes. Anthophytes

MiniLab 24.2

Observe

Looking at Germinating Seeds

Seeds are made up of a plant embryo, a seed coat, and in some plants, a food-storage tissue. Monocot and dicot seeds differ in structure.

Procedure



- 1 Obtain from your teacher a soaked, ungerminated corn kernel (monocot), a bean seed (dicot), and germinating corn and bean seeds.
- 2 Remove the seed coats from each of the ungerminated seeds. Examine the seed's structures under a microscope using low-power magnification. Locate and identify the embryo's structures and other seed structures.
- 3 Examine the germinating seeds. Locate and identify the structures you observed in the dormant seeds.

Analysis

1. **Diagram** Draw the dormant embryos in the soaked seeds, and label their structures. Draw the germinating seeds, and label their structures.
2. **Distinguish** List at least three major differences you observed in the internal structures of the corn and bean seeds.



Corn seed germination

are divided into families based on these differences. The relationships among these families are shown in *Figure 24.23* on the opposite page. Which of the families is part of your environment?

Section Assessment

Understanding Main Ideas

1. Explain the relationship between the pollination of a flower and the production of one or more seeds.
2. Name the part(s) of an anthophyte flower that becomes the fruit.
3. Describe the process of double fertilization in anthophytes.
4. Infer how the production of nectar could enhance the pollination of a flowering plant.

Thinking Critically

5. Sequence the formation of the female gametophyte in a flowering plant using illustrations.

Skill Review

6. **Make and Use Tables** Make a table that identifies whether each organ of a flower is involved in pollination, fruit formation, seed production, or seed dispersal. For more help, refer to *Make and Use Tables* in the **Skill Handbook**.



INVESTIGATE BioLab

Before You Begin

Flowers are the reproductive structures of angiosperms. They come in many colors and shapes. Often their colors or shapes are related to the manner in which pollination takes place. The major organs of a flower include the petals, sepals, stamens, and pistils. Some flowers are incomplete, which means they do not have all four kinds of organs. You will study a complete flower.



Examining the Organs of a Flower

PREPARATION

Problem

What do the organs of a flower look like? How are they arranged?

Objectives

In this BioLab, you will:

- **Observe** the organs of a flower.
- **Identify** the functions of flower organs.

Materials

| | |
|---|--------------------------|
| flower—any complete dicot flower that is available locally, such as phlox, carnation, or tobacco flower | microscope |
| hand lens (or dissecting microscope) | single-edged razor blade |
| colored pencils (red, green, blue) | coverslips (2) |
| microscope slides (2) | dropper |
| | water |
| | forceps (or tweezers) |

Safety Precautions

CAUTION: *Handle the razor blade with extreme caution. Always cut away from you. Use caution when handling a microscope, slides, and coverslips.*

Skill Handbook

If you need help with this lab, refer to the **Skill Handbook**.

PROCEDURE

1. Examine your flower. Locate the sepals and petals. Note their numbers, size, color, and arrangement. Record this data. Remove the sepals and petals from your flower by gently pulling them off the stem.
2. Using the hand lens, locate the stamens, each of which consists of a thin filament with an anther on the tip. Note and record the number of stamens.
3. Locate the pistil. The stigma at the top of the pistil is often sticky. The style is a long, narrow structure that leads from the stigma to the ovary.

- Place an anther onto a microscope slide and add a drop of water. Cut the anther into several pieces with the razor blade. Place a coverslip over the cut-up anther.

CAUTION: *Always take care when using a razor blade.*

- Examine the anther under low and high power of your microscope. The small, dotlike structures are pollen grains. Remove the slide from the stage of the microscope.
- Slice the pistil in half lengthwise with the razor blade. Mount one half, cut side facing up, on a microscope slide.
- Identify and examine the pistil's ovary with a hand lens or dissecting microscope. The many dotlike structures in the ovary are ovules. A tiny stalk connects each ovule to the wall of the ovary.
- Make a diagram of the flower, labeling all its parts. Color the female reproductive parts red. Color the male reproductive parts green. Color the remaining parts blue.
- CLEANUP AND DISPOSAL** Clean all equipment as instructed by your teacher, and return everything to its proper place. Properly dispose of coverslips and flower organs. Wash your hands thoroughly.



ANALYZE AND CONCLUDE

- Observe** How many stamens are present in your flower? How many pistils, ovaries, sepals, and petals?
- Compare and Contrast** Make a reasonable estimate for your flower of the number of pollen grains in the anther and the number of ovules in the ovary. Calculate the class average of the estimated number of pollen grains and estimated number of ovules.
- Interpret Data** Which number is greater? Pollen grains in one anther or ovules in one ovary? Give a possible explanation for your answer.

Apply Your Skill

Field Investigation Use a field guide to identify common wildflowers in your area. Most field guide identifications are made on the basis of color, shape, numbers, and arrangement of flower parts. If collecting is permitted, pick a few common flowers to press and make into a display of local flora.



Web Links To find out more about flowers, visit bdol.glencoe.com/flowers

Hybrid Plants

For thousands of years, humans have influenced the breeding of plants, especially food crops and flowers. Today's plant breeders create hybrid strains with a variety of desired characteristics, such as more colorful or fragrant flowers, tastier fruit, higher yields, or increased resistance to diseases and pests.

The perfect ear of corn The first step in creating a hybrid is the selection of parent plants with desirable characteristics. A breeder might select a corn plant that ripens earlier in the season, one that can be sown earlier in the spring because its seeds germinate well in cool, moist soil, or one with more kernels per ear.

The next step is to grow several self-pollinated generations of each plant to form a true-breeding line—plants that produce offspring that always show the desired characteristic. To do this, each plant must be prevented from cross-pollinating with other corn. The female flowers, called silks, grow on cobs near the middle of the corn stalk. The breeder covers the silks to prevent wind-borne pollen from fertilizing them. The pollen-producing male tassels are removed, and the breeder uses selected pollen to hand-pollinate each silk.

Once each true-breeding line has been established, the real experimentation begins. Breeders cross different combinations of true-breeding lines to see what characteristics the resulting F_1 hybrids will have. These trials show which of the true-breeding lines reliably pass their desired characteristic to hybrid offspring, and which crosses produce seeds that the breeder can market as a new, improved variety of corn.

Plant breeding today Cell culture and genetic engineering technologies are new plant breeding techniques. Protoplast fusion removes the cell walls from the cells of leaves or seedlings, then uses electricity or chemicals to fuse cells of two different species. Some of these



Technician performing hybridization studies

fused cells have been successfully cultured in the lab and grown into adult plants, though none have produced seeds.

Recombinant DNA technology has been used to insert specific genes into the chromosomes of a plant. This technique helps produce plants that are resistant to frost, drought, or disease.

Applying Biotechnology

Form an Opinion Scientists have genetically engineered hybrid corn to produce an insecticide that kills one of corn's most damaging insects, the European corn borer. The hybrid corn produces Bt delta endotoxin. Since its introduction in 1996, Bt-corn has been the subject of much controversy. Research this topic and form an opinion for or against the growing of Bt-corn. Create a file of scientific articles and information that supports your position. Discuss this topic with someone of the opposite opinion.



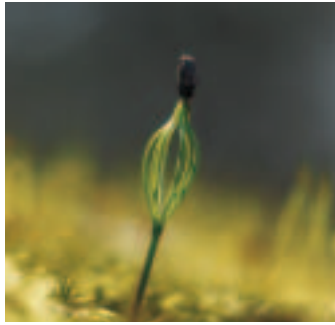
To find out more about hybrid seeds, visit bdol.glencoe.com/biotechnology

Chapter 24 Assessment

STUDY GUIDE

Section 24.1

Life Cycles of Mosses, Ferns, and Conifers



Key Concepts

- The gametophyte generation is dominant in mosses. Archegonia and antheridia form on separate or the same gametophyte. Fertilization requires a film of water on the gametophyte.
- Archegonia and antheridia develop on a prothallus, the fern gametophyte. Fertilization requires a film of water on the gametophyte. The sporophyte generation is dominant in ferns.
- Conifers have cones in which a male or female gametophyte forms. Sperm nuclei form in pollen grains and eggs form in ovules. The embryo is protected in a seed.

Vocabulary

megaspore (p. 638)
micropyle (p. 639)
microspore (p. 638)
protonema (p. 635)
vegetative reproduction (p. 634)

Section 24.2

Flowers and Flowering



Key Concepts

- Flowers are made up of four organs: sepals, petals, stamens, and pistils. A flower lacking any organ is called incomplete. Complete flowers have all four organs.
- Photoperiodism—responses of flowering plants to daylight-darkness conditions—affects flower production. Plants are called short-day, long-day, day-neutral, or intermediate depending upon their photoperiodic response.

Vocabulary

anther (p. 641)
day-neutral plant (p. 645)
long-day plant (p. 644)
ovary (p. 643)
petals (p. 641)
photoperiodism (p. 644)
pistil (p. 643)
sepals (p. 641)
short-day plant (p. 644)
stamen (p. 641)

Section 24.3

The Life Cycle of a Flowering Plant



Key Concepts

- The male gametophyte develops from a microspore in the anther. The female gametophyte develops from a megaspore in the ovule.
- Double fertilization occurs when a sperm nucleus joins with an egg to form a zygote. The second sperm nucleus joins the central cell to form endosperm.
- Fruits and seeds are modified for dispersal. Seeds can stay dormant for a long time before they germinate.

Vocabulary

dormancy (p. 654)
double fertilization (p. 651)
endosperm (p. 651)
germination (p. 654)
hypocotyl (p. 655)
polar nuclei (p. 648)
radicle (p. 655)



To help you review the life cycles of mosses, ferns, and conifers, use the Organizational Study Fold on page 633.



Chapter 24 Assessment

Vocabulary Review

Review the Chapter 24 vocabulary words listed in the Study Guide on page 661. Match the words with the definitions below.

- in seed plants, the opening in the ovule through which the pollen tube enters
- male reproductive organ of a flower that consists of an anther and a filament
- the first part of the stem to push above ground from a germinating seed
- in mosses, the small green filament of haploid cells that develops from a spore
- plants that produce flowers only after exposure to short nights

Understanding Key Concepts

- Moss gametophytes are _____ and form gametes by _____.
A. diploid—meiosis C. diploid—mitosis
B. haploid—mitosis D. haploid—meiosis
- Which of the following structures can develop as part of an anthophyte?

A.



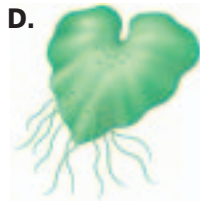
C.



B.



D.



- The endosperm of an anthophyte seed is _____.
A. haploid C. triploid
B. monoploid D. diploid
- Producing a new plant from part of another plant is _____.
A. photoperiodism
B. double fertilization
C. vegetative reproduction
D. germination

- A flower that naturally has eight petals and four sepals and four pistils is called _____.
A. asexual C. complete
B. incomplete D. partial
- The male gametophyte of a conifer is called a _____.
A. pollen grain C. cone
B. needle D. cotyledon
- Meiosis begins the _____ stage in a plant's life cycle.
A. bryophyte C. sporophyte
B. pterophyte D. gametophyte
- Ferns produce male gametes in _____.
A. antheridia C. rhizomes
B. protonemas D. archegonia

Constructed Response

- Open Ended** Many animals, including humans, eat seeds such as peas, beans, peanuts, and almonds. Why are seeds a good food source?
- Open Ended** How does dormancy help the survival of a plant species in a desert biome?
- Open Ended** The root is usually the first organ to emerge from a germinating seed. Evaluate how this benefits the plant more than if another organ emerged first.

Thinking Critically

- Predict** You are given three seeds. One is prickly, another has a winglike structure, and the third is tiny. How might each of the seeds be dispersed?
- REAL WORLD BIOCHALLENGE** The U.S. Fish and Wildlife Service has a list of endangered or threatened flowering plant species. Visit bdol.glencoe.com to investigate five plants on this list. Determine why they are considered endangered and what is being done to preserve them. What might result if one of your plants became extinct? Prepare a poster or give multimedia presentation of your results to your class.



Chapter 24 Assessment

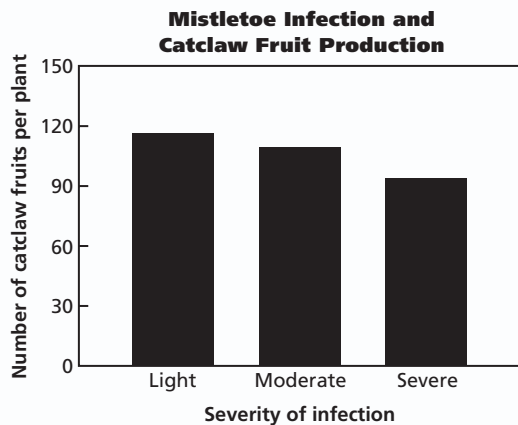
Standardized Test Practice

All questions aligned and verified by



Part 1 Multiple Choice

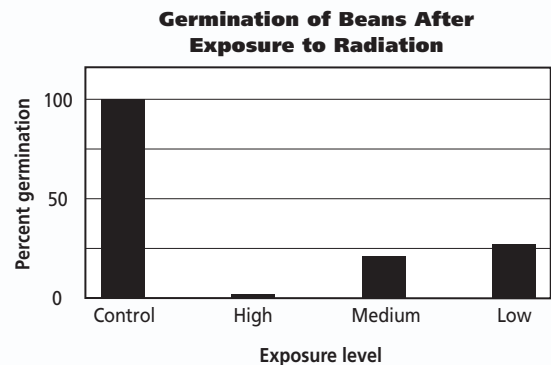
Desert mistletoe grows on a desert plant named catclaw, *Acacia greggii*. Predict a trend from the data to answer question 19. Analyze the graph and answer questions 20 and 21.



19. The data was collected during a drought. When drought is not severe, mistletoe infestation does not reduce fruit production. A graph of this situation would show _____.
- bars unequal in height
 - bars much lower than the bars in the graph above
 - two high bars and one low bar
 - all bars the same height
20. As infection of catclaw becomes more severe, _____.
- fruit production increases
 - fruit production decreases
 - fruit production remains unchanged
 - catclaw plants die

21. If the rate of infestation by mistletoe of catclaw increases over the years, catclaw numbers may _____.
- decrease
 - increase
 - remain the same
 - decrease, then increase

Analyze and evaluate the graph below to answer questions 22–24.



22. Which group of beans had the highest percentage of germination?
- control
 - high-exposure
 - medium-exposure level
 - low-exposure level level
23. As the radiation dose increases, germination _____.
- increases
 - decreases
 - stops
 - is not affected
24. When beans are given a low dose of radiation, about _____ germinate.
- 25 percent
 - 50 percent
 - none
 - 100 percent

Part 2 Constructed Response/Grid In

Record your answer on your answer document.

25. **Open Ended** Plant geneticists have learned that about one-third of the genes in two different plant genomes are not found in any sequenced fungus or animal genome. Infer why plants have many genes that do not have counterparts in the fungus kingdom or the animal kingdom.



BioDigest

UNIT 7 REVIEW

Plants

Plants provide food and shelter for most of Earth's organisms. Through the process of photosynthesis, they transform the radiant energy in light into chemical energy in food and release oxygen. All plants are multicellular eukaryotes whose cells are surrounded by a cell wall made of cellulose.

Non-Seed Plants

Non-seed plants reproduce by forming spores. A spore is a haploid (n) reproductive cell, produced by meiosis, which can withstand harsh environmental conditions. When conditions become favorable, a spore can develop into the haploid, gametophyte generation of a plant.

Mosses, Liverworts, and Hornworts

Bryophyta (mosses), Hepaticophyta (liverworts), and Anthocerophyta (hornworts) are divisions of non-seed nonvascular plants that live in cool, moist habitats. These plant groups have no vascular tissues to move water and nutrients from one part of the plant to another. They usually grow no more than several centimeters tall.



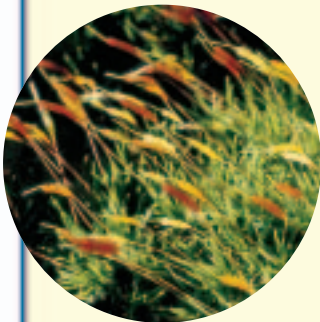
Mosses often grow in masses that form thick carpets.

Club Mosses

Club mosses are non-seed vascular plants in the division Lycopphyta. They are found primarily in moist environments and are usually only a few centimeters high. Fossil lycophytes grew as high as 30 m and formed a large part of the vegetation of Paleozoic forests.

FOCUS ON ADAPTATIONS

Alternation of Generations



The leafy moss gametophyte is haploid. The spore stalks and capsules are diploid.

The life cycles of plants have two stages, called generations. The diploid ($2n$) stage is called the sporophyte generation. It produces haploid (n) spores that develop into the gametophyte generation. The gametophyte generation produces male and female gametes that can unite and begin a new sporophyte generation.

In nonvascular plants, the sporophyte is smaller than the gametophyte, and usually remains attached to the gametophyte. The nonvascular sporophyte is dependent upon the nonvascular gametophyte for water and its nutrition. In vascular plants, the sporophyte is dominant and independent of the gametophyte. Vascular gametophytes are minute and usually are buried in soil or are enclosed within the vascular sporophyte.

Horsetails

Horsetails are non-seed vascular plants in the division ArthropHYTA. They are common in areas with damp soil, such as stream banks and sometimes along roadsides. Present-day horsetails are small, but their ancestors were treelike.

Ferns

Ferns, division Pterophyta, are diverse non-seed vascular plants. They have leaves called fronds that grow up from an underground stem called the rhizome. Ferns are found in many different habitats, including shady forests, stream banks, roadsides, and abandoned pastures.



Fern fronds are sometimes divided into leaflets.

Seed Plants

A seed is a reproductive structure that contains a sporophyte embryo and a food supply that are enclosed in a protective coating. The food supply nourishes the young plant during the first stages of growth. Like spores, seeds can survive harsh conditions. The seed develops into the sporophyte generation of the plant. Seed plants include conifers and flowering plants.

Cycads, Ginkgoes, and Joint Firs

Plants in divisions Cycadophyta (cycads), Ginkgophyta (ginkgoes), and Gnetophyta (joint firs), along with those in Coniferophyta, are sometimes called gymnosperms. Seeds of these plants

Seeds of conifers develop at the base of each woody scale of female cones.



are not part of a fruit. Their male and female reproductive organs are in separate structures. Seeds develop in the female reproductive structure. These plants have different forms and grow in diverse environments.

Conifers

Conifers, division Coniferophyta, produce seeds, usually in woody strobili called cones, and have needle-shaped or scalelike leaves. Most conifers are evergreen plants, which means they bear leaves all year round.

Conifers are common in cold or dry habitats. Their needles have a compact shape and a thick, waxy covering that helps reduce water loss. Conifer stems are covered with a thick layer of bark that insulates the tissues inside. These structural adaptations enable conifers to survive below freezing temperatures.

VITAL STATISTICS

Conifers

Examples: Pine, spruce, fir, larch, yew, redwood, juniper.

Plant giants: Giant sequoias of central California, to 99 m tall, the most massive organisms in the world; coast redwoods of California, to 117 m, the tallest trees in the world.

Flowering Plants

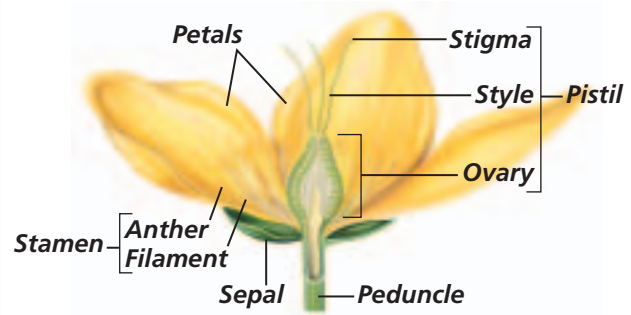
The flowering plants, division Anthophyta, form the largest and most diverse group of plants on Earth today. They provide much of the food eaten by humans. Anthophytes produce flowers and develop seeds that are part of a fruit.

Monocots and Dicots

The anthophytes are in two classes: the monocotyledons and the dicotyledons. Cotyledons, or "seed leaves," are part of the seed along with the plant embryo. Monocots have one seed leaf and dicots have two seed leaves.



Monocots include grasses, orchids (left photo), and palms. Dicots include many flowering trees (right photo) and wildflowers.



Flowers

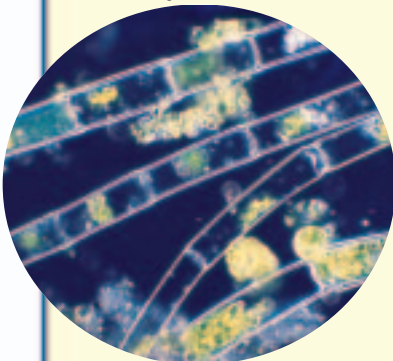
Flowers are the organs of reproduction in anthophytes. The pistil is the female reproductive organ. At the base of the pistil is the ovary. Inside the ovary are the ovules. Ovules contain the female gametophyte. A female gamete—an egg cell—forms in each ovule. The stamen is the male reproductive organ of a flower. Pollen grains that

form inside the anther eventually contain male gametes called sperm.

FOCUS ON ADAPTATIONS

Moving from Water to Land

LM Magnification: 400×



Plants probably evolved from filamentous green algae.

All plants probably evolved from filamentous green algae that lived in nutrient-rich waters of Earth's ancient oceans. Water and dissolved minerals can diffuse directly into the cells of an ocean-dwelling alga. As land plants evolved, new structures developed that allowed water and dissolved minerals to be taken in from the environment and to be transported to all parts of the plant.

Nonvascular plants In nonvascular plants, water and nutrients travel from one cell to another by the processes of osmosis and diffusion. As a result, nonvascular plants are limited to moist environments.



Plants that depend on the wind to carry pollen from anther to stigma tend to have small, inconspicuous flowers. The pollen of corn is carried by the wind from these male flowers to female flowers that make up an ear of corn.

Pollen

In seed plants, the sperm develop inside of the thick-coated pollen grains. Pollen is an important structural adaptation that has enabled seed plants to live in diverse land habitats. Pollination is the transfer of pollen grains from the anther to the stigma of the pistil.

Pollinators

Pollen can be transferred by wind, insects, birds, and even bats. Some flowers have colorful or perfumed petals that attract pollinators. Flowers also can contain sweet nectar, as well as pollen, which provides pollinators with food.

Vascular plants The stems of most plants contain vascular tissues made up of tubelike, elongated cells through which water, food, and other materials move from one part of the plant to another. One reason vascular plants can grow larger than nonvascular plants is that vascular tissue allows a more efficient method of internal transport than osmosis and diffusion. In addition, vascular tissues include thickened fibers that can support upright growth.

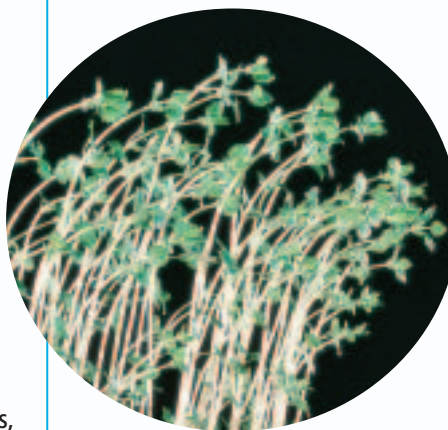
An unbroken column of water travels from the roots in xylem tissues. Sugars formed by photosynthesis travel throughout the plant in phloem tissues.

Fruit

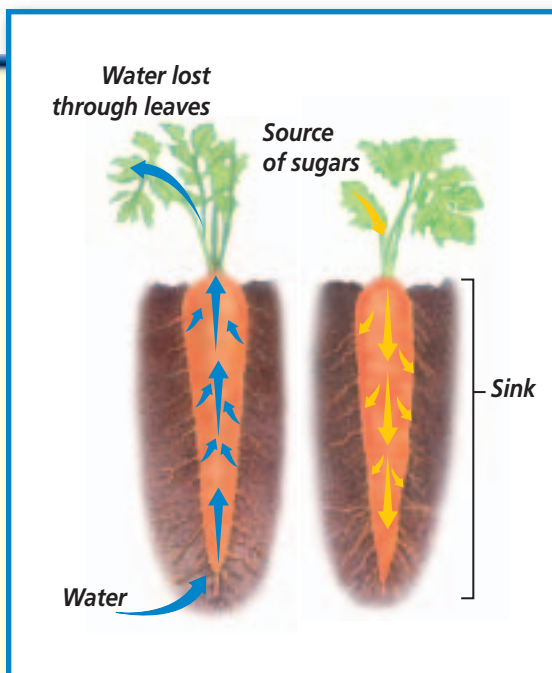
Following fertilization, a fruit with seeds can develop. Fruits help protect seeds until they are mature. Some flowering plants develop fleshy fruits, such as apples, melons, tomatoes, or squash. Other flowering plants develop dry fruits, such as peanuts, walnuts, or sunflowers. Fruits also can help disperse seeds.

Plant Responses

Plants respond to stimuli in their environment such as light, temperature, and water availability. Chemicals called hormones control some of these responses by increasing cell division and growth.



The phototropic response shown here is the result of increased cell growth on the side of the stem away from the light.





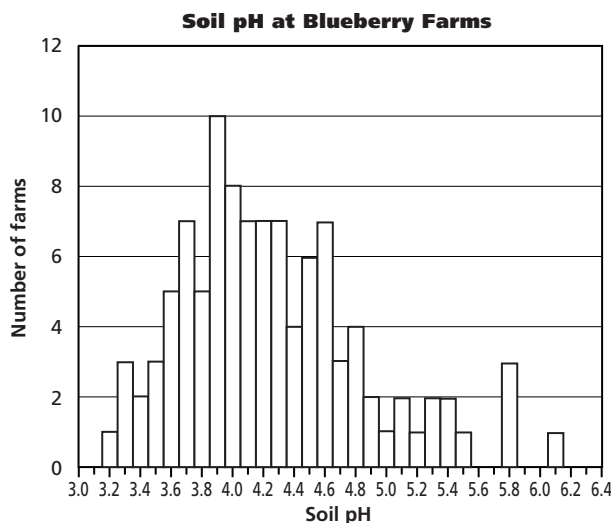
TEST-TAKING TIP

Plan Your Work and Work Your Plan

Set up a study schedule for yourself well in advance of your test. Plan your workload so that you do a little each day rather than a lot all at once. The key to retaining information is to repeatedly review and practice it. There is truth in the saying, "Use it or lose it."

Part 1 Multiple Choice

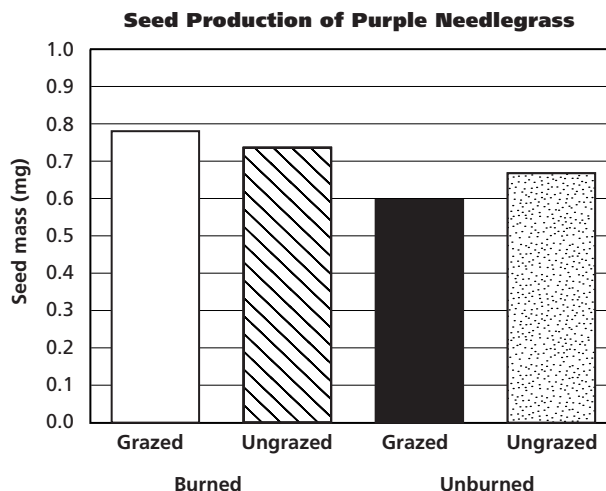
Blueberry plants grow best and have optimal berry production in soils that have a pH range of 4.0–5.2. Recall that a substance with a pH less than 7 is called acidic. Scientists tested the soils on 104 commercial blueberry farms, then compiled their data. Analyze the graph of their data below to answer questions 1 and 2.



- Which of the following statements best describes the soils at most blueberry farms?
 - within the pH range for optimal berry production
 - lower than the pH range for optimal berry production
 - higher than the pH range for optimal berry production
 - both lower and higher than the pH range for optimal berry production

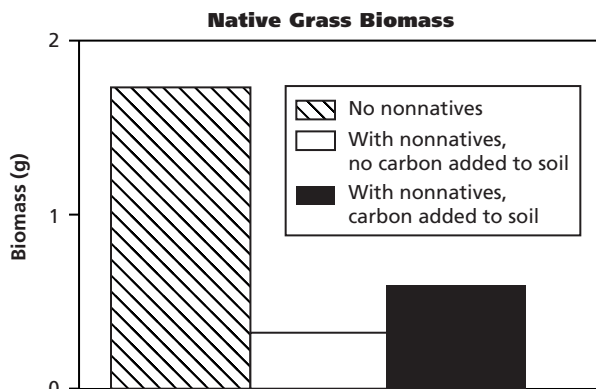
- What percentage of the blueberry farms have soils too acidic for optimal berry production?
 - 57%
 - 35%
 - 100%
 - 9%

Study the graph below about seed production responses of purple needlegrass in California to answer questions 3–5.



- The largest seed mass of purple needlegrass occurs when the habitat is _____.
 - grazed and unburned
 - ungrazed and unburned
 - grazed and burned
 - ungrazed and burned
- The smallest seed mass of purple needle grass occurs when the habitat is _____.
 - grazed and unburned
 - ungrazed and unburned
 - grazed and burned
 - ungrazed and burned
- If you wanted to grow purple needlegrass with seeds with larger mass, how would you manage your land?
 - graze only
 - burn only
 - graze and burn
 - neither graze nor burn

The roots of some nonnative plants produce chemicals that interfere with the growth of native grasses. Analyze the graph below to answer questions 6 and 7.



6. In this study, the effect of carbon on native plants _____.
- is somewhat beneficial
 - is harmful
 - completely counteracts the effect of the chemical given off by the roots of the nonnative plants
 - cannot be determined by analyzing the graph

7. When native grasses are grown with nonnative plants nearby and carbon is not added to the soil, the biomass of the native grasses is _____.
- less than grasses grown without the nonnative plants nearby regardless of whether carbon is added to the soil
 - greater than without nonnative plants nearby
 - not affected by the addition of carbon to the soil
 - less than without nonnatives nearby, but greater than when carbon is added to the soil
8. Mosses, ferns, and club mosses are alike because they _____.
- require water for fertilization
 - have adaptations for conserving water
 - need insects for pollination
 - grow best in warm, sunny, and dry habitats
9. Club mosses, horsetails, and conifers have specialized leaves that form reproductive structures known as _____.
- sori
 - flowers
 - protonema
 - strobili

Part 2 Constructed Response/Grid In

Record your answers or fill in the bubbles on your answer document using the correct place value.

10. **Open Ended** Snow buttercups in the alpine tundra have flowers that orient themselves toward and track the apparent movement of the sun across the sky. Biologists hypothesized that this response was stimulated by the blue wavelength component of light. It is known that red filters can block blue wavelengths. Describe an experiment that would test this hypothesis.
11. **Open Ended** Why do vascular plants have an adaptive advantage over nonvascular plants?
12. **Open Ended** Using the table to the right, choose two geographic areas and infer why the number of seed plants in the two areas differ.
- | Geographic Area | Estimated Number |
|------------------------|------------------|
| Europe | 13 638 |
| Africa | 74 232 |
| Australia/ New Zealand | 81 876 |
| Pacific Islands | 10 758 |
| Northern America | 34 455 |
| Southern America | 115 242 |
13. **Grid In** A change in pH of one represents a 10-times change in the hydrogen ion concentration of a substance. A change in pH of two represents a 100-times change in the hydrogen ion concentration of a substance. Using the graph about soil pH on page 668 for questions 1 and 2, find to the nearest whole number the change in soil pH from the lowest to the highest recorded number. This number represents a _____-times change in hydrogen ion concentration.

