chapter 10

Plant Reproduction

The BIG Idea

Plants have adaptations that enable them to reproduce in specific habitats.

Section 1
Introduction to Plant Reproduction

Main Idea Reproduction in plants can be asexual or sexual. Plant life cycles include an alternation of generations.

Section 2
Seedless Reproduction

Main Idea The joining of a seedless plant's egg and sperm requires moist conditions and produces a spore.

Section 3
Seed Reproduction

Main Idea Reproduction in seed plants involves pollen grains—the sources of sperm, and ovules—the sources of the eggs. The joining of eggs and sperms can produce seeds.

A Forest from Ashes

Saplings and other plants are growing among the remains of trees destroyed by fire. Where did these new plants come from? Some may have grown from seeds, and others may have grown from roots or stems that survived underground. These plants are the result of plant reproduction.

Science Journal List three plants that reproduce by forming seeds.

Massimo Mastrorillo/CORBIS

Start-Up Activities

LAUNCH LAB

Do all fruits contain seeds?

You might know that most plants grow from seeds. Seeds are usually found in the fruits of plants. When you eat watermelon, it can contain many small seeds. Do some plants produce fruits without seeds? Do this lab to find out.

1. Obtain two grapes from your teacher. Each grape should be from a different plant.
2. Split each grape in half and examine the insides of each grape. **WARNING:** *Do not eat the grapes.*
3. **Think Critically** Were seeds found in both grapes? Hypothesize how new grape plants could be grown if no seeds are produced. In your Science Journal, list three other fruits you know of that do not contain seeds.

Science Online

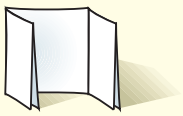
Preview this chapter's content and activities at life.msscience.com

FOLDABLES™ Study Organizer

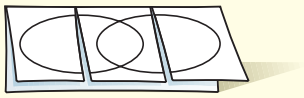
Plant Reproduction Make the following Foldable to compare and contrast the sexual and asexual characteristics of a plant.

STEP 1 **Fold** one sheet of paper lengthwise.

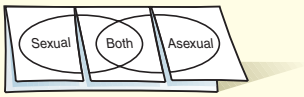
STEP 2 **Fold** into thirds.



STEP 3 **Unfold and draw** overlapping ovals. **Cut** the top sheet along the folds.



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



Construct a Venn Diagram As you read the chapter, list the characteristics unique to sexual reproduction under the left tab, those unique to asexual reproduction under the right tab, and those characteristics common to both under the middle tab.

Massimo Mastrorillo/CORBIS

Get Ready to Read

Summarize

1 Learn It! Summarizing helps you organize information, focus on main ideas, and reduce the amount of information to remember. To summarize, restate the important facts in a short sentence or paragraph. Be brief and do not include too many details.

2 Practice It! Read the text on page 290 labeled Germination. Then read the summary below and look at the important facts from that passage.

Summary

Germination is the growth of a plant from a seed. It requires certain environmental conditions. Processes occur within the seed that result in the growth of roots, a stem, and leaves.

Important Facts

A series of events that results in the growth of a plant from a seed is called **germination.**

Seeds will not germinate until environmental conditions are right. Temperature, the presence or absence of light, availability of water, and amount of oxygen present can affect germination. Sometimes the seed must pass through an animal's digestive system before it will germinate.

Germination begins when seed tissues absorb water. This causes the seed to swell and the seed coat to break open.

Next, a series of chemical reactions occurs that releases energy from the stored food in the cotyledons or endosperm for growth. Eventually, a root grows from the seed, followed by a stem and leaves.

3 Apply It! Practice summarizing as you read this chapter. Stop after each lesson and write a brief summary.

Reading Tip

Reread your summary to make sure you didn't change the author's original meaning or ideas.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1 **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.

- Write an **A** if you **agree** with the statement.
- Write a **D** if you **disagree** with the statement.

2 **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.

- If any of your answers changed, explain why.
- Change any false statements into true statements.
- Use your revised statements as a study guide.

Before You Read A or D		Statement	After You Read A or D
	1	Both asexual and sexual plant reproduction involves sex cells.	
	2	Plants produced by asexual reproduction are genetically identical to the parent plants.	
	3	The structures of a gametophyte plant are made of haploid cells.	
	4	Insects usually move moss sperm to moss eggs.	
	5	The gametophyte stage of mosses is small and rarely observed by humans.	
	6	Generally, fern fronds have structures on them that produce spores.	
	7	An embryo, stored food, and seed coat are parts of a seed.	
	8	Gymnosperm seeds are produced inside flowers.	
	9	An angiosperm fruit that has one or more seeds grows after fertilization.	
	10	Seed germination can occur within days after seed dispersal.	

Science Online

Print out a worksheet of this page at life.msscience.com

section 1

Introduction to Plant Reproduction

as you read

What You'll Learn

- **Distinguish** between the two types of plant reproduction.
- **Describe** the two stages in a plant's life cycle.

Why It's Important

You can grow new plants without using seeds.

Review Vocabulary

fertilization: in sexual reproduction, the joining of a sperm and an egg

New Vocabulary

- spore
- gametophyte stage
- sporophyte stage

Types of Reproduction

Do people and plants have anything in common? You don't have leaves or roots, and a plant doesn't have a heart or a brain. Despite these differences, you are alike in many ways—you need water, oxygen, energy, and food to grow. Like humans, plants also can reproduce and make similar copies of themselves. Although humans have only one type of reproduction, most plants can reproduce in two different ways, as shown in **Figure 1.**

Sexual reproduction in plants and animals requires the production of sex cells—usually called sperm and eggs—in reproductive organs. The offspring produced by sexual reproduction are genetically different from either parent organism.

A second type of reproduction is called asexual reproduction. This type of reproduction does not require the production of sex cells. During asexual reproduction, one organism produces offspring that are genetically identical to it. Most plants have this type of reproduction, but humans and most other animals don't.

In crocus flowers, bees and other insects help get the sperm to the egg.

A cutting from this impatiens plant can be placed in water and will grow new roots. This new plant can then be planted in soil.

Figure 1 Many plants reproduce sexually with flowers that contain male and female parts. Other plants can reproduce asexually.

(l)Stephen Dalton/Photo Researchers, (r)Matt Meadows

Figure 2 Asexual reproduction in plants takes many forms.

The eyes on these potatoes have begun to sprout. If a potato is cut into pieces, each piece that contains an eye can be planted and will grow into a new potato plant.

Grass plants spread by reproducing asexually.

Asexual Plant Reproduction

Do you like to eat oranges and grapes that have seeds, or do you like seedless fruit? If these plants do not produce seeds, how do growers get new plants? Growers can produce new plants by asexual reproduction because many plant cells have the ability to grow into a variety of cell types. New plants can be grown from just a few cells in the laboratory. Under the right conditions, an entire plant can grow from one leaf or just a portion of the stem or root. When growers use these methods to start new plants, they must make sure that the leaf, stem, or root cuttings have plenty of water and anything else that they need to survive.

Asexual reproduction has been used to produce plants for centuries. The white potatoes shown in **Figure 2** were probably produced asexually. Many plants, such as lawn grasses also shown in **Figure 2,** can spread and cover wide areas because their stems grow underground and produce new grass plants asexually along the length of the stem.

Sexual Plant Reproduction

Although plants and animals have sexual reproduction, there are differences in the way that it occurs. An important event in sexual reproduction is fertilization. Fertilization occurs when a sperm and egg combine to produce the first cell of the new organism, the zygote. How do the sperm and egg get together in plants? In some plants, water or wind help bring the sperm to the egg. For other plants, animals such as insects help bring the egg and sperm together.

Reading Check ***How does fertilization occur in plants?***

Mini LAB

Observing Asexual Reproduction

Procedure

1. Using a pair of scissors, cut a stem with at least two pairs of leaves from a coleus or another houseplant.
2. Carefully remove the bottom pair of leaves.
3. Place the cut end of the stem into a cup that is half-filled with water for two weeks. Wash your hands.
4. Remove the new plant from the water and plant it in a small container of soil.

Analysis

1. Draw and label your results in your **Science Journal.**
2. Predict how the new plant and the plant from which it was taken are genetically related.

(l)Holt Studios/Nigel Cattlin/Photo Researchers, (r)Inga Spence/Visuals Unlimited

Figure 3 Some plants can fertilize themselves. Others require two different plants before fertilization can occur.

Flowers of pea plants contain male and female structures, and each flower can fertilize itself.

These holly flowers contain only male reproductive structures, so they can't fertilize themselves.

Compare the flowers of this female holly plant to those of the male plant.

Science Online

Topic: Male and Female Plants

Visit life.msscience.com for Web links to information about male and female plants.

Activity List four plants that have male and female reproductive structures on separate plants.

Reproductive Organs A plant's female reproductive organs produce eggs and male reproductive organs produce sperm. Depending on the species, these reproductive organs can be on the same plant or on separate plants, as shown in **Figure 3.** If a plant has both organs, it usually can reproduce by itself. However, some plants that have both sex organs still must exchange sex cells with other plants of the same type to reproduce.

In some plant species, the male and female reproductive organs are on separate plants. For example, holly plants are either female or male. For fertilization to occur, holly plants with flowers that have different sex organs must be near each other. In that case, after the eggs in female holly flowers are fertilized, berries can form.

Another difference between you and a plant is how and when plants produce sperm and eggs. You will begin to understand this difference as you examine the life cycle of a plant.

Plant Life Cycles

All organisms have life cycles. Your life cycle started when a sperm and an egg came together to produce the zygote that would grow and develop into the person you are today. A plant also has a life cycle. It can start when an egg and a sperm come together, eventually producing a mature plant.

(l)H. Reinhard/OKAPIA/Photo Researchers, (c)John W. Bova/Photo Researchers, (r)John D. Cunningham/Visuals Unlimited

Two Stages During your life cycle, all structures in your body are formed by mitosis and cell division and are made up of diploid cells—cells with a full set of chromosomes. However, sex cells form by meiosis and are haploid—they have half a set of chromosomes.

Plants have a two-stage life cycle, as shown in **Figure 4.** The two stages are the gametophyte (guh MEE tuh fite) stage and the sporophyte (SPOHR uh fite) stage.

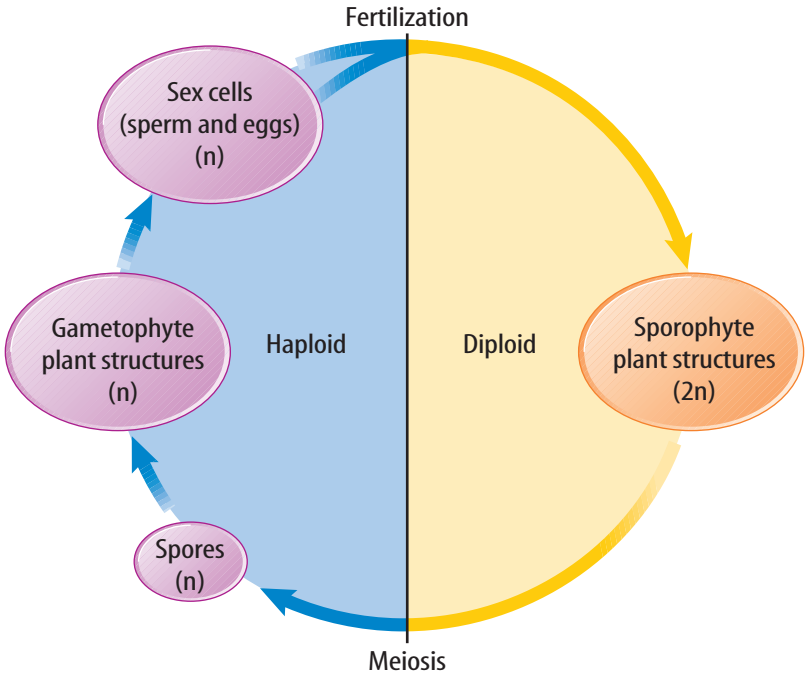


Figure 4 Plants produce diploid and haploid plant structures. **Identify** *the process that begins the gametophyte stage.*

Gametophyte Stage When reproductive cells undergo meiosis and produce haploid cells called **spores,** the **gametophyte stage** begins. Spores divide by mitosis and cell division and form plant structures or an entire new plant made of haploid cells. Some of these cells undergo mitosis and cell division and form haploid sex cells.

Sporophyte Stage Fertilization—the joining of haploid sex cells—begins the **sporophyte stage.** Cells formed in this stage have the diploid number of chromosomes. Meiosis in some of these cells forms spores, and the cycle repeats.

Reading Check ***What process begins the sporophyte stage?***

section 1 review

Summary

Types of Reproduction

- Asexual reproduction results in offspring that are genetically identical to the parent plant.
- Sexual reproduction requires fertilization and results in offspring that are genetically different from either parent.
- Female reproductive organs produce eggs.
- Male reproductive organs produce sperm.

Plant Life Cycles

- The gametophyte stage of the plant life cycle begins with meiosis.
- The sporophyte stage begins with fertilization.

Self Check

1. **List** three differences between the gametophyte stage and the sporophyte stage of the plant life cycle.
2. **Describe** how plants reproduce asexually.
3. **Compare and contrast** sexual reproduction in plants and animals.
4. **Think Critically** You admire a friend's houseplant. What would you do to grow an identical plant?

Applying Skills

5. **Draw Conclusions** Using a microscope, you see that the nuclei of a plant's cells contain half the usual number of chromosomes. What is the life cycle stage of this plant?

section 2

Seedless Reproduction

as you read

What You'll Learn

- **Examine** the life cycles of a moss and a fern.
- **Explain** why spores are important to seedless plants.
- **Identify** some special structures used by ferns for reproduction.

Why It's Important

Mosses help build new soil on bare rock or cooled lava, making it possible for other plants to take root.

Review Vocabulary

photosynthesis: food-making process by which plants and many other producers use light energy to produce glucose and oxygen from carbon dioxide and water

New Vocabulary

- frond
- rhizome
- sori
- prothallus

The Importance of Spores

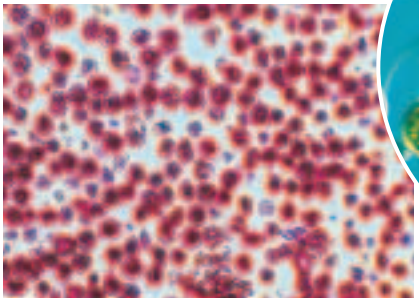
If you want to grow ferns and moss plants, you can't go to a garden store and buy a package of seeds—they don't produce seeds. You could, however, grow them from spores. The sporophyte stage of these plants produces haploid spores in structures called spore cases. When the spore case breaks open, the spores are released and spread by wind or water. The spores, shown in **Figure 5,** can grow into plants that will produce sex cells.

Seedless plants include all nonvascular plants and some vascular plants. Nonvascular plants do not have structures that transport water and substances throughout the plant. Instead, water and substances simply move from cell to cell. Vascular plants have tubelike cells that transport water and substances throughout the plant.

Nonvascular Seedless Plants

If you walked in a damp, shaded forest, you probably would see mosses covering the ground or growing on a log. Mosses, liverworts, and hornworts are all nonvascular plants.

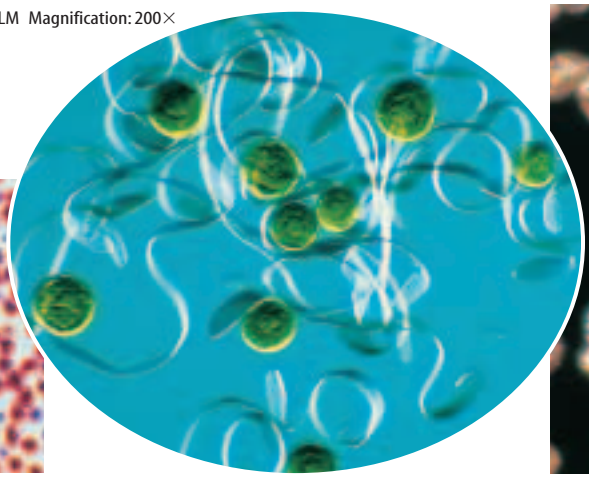
The sporophyte stage of most nonvascular plants is so small that it can be easily overlooked. Moss plants have a life cycle typical of how sexual reproduction occurs in this plant group.



Moss spores

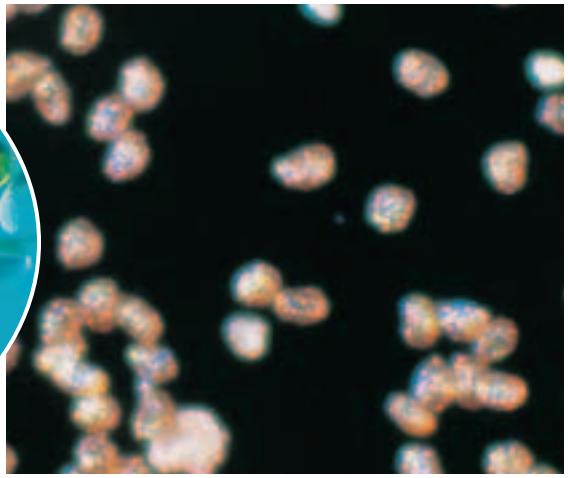
Stained LM Magnification: 69×

LM Magnification: 200×



Horsetail spores

LM Magnification: 120×



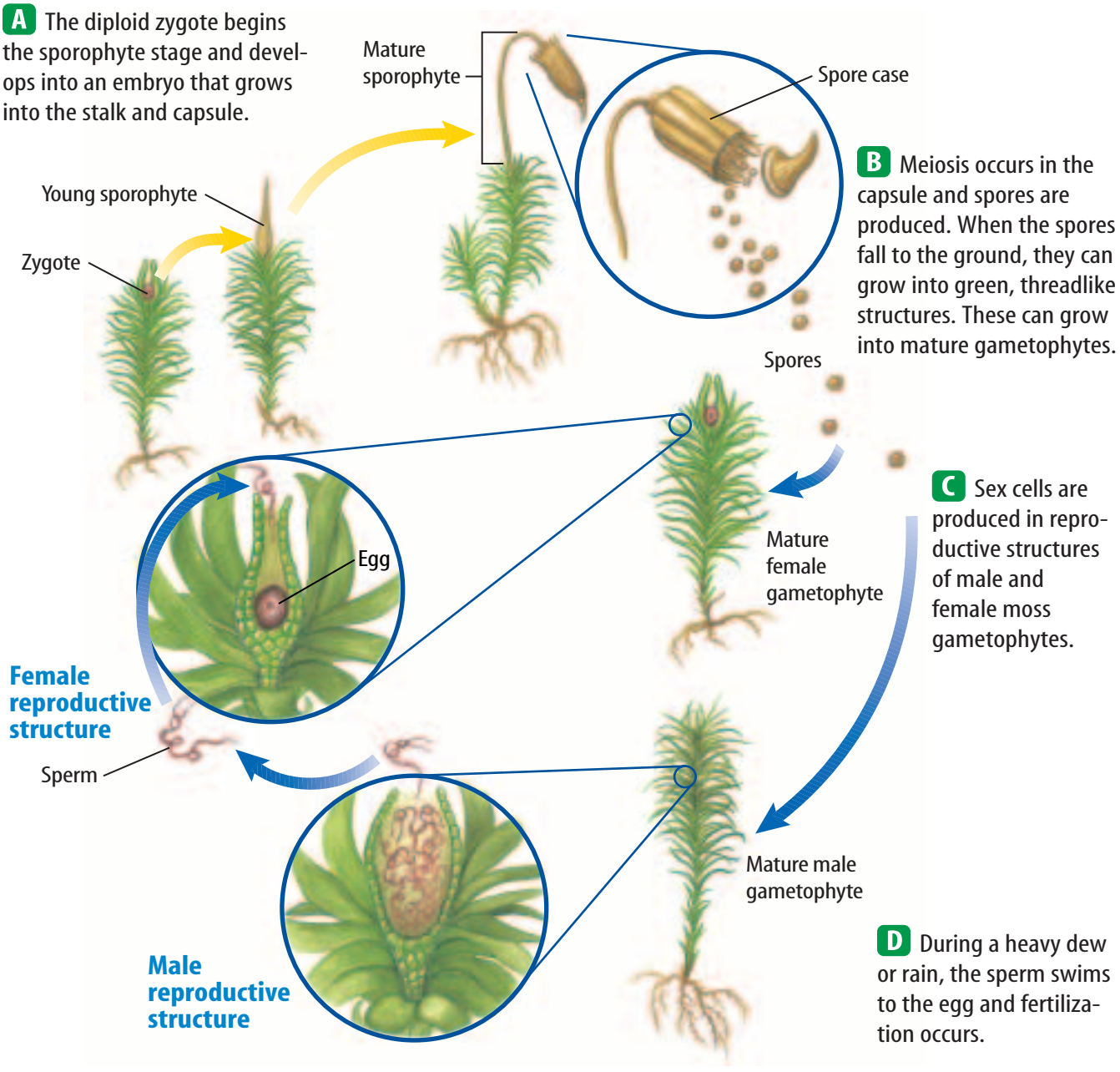
Fern spores

Figure 5 Spores come in a variety of shapes, but all are small and have a waterproof coating.

(l)Biology Media/Photo Researchers, (c)Andrew Syred/Science Photo Library/Photo Researchers, (r)Runk/Schoenberger from Grant Heilman

The Moss Life Cycle You recognize mosses as green, low-growing masses of plants. This is the gametophyte stage, which produces the sex cells. But the next time you see some moss growing, get down and look at it closely. If you see any brownish stalks growing up from the tip of the gametophyte plants, you are looking at the sporophyte stage. The sporophyte stage does not carry on photosynthesis. It depends on the gametophyte for nutrients and water. On the tip of the stalk is a tiny capsule. Inside the capsule millions of spores have been produced. When environmental conditions are just right, the capsule opens and the spores either fall to the ground or are blown away by the wind. New moss gametophytes can grow from each spore and the cycle begins again, as shown in **Figure 6.**

Figure 6 The life cycle of a moss alternates between gametophyte and sporophyte stages.
Identify *the structures that are produced by the gametophyte stage.*



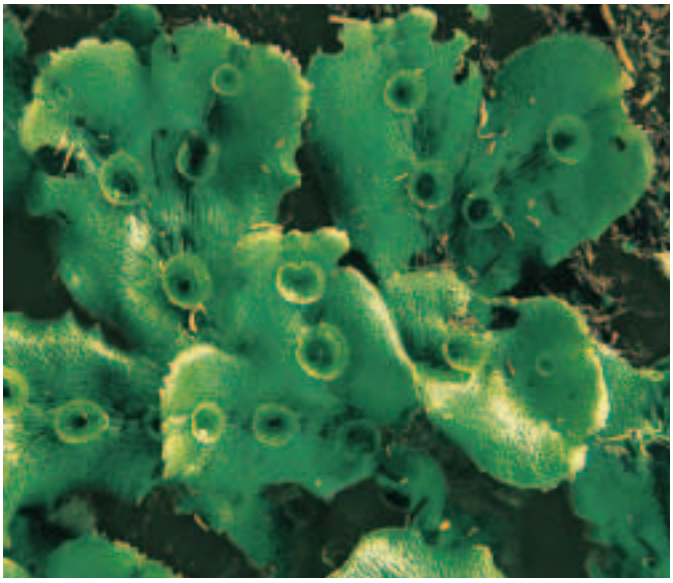


Figure 7 Small balls of cells grow in cuplike structures on the surface of the liverwort.

Nonvascular Plants and Asexual Reproduction Nonvascular plants also can reproduce asexually. For example, if a piece of a moss gametophyte plant breaks off, it can grow into a new plant. Liverworts can form small balls of cells on the surface of the gametophyte plant, as shown in **Figure 7.** These are carried away by water and grow into new gametophyte plants if they settle in a damp environment.

Vascular Seedless Plants

Millions of years ago most plants on Earth were vascular seedless plants. Today they are not as widespread.

Most vascular seedless plants are ferns. Other plants in this group include horsetails and club mosses. All of these plants have vascular tissue to transport water from their roots to the rest of the plant. Unlike the nonvascular plants, the gametophyte of vascular seedless plants is the part that is small and often overlooked.

The Fern Life Cycle The fern plants that you see in nature or as houseplants are fern sporophyte plants. Fern leaves are called **fronds.** They grow from an underground stem called a **rhizome.** Roots that anchor the plant and absorb water and nutrients also grow from the rhizome. Fern sporophytes make their own food by photosynthesis. Fern spores are produced in structures called **sori** (singular, *sorus*), usually located on the underside of the fronds. Sori can look like crusty rust-, brown-, or dark-colored bumps. Sometimes they are mistaken for a disease or for something growing on the fronds.

If a fern spore lands on damp soil or rocks, it can grow into a small, green, heart-shaped gametophyte plant called a **prothallus** (proh THA lus). A prothallus is hard to see because most of them are only about 5 mm to 6 mm in diameter. The prothallus contains chlorophyll and can make its own food. It absorbs water and nutrients from the soil. The life cycle of a fern is shown in **Figure 8.**

Reading Check *What is the gametophyte plant of a fern called?*

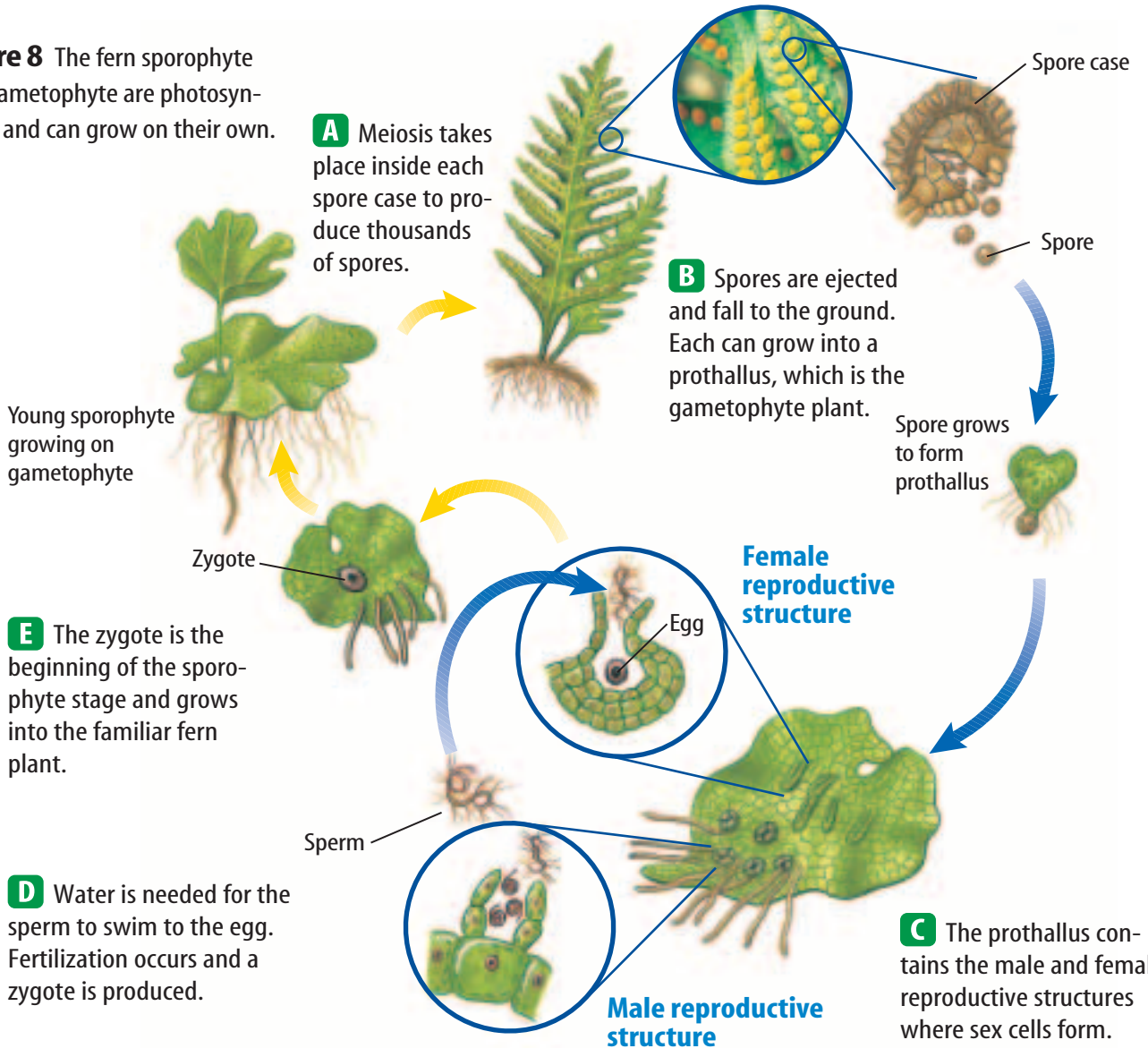
Ferns may reproduce asexually, also. Fern rhizomes grow and form branches. New fronds and roots develop from each branch. The new rhizome branch can be separated from the main plant. It can grow on its own and form more fern plants.

INTEGRATE History

Catapults For thousands of years, humans have used catapults to launch objects. The spore cases of ferns act like tiny catapults as they eject their spores. In your Science Journal list tools, toys, and other objects that have used catapult technology throughout history.

Kathy Merrifield 2000/Photo Researchers

Figure 8 The fern sporophyte and gametophyte are photosynthetic and can grow on their own.



section 2 review

Summary

The Importance of Spores

- Seedless plants reproduce by forming spores.
- Seedless plants include all nonvascular plants and some vascular plants.

Nonvascular Seedless Plants

- Spores are produced by the sporophyte stage and can grow into gametophyte plants.
- The sporophyte cannot photosynthesize.

Vascular Seedless Plants

- Fern sporophytes have green fronds that grow from an underground rhizome.

Self Check

1. **Describe** the life cycle of mosses.
2. **Explain** each stage in the life cycle of a fern.
3. **Compare and contrast** the gametophyte plant of a moss and the gametophyte plant of a fern.
4. **Describe** asexual reproduction in seedless plants.
5. **Think Critically** Why do some seedless plants reproduce only asexually during dry times of the year?

Applying Math

6. **Solve One-Step Equations** If moss spores are 0.1 mm in diameter, how many equal the diameter of a penny?

Kathy Merrifield 2000/Photo Researchers

LAB

Comparing Seedless Plants

All seedless plants have specialized structures that produce spores. Although these sporophyte structures have a similar function, they look different. The gametophyte plants also are different from each other. Do this lab to observe the similarities and differences among three groups of seedless plants.

Real-World Question

How are the gametophyte stages and the sporophyte stages of liverworts, mosses, and ferns similar and different?

Goals

- **Describe** the sporophyte and gametophyte forms of liverworts, mosses, and ferns.
- **Identify** the spore-producing structures of liverworts, mosses, and ferns.

Materials

live mosses, liverworts, and ferns with gametophytes and sporophytes
microscope slides and coverslips (2)
magnifying lens
forceps
dropper
microscope
dissecting needle
pencil with eraser

Safety Precautions

Procedure

1. Obtain a gametophyte of each plant. With a magnifying lens, observe the rhizoids, leafy parts, and stemlike parts, if any are present.
2. Obtain a sporophyte of each plant and use a magnifying lens to observe it.
3. Locate and remove a spore structure of a moss plant. Place it in a drop of water on a slide.

4. Place a coverslip over it. Use the eraser of a pencil to gently push on the coverslip to release the spores. **WARNING:** *Do not break the coverslip.* Observe the spores under low and high power.
5. Make labeled drawings of all observations in your Science Journal.
6. Repeat steps 3–5 using a fern.

Conclude and Apply

1. **Compare** the gametophyte's appearance to the sporophyte's appearance for each plant.
2. **List** structure(s) common to all three plants.
3. **Hypothesize** about why each plant produces a large number of spores.

Communicating Your Data

Prepare a bulletin board that shows differences between the sporophyte and gametophyte stages of liverworts, mosses, and ferns. **For more help, refer to the Science Skill Handbook.**

Matt Meadows

section 3

Seed Reproduction

(l)John Kaprielian/Photo Researchers, (r)Scott Camazine/Sue Trainor/Photo Researchers

The Importance of Pollen and Seeds

All the plants described so far have been seedless plants. However, the fruits and vegetables that you eat come from seed plants. Oak, maple, and other shade trees are also seed plants. All flowers are produced by seed plants. In fact, most of the plants on Earth are seed plants. How do you think they became such a successful group? Reproduction that involves pollen and seeds is part of the answer.

Pollen In seed plants, some spores develop into small structures called pollen grains. A **pollen grain,** as shown in **Figure 9,** has a water-resistant covering and contains male gametophyte parts that can produce sperm. Sperm of seed plants do not need to swim to the female part of the plant. Instead, they are carried as part of the pollen grain by gravity, wind, water currents, or animals. The transfer of pollen grains of a species to the female part of the plant of the same species is called **pollination.**

After the pollen grain reaches the female part of a plant, sperm and a pollen tube are produced. The sperm moves through the pollen tube, then fertilization can occur.

Figure 9 The waterproof covering of a pollen grain is unique and can be used to identify the plant that it came from. This pollen from a ragweed plant is a common cause of hay fever.

Color-enhanced SEM
Magnification: 3000×

as you read

What You'll Learn

- **Examine** the life cycles of typical gymnosperms and angiosperms.
- **Describe** the structure and function of the flower.
- **Discuss** methods of seed dispersal in seed plants.

Why It's Important

Seeds from cones and flowers produce most plants on Earth.

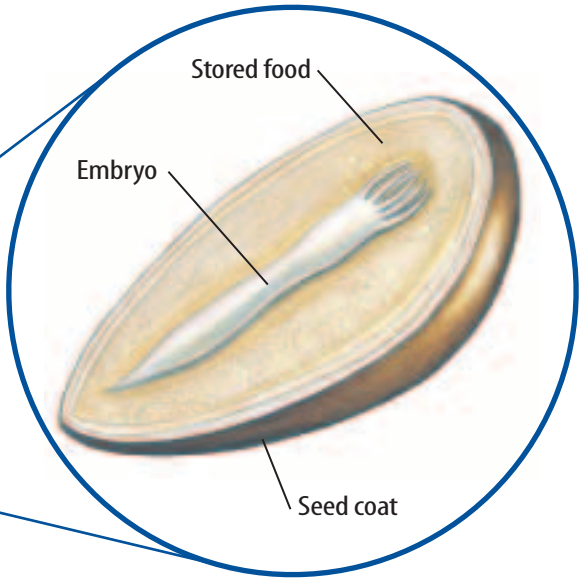
Review Vocabulary

gymnosperms: vascular plants that do not flower, generally have needlelike or scalelike leaves, and produce seeds that are not protected by fruit

New Vocabulary

- pollen grain
- pollination
- ovule
- stamen
- pistil
- ovary
- germination

Figure 10 Seeds have three main parts—a seed coat, stored food, and an embryo. This pine seed also has a wing. **Infer** *the function of the wing.*



Science Online

Topic: Seed Banks

Visit life.msscience.com for Web links to information about conserving the seeds of many useful and endangered plants.

Activity List three organizations that manage seed banks, and give examples of the kinds of plants each organization works to conserve.

Seeds Following fertilization, the female part of a plant can develop into a seed. A seed consists of an embryo, stored food, and a protective seed coat, as shown in **Figure 10.** The embryo has structures that eventually will produce the plant's stem, leaves, and roots. In the seed, the embryo grows to a certain stage and then stops until the seed is planted. The stored food provides energy that is needed when the plant embryo begins to grow. Because the seed contains an embryo and stored food, a new plant can develop more rapidly from a seed than from a spore.

Reading Check ***What are the three parts of a seed?***

Gymnosperms (JIHM nuh spurmz) and angiosperms are seed plants. One difference between the two groups is the way seeds develop. In gymnosperms, seeds usually develop in cones—in angiosperms, seeds develop in flowers and fruit.

Gymnosperm Reproduction

If you have collected cones of pines or spruces or used them in a craft project, you probably noticed that many shapes and sizes of cones exist. You probably also noticed that some cones contain seeds. Cones are the reproductive structures of gymnosperms. Each gymnosperm species has a different cone.

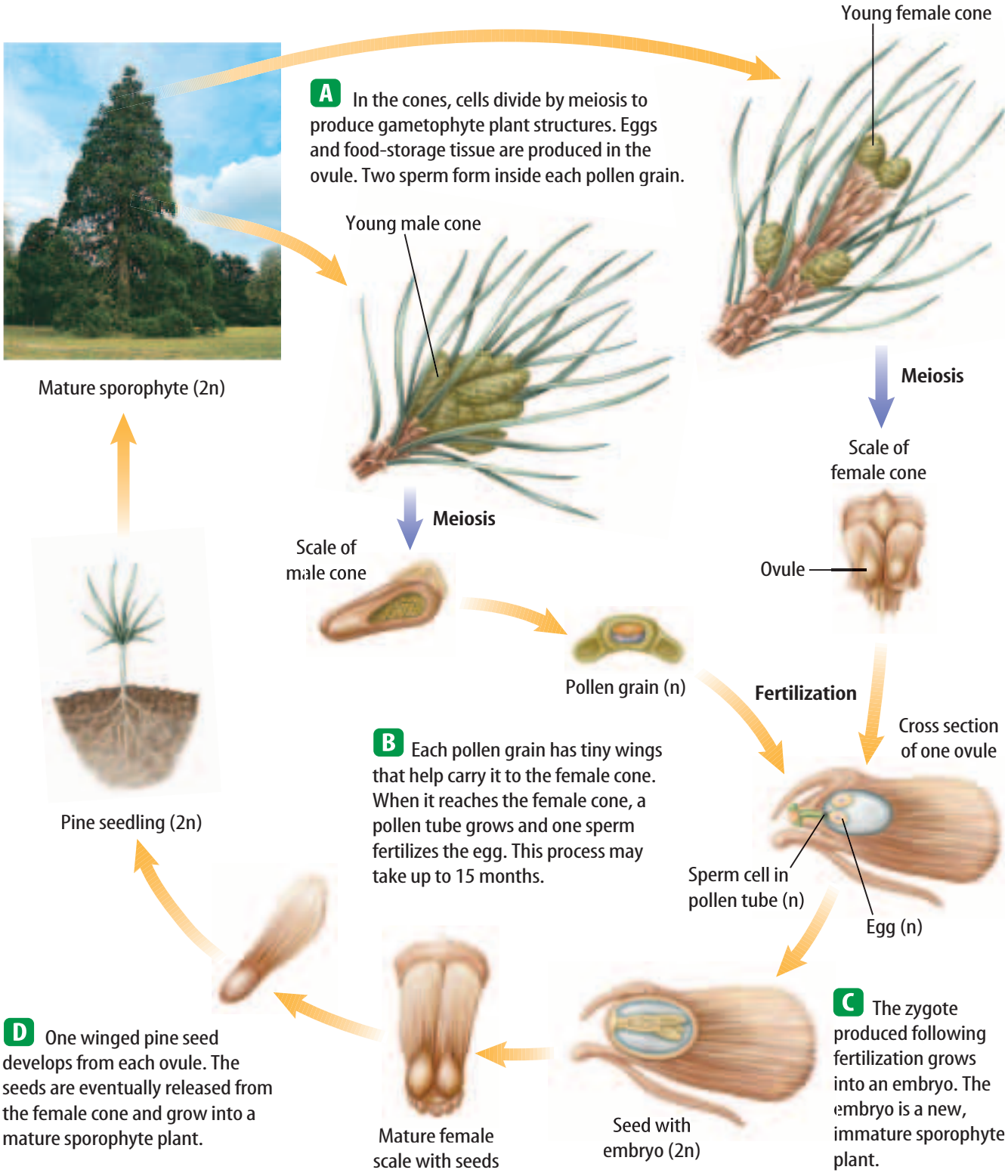
Gymnosperm plants include pines, firs, spruces, cedars, cycads, and ginkgoes. The pine is a familiar gymnosperm. Production of seeds in pines is typical of most gymnosperms.

Cones A pine tree is a sporophyte plant that produces male cones and female cones as shown in **Figure 11.** Male and female gametophyte structures are produced in the cones but you'd need a magnifying lens to see these structures clearly.

Dr. WM. H. Harlow/Photo Researchers

A mature female cone consists of a spiral of woody scales on a short stem. At the base of each scale are two ovules. The egg is produced in the **ovule.** Pollen grains are produced in the smaller male cones. In the spring, clouds of pollen are released from the male cones. Anything near pine trees might be covered with the yellow, dustlike pollen.

Figure 11 Seed formation in pines, as in most gymnosperms, involves male and female cones.



Christian Grzimek/OKAPIA/Photo Researchers

Figure 12 Seed development can take more than one year in pines. The female cone looks different at various stages of the seed-production process.

Cone at pollination | Cone at the end of the first year | Mature, second-year cone

Gymnosperm Seeds Pollen is carried from male cones to female cones by the wind. However, most of the pollen falls on other plants, the ground, and bodies of water. To be useful, the pollen has to be blown between the scales of a female cone. There it can be trapped in the sticky fluid secreted by the ovule. If the pollen grain and the female cone are the same species, fertilization and the formation of a seed can take place.

If you are near a pine tree when the female cones release their seeds, you might hear a crackling noise as the cones' scales open. It can take a long time for seeds to be released from a female pine cone. From the moment a pollen grain falls on the female cone until the seeds are released, can take two or three years, as shown in **Figure 12.** In the right environment, each seed can grow into a new pine sporophyte.

INTEGRATE Environment

Seed Germination Some gymnosperm seeds will not germinate until the heat of a fire causes the cones to open and release the seeds. Without fires, these plants cannot reproduce. In your Science Journal, explain why some forest fires could be good for the environment.

Angiosperm Reproduction

You might not know it, but you are already familiar with angiosperms. If you had cereal for breakfast or bread in a sandwich for lunch, you ate parts of angiosperms. Flowers that you send or receive for special occasions are from angiosperms. Most of the seed plants on Earth today are angiosperms.

All angiosperms have flowers. The sporophyte plant produces the flowers. Flowers are important because they are reproductive organs. Flowers contain gametophyte structures that produce sperm or eggs for sexual reproduction.

(l)Stephen P. Parker/Photo Researchers, (c)M. J. Griffith/Photo Researchers, (r)Dan Suzio/Photo Researchers

The Flower When you think of a flower, you probably imagine something with a pleasant aroma and colorful petals. Although many such flowers do exist, some flowers are drab and have no aroma, like the flowers of the maple tree shown in **Figure 13.** Why do you think such variety among flowers exists?

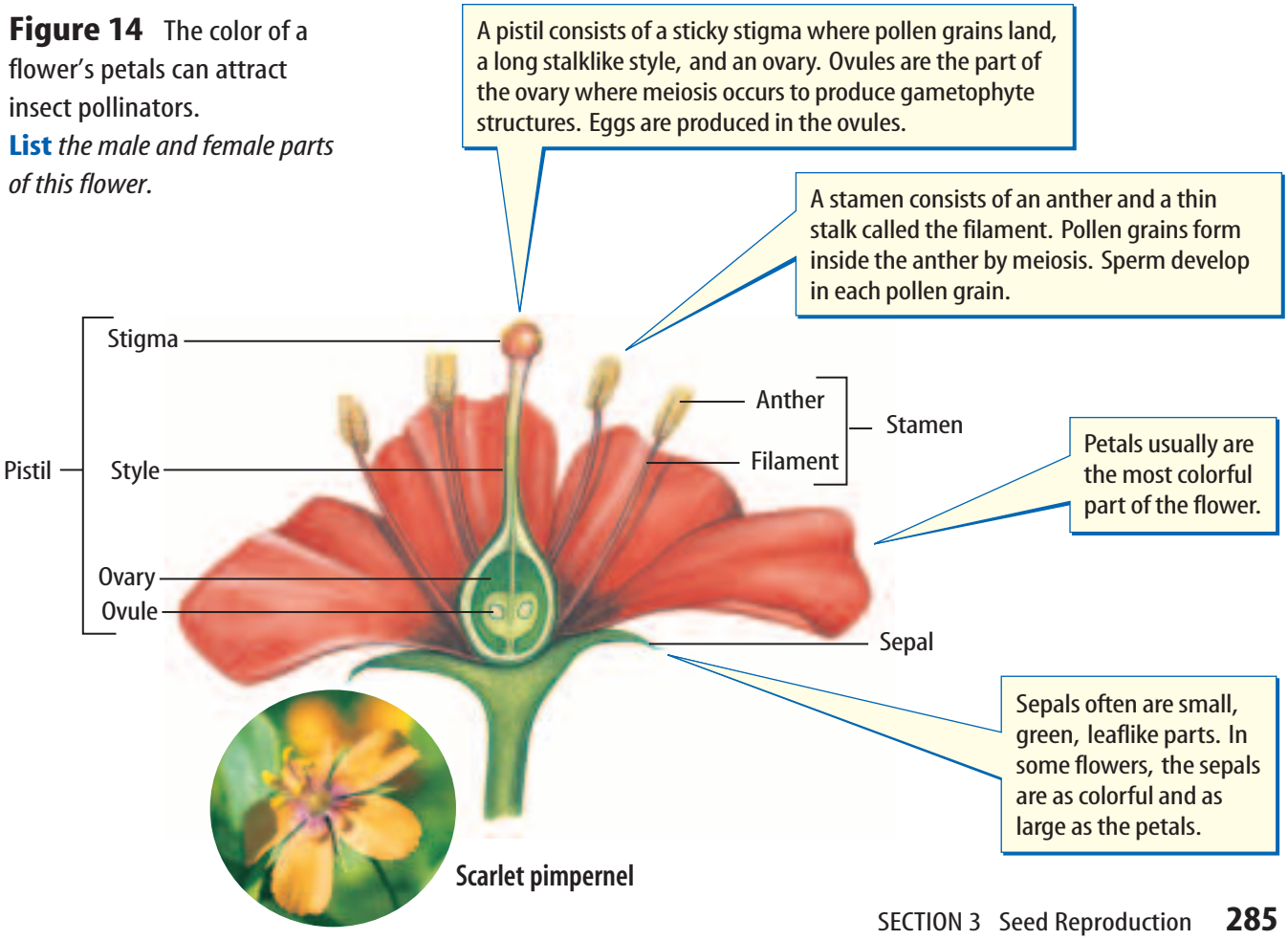
Most flowers have four main parts—petals, sepals, stamen, and pistil—as shown in **Figure 14.** Generally, the colorful parts of a flower are the petals. Outside the petals are usually leaflike parts called sepals. Sepals form the outside of the flower bud. Sometimes petals and sepals are the same color.

Inside the flower are the reproductive organs of the plant. The **stamen** is the male reproductive organ. Pollen is produced in the stamen. The **pistil** is the female reproductive organ. The **ovary** is the swollen base of the pistil where ovules are found. Not all flowers have every one of the four parts. Remember the holly plants you learned about at the beginning of the chapter? What flower part would be missing on a flower from a male holly plant?

Figure 13 Maple trees produce clusters of flowers early in the spring.
Describe *how these flowers are different from those of the crocus shown in* ***Figure 1.***

Reading Check ***Where are ovules found in the flower?***

Figure 14 The color of a flower's petals can attract insect pollinators.
List *the male and female parts of this flower.*



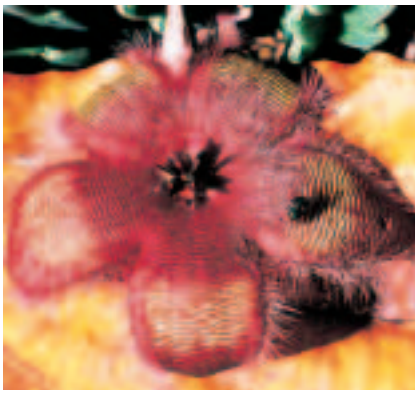
(tl)Gustav Verderber/Visuals Unlimited, (tr)Rob Simpson/Visuals Unlimited, (b)Alvin E. Staffan/Photo Researchers

Figure 15 Looking at flowers will give you a clue about how each one is pollinated.

Honeybees are important pollinators. They are attracted to brightly colored flowers, especially blue and yellow flowers.

Flowers that are pollinated at night, like this cactus flower being pollinated by a bat, are usually white.

Flowers that are pollinated by hummingbirds usually are brightly colored, especially bright red and yellow.



Flowers that are pollinated by flies usually are dull red or brown. They often have a strong odor like rotten meat.

The flower of this wheat plant does not have a strong odor and is not brightly colored. Wind, not an animal, is the pollinator of wheat and most other grasses.

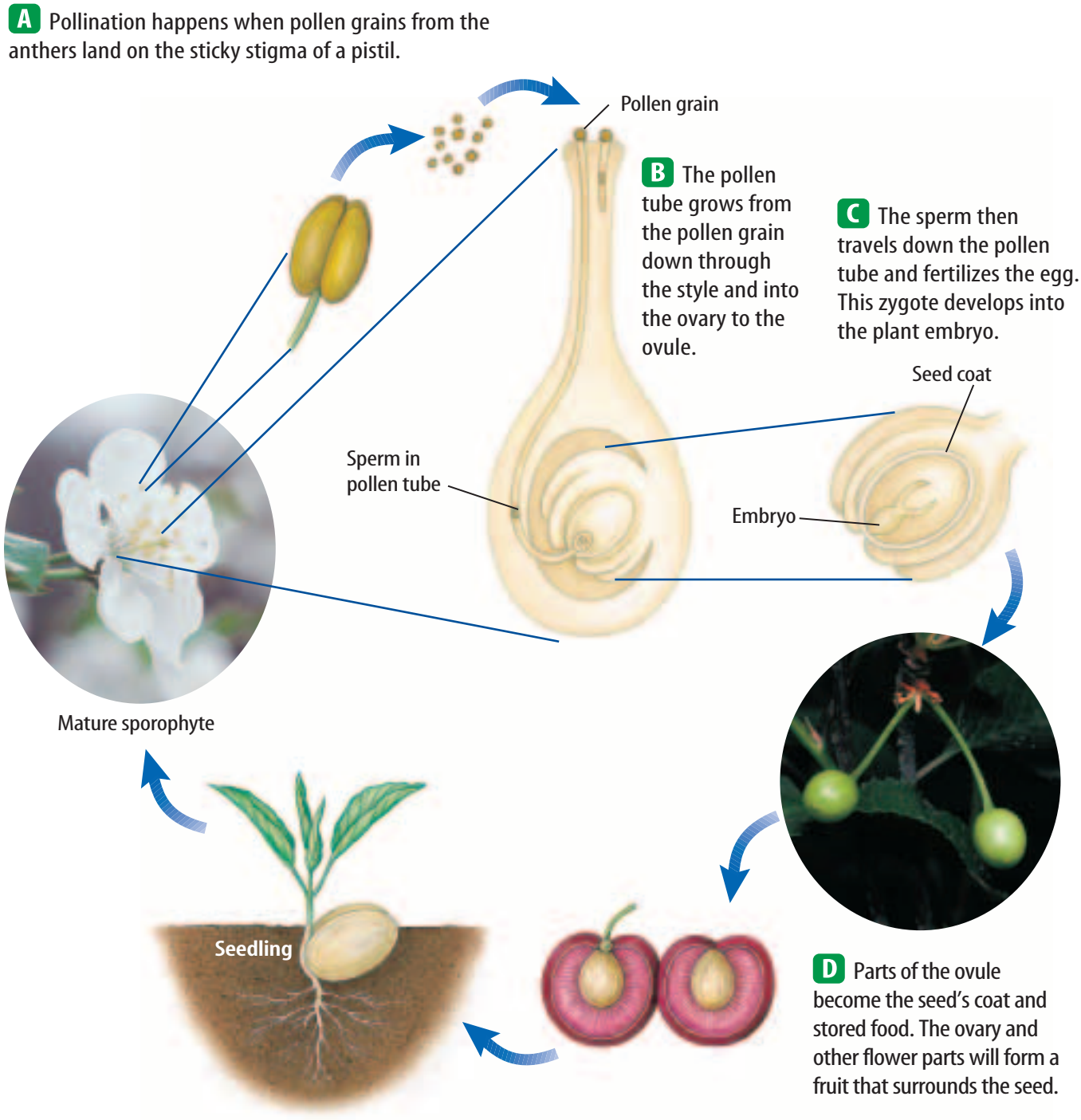
(tl)C. Nuridsany & M. Perennou/Science Photo Library/Photo Researchers, (tr)Merlin D. Tuttle/Photo Researchers, (bl)Anthony Mercreca Photo/Photo Researchers, (bc)Kjell B. Sandved/Photo Researchers, (br)Holt Studios LTD/Photo Researchers

Importance of Flowers The appearance of a plant's flowers can tell you something about the life of the plant. Large flowers with brightly colored petals often attract insects and other animals, as shown in **Figure 15.** These animals might eat the flower, its nectar, or pollen. As they move about the flower, the animals get pollen on their wings, legs, or other body parts. Later, these animals spread the flower's pollen to other plants that they visit. Other flowers depend on wind, rain, or gravity to spread their pollen. Their petals can be small or absent. Flowers that open only at night, such as the cactus flower in **Figure 15,** usually are white or yellow and have strong scents to attract animal pollinators. Following pollination and fertilization, the ovules of flowers can develop into seeds.

Reading Check *How do animals spread pollen?*

Angiosperm Seeds The development of angiosperm seeds is shown in **Figure 16.** Pollen grains reach the stigma in a variety of ways. Pollen is carried by wind, rain, or animals such as insects, birds, and mammals. A flower is pollinated when pollen grains land on the sticky stigma. A pollen tube grows from the pollen grain down through the style. The pollen tube enters the ovary and reaches an ovule. The sperm then travels down the pollen tube and fertilizes the egg in the ovule. A zygote forms and grows into the plant embryo.

Figure 16 In angiosperms, seed formation begins with the formation of sperm and eggs in the male and female flower parts.



William J. Weber/Visuals Unlimited

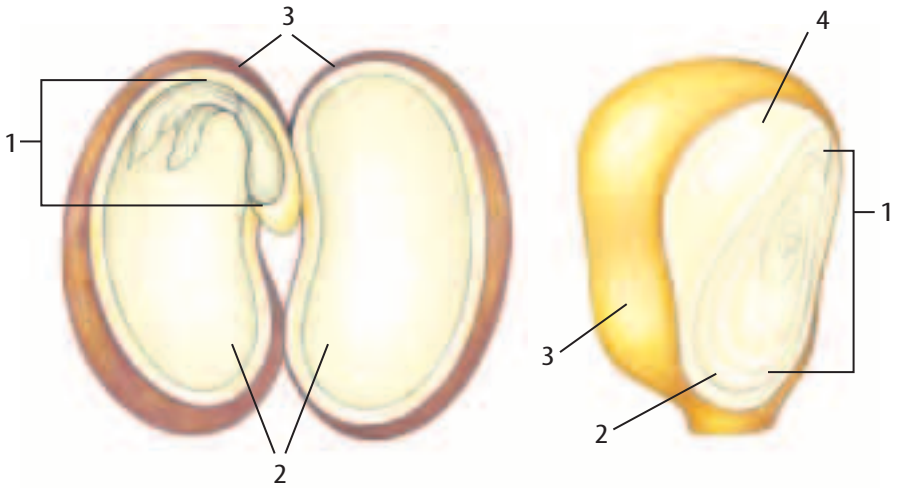


Figure 17 Seeds of land plants are capable of surviving unfavorable environmental conditions.
1. Immature plant
2. Cotyledon(s)
3. Seed coat
4. Endosperm

Seed Development Parts of the ovule develop into the stored food and the seed coat that surround the embryo, and a seed is formed, as shown in **Figure 17.** In the seeds of some plants, like beans and peanuts, the food is stored in structures called cotyledons. The seeds of other plants, like corn and wheat, have food stored in a tissue called endosperm.

Seed Dispersal

INTEGRATE Earth Science

Sometimes, plants just seem to appear. They probably grew from a seed, but where did the seed come from? Plants have many ways of dispersing their seeds, as shown in **Figure 18.** Most seeds grow only when they are placed on or in soil. Do you know how seeds naturally get to the soil? For many seeds, gravity is the answer. They fall onto the soil from the parent plant on which they grew. However, in nature some seeds can be spread great distances from the parent plant.

Wind dispersal usually occurs because a seed has an attached structure that moves it with air currents. Some plants have very small seeds that become airborne when released by the plant.

Reading Check *How can wind disperse seeds?*

Animals can disperse many seeds. Some seeds are eaten with fruits, pass through an animal's digestive system, and are dispersed as the animal moves from place to place. Seeds can be carried great distances and stored or buried by animals. Attaching to fur, feathers, and clothing is another way that seeds are dispersed by animals.

Water also disperses seeds. Raindrops can knock seeds out of a dry fruit. Some fruits and seeds float on flowing water or ocean currents. When you touch the seedpod of an impatiens flower, it explodes. The tiny seeds are ejected and spread some distance from the plant.

Mini LAB

Modeling Seed Dispersal

Procedure

1. Find a **button** you can use to represent a seed.
2. Examine the seeds pictured in **Figure 18** and invent a way that your button seed could be dispersed by wind, water, on the fur of an animal, or by humans.
3. Bring your button seed to class and demonstrate how it could be dispersed.

Analysis

1. Explain how your button seed was dispersed.
2. In your **Science Journal,** write a paragraph describing your model. Also describe other ways you could model seed dispersal.

Try at Home

NATIONAL GEOGRAPHIC

VISUALIZING SEED DISPERSAL

Figure 18

Plants have many adaptations for dispersing seeds, often enlisting the aid of wind, water, or animals.

▲ Equipped with tiny hooks, burrs cling tightly to fur and feathers.

▲ Pressure builds within the seed-pods of this jewelweed plant until the pod bursts, flinging seeds far and wide.

▼ Some seeds buried by animals, such as this squirrel, go uneaten and sprout the next spring.

▼ Dandelion seeds are easily dislodged and sail away on a puff of wind.

▲ Encased in a thick, buoyant husk, a coconut may be carried hundreds of kilometers by ocean currents.

▶ Blackberry seeds eaten by this white-footed mouse will pass through its digestive tract and be deposited in a new location.

(tl)Kevin Shafer/CORBIS, (bcl)Tom & Pat Leeson, (bcr)Darryl Torckler/Stone/Getty Images, (others)Dwight Kuhn

Germination A series of events that results in the growth of a plant from a seed is called **germination.** When dispersed from the plant, some seeds germinate in just a few days and other seeds take weeks or months to grow. Some seeds can stay in a resting stage for hundreds of years. In 1982, seeds of the East Indian lotus sprouted after 466 years.

Seeds will not germinate until environmental conditions are right. Temperature, the presence or absence of light, availability of water, and amount of oxygen present can affect germination. Sometimes the seed must pass through an animal's digestive system before it will germinate. Germination begins when seed tissues absorb water. This causes the seed to swell and the seed coat to break open.

Applying Math — Calculate Using Percents

HOW MANY SEEDS WILL GERMINATE? The label on a packet of carrot seeds says that it contains about 200 seeds. It also claims that 95 percent of the seeds will germinate. How many seeds should germinate if the packet is correct?

Solution

1 *This is what you know:*

- quantity = 200
- percentage = 95

2 *This is what you need to find out:*

What is 95 percent of 200?

3 *This is the procedure you need to use:*

- Set up the equation for finding percentage: $\frac{95}{100} = \frac{x}{200}$
- Solve the equation for x: $x = \frac{95 \times 200}{100}$

4 *Check your answer:*

Divide by 200 then multiply by 100. You should get the original percentage of 95.

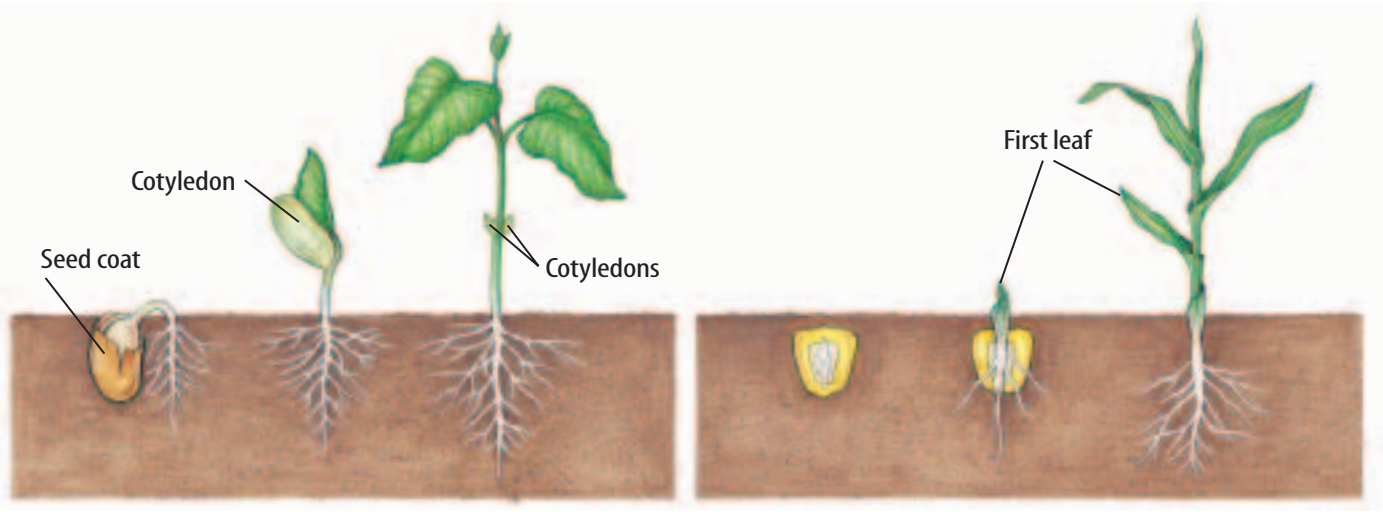
Practice Problems

1. The label on a packet of 50 corn kernels claims that 98 percent will germinate. How many kernels will germinate if the packet is correct?
2. A seed catalog states that a packet contains 1,120 spinach seeds with a germination rate of 65 percent. How many spinach plants should the packet produce?

ScienceOnline — For more practice, visit life.msscience.com/math_practice

Doug Martin

Figure 19 Seed germination results in a new plant.



In beans, the cotyledons rise above the soil. As the stored food is used, the cotyledons shrivel and fall off.

In corn, the stored food in the endosperm remains in the soil and is gradually used as the plant grows.

Next, a series of chemical reactions occurs that releases energy from the stored food in the cotyledons or endosperm for growth. Eventually, a root grows from the seed, followed by a stem and leaves as shown in **Figure 19.** After the plant emerges from the soil, photosynthesis can begin. Photosynthesis provides food as the plant continues to grow.

section 3 review

Summary

The Importance of Pollen and Seeds

- In seed plants, spores develop into pollen grains.
- Pollination is the transfer of pollen from a male plant part to a female plant part.

Gymnosperm Reproduction

- Cones are reproductive structures of gymnosperms.
- Seeds are produced in female cones.

Angiosperm Reproduction

- Flowers are reproductive structures of angiosperms.
- Female flower parts develop into seeds.

Seed Dispersal

- Seeds can be dispersed in several ways.
- Germination is the growth of a plant from a seed.

Self Check

1. **Compare and contrast** the life cycles of gymnosperms and angiosperms.
2. **Draw and label** a diagram showing all four parts of a flower.
3. **Describe** the three parts of a seed and their functions.
4. **Explain** the process of germination.
5. **Think Critically** Walnut trees produce edible seeds with a hard outer covering. Maple trees produce seeds with winglike edges. What type of seed dispersal applies to each type of tree?

Applying Skills

6. **Research information** to find out what conditions are needed for seed germination of three plants, such as corn, peas, and beans. How long does each type of seed take to germinate?

LAB

Design Your Own

Germination Rate of Seeds

Goals

- **Design** an experiment to test the effect of an environmental factor on seed germination rate.
- **Compare** germination rates under different conditions.

Possible Materials

seeds
water
salt
potting soil
plant trays or plastic cups
**seedling warming cables*
thermometer
graduated cylinder
beakers
**Alternate materials*

Safety Precautions

WARNING: *Some kinds of seeds are poisonous. Do not place any seeds in your mouth. Be careful when using any electrical equipment to avoid shock hazards.*

Real-World Question

Many environmental factors affect the germination rate of seeds. Among these are soil temperature, air temperature, moisture content of soil, and salt content of soil. What happens to the germination rate when one of these variables is changed? How do environmental factors affect seed germination? Can you determine a way to predict the best conditions for seed germination?

Form a Hypothesis

Based on your knowledge of seed germination, state a hypothesis to explain how environmental factors affect germination rates.

Doug Martin

Matt Meadows

Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write your hypothesis and decide how you will test it. Identify which results will confirm the hypothesis.
2. **List** the steps you need to take to test your hypothesis. Be specific, and describe exactly what you will do at each step. List your materials.
3. **Prepare** a data table in your Science Journal to record your observations.
4. Reread your entire experiment to make sure that all of the steps are in a logical order.
5. **Identify** all constants, variables, and controls of the experiment.

Follow Your Plan

1. Make sure your teacher approves your plan and your data table before you proceed.
2. Use the same type and amount of soil in each tray.
3. While the experiment is going on, record your observations accurately and complete the data table in your Science Journal.

Analyze Your Data

1. **Compare** the germination rate in the two groups of seeds.
2. **Compare** your results with those of other groups.
3. Did changing the variable affect germination rates? Explain.
4. Make a bar graph of your experimental results.

Conclude and Apply

1. **Interpret** your graph to estimate the conditions that give the best germination rate.
2. **Describe** the conditions that affect germination rate.

Communicating Your Data

Write a short article for a local newspaper telling about this experiment. Give some ideas about when and how to plant seeds in the garden and the conditions needed for germination.

TIME SCIENCE AND Society

SCIENCE ISSUES THAT AFFECT YOU!

Genetic Engineering

Genetically modified "super" corn can resist heat, cold, drought, and insects.

What would happen if you crossed a cactus with a rose? Well, you'd either get an extra spiky flower, or a bush that didn't need to be watered very often. Until recently, this sort of mix was the stuff science fiction was made of. But now, with the help of genetic engineering, it may be possible.

Genetic engineering is a way of taking genes—sections of DNA that produce certain traits, like the color of a flower or the shape of a nose—from one species and giving them to another.

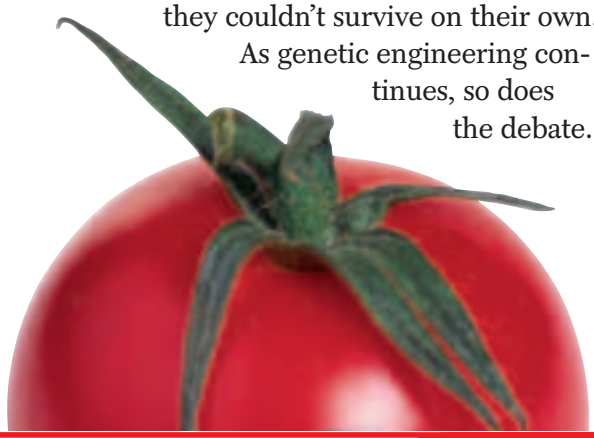
In 1983, the first plant was genetically modified, or changed. Since then, many crops in the U.S. have been modified in this way, including soybeans, potatoes, tomatoes, and corn.

One purpose of genetic engineering is to transfer an organism's traits. For example, scientists have changed lawn grass by adding to it the gene from another grass species. This gene makes lawn grass grow slowly, so it doesn't have to be mowed very often. Genetic engineering can also make plants that grow bigger and faster, repel insects, or resist herbicides. These changes could allow farmers to produce more crops with fewer chemicals. Scientists predict that genetic engineering soon will produce crops that are more nutritious and that can resist cold, heat, or even drought.

Genetic engineering is a relatively new process, and some people are worried about the long-term risks. One concern is that people might be allergic to modified foods and not realize it until it's too late. Other people say that genetic engineering is unnatural. Also, farmers must purchase the patented genetically modified seeds each growing season from the companies that make them, rather than saving and replanting the seeds from their current crops.

People in favor of genetic engineering reply that there are always risks with new technology, but proper precautions are being taken. Each new plant is tested and then approved by U.S. governmental agencies. And they say that most "natural" crops aren't really natural. They are really hybrid plants bred by agriculturists, and they couldn't survive on their own.

As genetic engineering continues, so does the debate.



Debate **Research the pros and cons of genetic engineering at the link shown to the right. Decide whether you are for or against genetic engineering. Debate your decision with a classmate.**

ScienceOnline

For more information, visit life.msscience.com/time

(t)Kevin Laubacher/FPG, (b)Michael Black/Bruce Coleman, Inc.

Reviewing Main Ideas

Section 1 Introduction to Plant Reproduction

1. Plants reproduce sexually and asexually. Sexual reproduction involves the formation of sex cells and fertilization.
2. Asexual reproduction does not involve sex cells and produces plants genetically identical to the parent plant.
3. Plant life cycles include a gametophyte and a sporophyte stage. The gametophyte stage begins with meiosis. The sporophyte stage begins when the egg is fertilized by a sperm.
4. In some plant life cycles, the sporophyte and gametophyte stages are separate and not dependent on each other. In other plant life cycles, they are part of the same organism.

Section 2 Seedless Reproduction

1. For liverworts and mosses, the gametophyte stage is the familiar plant form. The sporophyte stage produces spores.
2. In ferns, the sporophyte stage is the familiar plant form.
3. Seedless plants, like mosses and ferns, use sexual reproduction to produce spores.

Section 3 Seed Reproduction

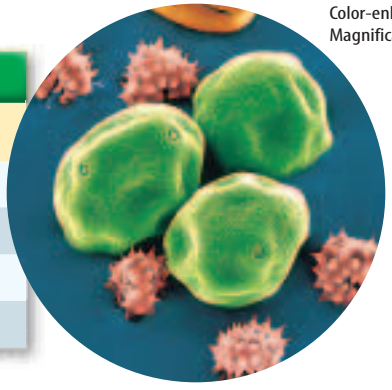
1. In seed plants the male reproductive organs produce pollen grains that eventually contain sperm. Eggs are produced in the ovules of the female reproductive organs.
2. The male and female reproductive organs of gymnosperms are called cones. Wind usually moves pollen from the male cone to the female cone for pollination.
3. The reproductive organs of angiosperms are in a flower. The male reproductive organ is the stamen, and the female reproductive organ is the pistil. Gravity, wind, rain, and animals can pollinate a flower.
4. Seeds of gymnosperms and angiosperms are dispersed in many ways. Wind, water, and animals spread seeds. Some plants can eject their seeds.
5. Germination is the growth of a plant from a seed.

Visualizing Main Ideas

Copy and complete the following table that compares reproduction in different plant groups.

Plant Reproduction

Plant Group	Seeds?	Pollen?	Cones?	Flowers?
Mosses				
Ferns				
Gymnosperms				
Angiosperms				



Color-enhanced SEM
Magnification: 100×

Oliver Meckes/Photo Researchers

chapter 10 Review

Using Vocabulary

frond p. 278	pollination p. 281
gametophyte stage p. 275	prothallus p. 278
germination p. 290	rhizome p. 278
ovary p. 285	sori p. 278
ovule p. 283	spore p. 275
pistil p. 285	sporophyte stage p. 275
pollen grain p. 281	stamen p. 285

Fill in the blank with the correct vocabulary word or words.

1. A(n) _____ is the leaf of a fern.

2. In seed plants, the _____ contains the egg.

3. The plant structures in the _____ are made up of haploid cells.

4. The green, leafy moss plant is part of the _____ in the moss life cycle.

5. Two parts of a sporophyte fern are a frond and _____.

6. The female reproductive organ of the flower is the _____.

7. The _____ is the swollen base of the pistil.

Checking Concepts

Choose the word or phrase that best answers the question.

8. How are colorful flowers usually pollinated?
A) insects **C)** clothing
B) wind **D)** gravity

9. What type of reproduction produces plants that are genetically identical?
A) asexual **C)** spore
B) sexual **D)** flower

10. Which of the following terms describes the cells in the gametophyte stage?
A) haploid **C)** diploid
B) prokaryote **D)** missing a nucleus

11. What structures do ferns form when they reproduce sexually?
A) spores **C)** seeds
B) anthers **D)** flowers

12. What contains food for the plant embryo?
A) endosperm **C)** stigma
B) pollen grain **D)** root

Use the photo below to answer question 13.

13. What disperses the seeds shown above?
A) rain **C)** wind
B) animals **D)** insects

14. What is the series of events that results in a plant growing from a seed?
A) pollination **C)** germination
B) prothallus **D)** fertilization

15. In seedless plants, meiosis produces what kind of plant structure?
A) prothallus **C)** flowers
B) seeds **D)** spores

16. Ovules and pollen grains take part in what process?
A) germination
B) asexual reproduction
C) seed dispersal
D) sexual reproduction

17. What part of the flower receives the pollen grain from the anther?
A) sepal **C)** stamen
B) petal **D)** stigma

Ed Reschke/Peter Arnold, Inc.

Thinking Critically

18. Explain why male cones produce so many pollen grains.

19. Predict whether a seed without an embryo could germinate. Explain your answer.

20. Discuss the importance of water in the sexual reproduction of nonvascular plants and ferns.

21. Infer why the sporophyte stage in mosses is dependent on the gametophyte stage.

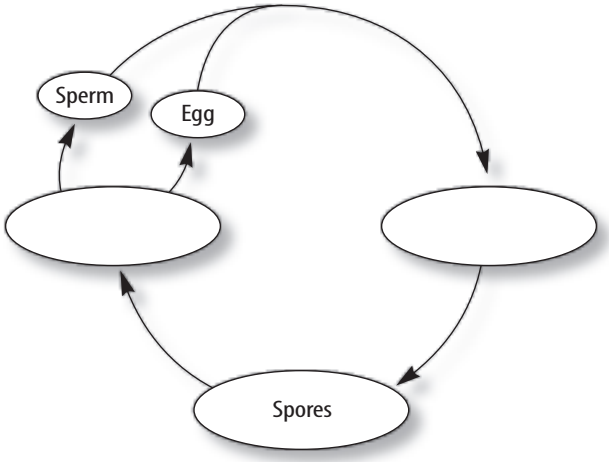
22. List the features of flowers that ensure pollination.

23. Compare and contrast the fern sporophyte and gametophyte stages.

24. Interpret Scientific Illustrations Using **Figure 16,** sequence these events.

- pollen is trapped on the stigma
- pollen tube reaches the ovule
- fertilization
- pollen released from the anther
- pollen tube forms through the style
- a seed forms

25. Concept Map Copy and complete this concept map of a typical plant life cycle.



26. Predict Observe pictures of flowers or actual flowers and predict how they are pollinated. Explain your prediction.

Performance Activities

27. Display Collect several different types of seeds and use them to make a mosaic picture of a flower.

28. Technical Writing Write a newspaper story to tell people about the importance of gravity, water, wind, insects, and other animals in plant life cycles.

Applying Math

29. Germination Rates A seed producer tests a new batch of corn seeds before putting them on the market. The producer plants a sample of 150 seeds, and 110 of the seeds germinate. What is the germination rate for this batch of corn seeds?

30. Seed Production Each blossom on an apple tree, if fertilized, can become a fruit. Suppose an apple tree bears 1,200 blossoms in the spring. If 95 percent are pollinated, how many apples could the tree produce? If each apple contains five seeds, how many seeds would the tree produce?

Use the table below to answer question 31.

Onion Seed Data

Temperature (C)	10	15	20	25	30	35
Days to germinate	13	7	5	4	4	13

31. Onion Seeds Make a bar graph for the following data table about onion seeds. Put days on the horizontal axis and temperature on the vertical axis.

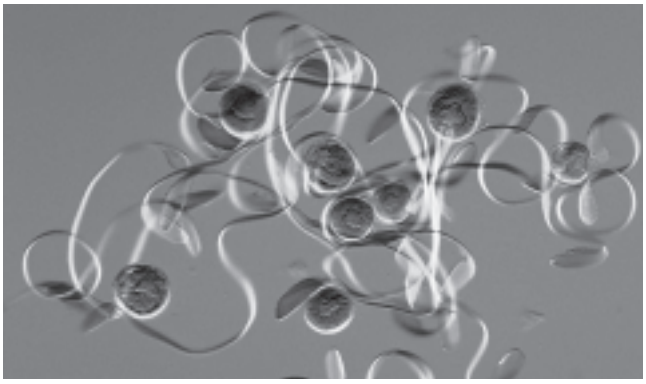
Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Which statement applies to asexual reproduction?
- **A.** Sperm and egg are required.
- **B.** Offspring are genetically different from the parents.
- **C.** Most animals reproduce in this way.
- **D.** Offspring are genetically identical to the parent.

2. Which term describes the uniting of a sperm and egg to form a zygote?
- **A.** fertilization
- **B.** meiosis
- **C.** pollination
- **D.** germination

Use the picture below to answer questions 3 and 4.



3. What is the primary method by which these horsetail spores are dispersed?
- **A.** water
- **B.** insects
- **C.** wind
- **D.** grazing animals

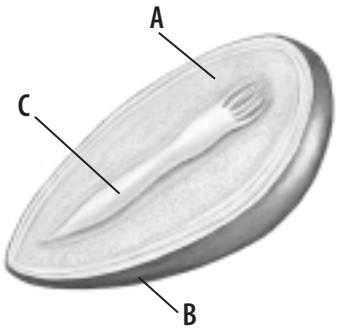
Test-Taking Tip

Come Back To It Never skip a question. If you are unsure of an answer, mark your best guess on another sheet of paper and mark the question in your test booklet to remind you to come back to it at the end of the test.

4. The horsetail plant that produced these spores uses tubelike cells to transport water and other substances from one part of the plant to another. What type of plant is a horsetail?
- **A.** vascular
- **B.** seed
- **C.** nonvascular
- **D.** pollinated

5. Which of the following is a characteristic of angiosperms?
- **A.** production of cones
- **B.** seeds not protected by fruit
- **C.** growth from a rhizome
- **D.** production of flowers

Use the illustration below to answer questions 6 and 7.



6. Structure B represents which part of this seed?
- **A.** stored food
- **B.** embryo
- **C.** seed coat
- **D.** ovary

7. Which part(s) of this seed will grow into stems, roots, and leaves?
- **A.** A
- **B.** B
- **C.** C
- **D.** A and B

8. What causes seed germination to begin?
- **A.** warm temperature
- **B.** exposure to water
- **C.** at least 9 hours of daylight in a 24-hour period
- **D.** soil rich in organic material

Andrew Syred/Science Photo Library/Photo Researchers

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

9. Sperm and eggs are found in different parts of plants. Explain why it is important for these cells to unite, and describe some factors in an environment that help unite them.

10. Make a sketch of a fern plant. Label the fronds, rhizome, roots, and sori.

Use the illustration below to answer questions 11 and 12.

11. What type of seed plant produces the structure shown here? Describe how it is involved in the reproduction of this plant.

12. Why are the scales open?

13. Describe the importance of flowers in angiosperms. What factors can differ from one flower to another?

14. Explain the role played by animals that eat fruits in the dispersal and germination of seeds.

15. Describe the characteristics of certain plants, such as grasses, that enable them to be distributed widely in an environment.

Part 3 Open Ended

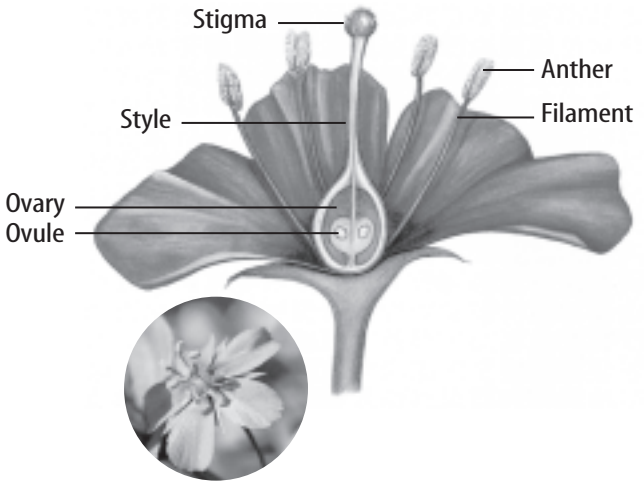
Record your answers on a sheet of paper.

16. You have a holly plant in your yard which, despite having ample water, sunlight, and fertilizer, has never produced berries. The flowers produced by this plant have only female structures. What could you do to help this plant produce berries?

17. Why is it important that spores produced during the gametophyte stage of a plant's life cycle be haploid cells?

18. Describe some of the factors that have contributed to the success of seed plants.

Use the illustration below to answer questions 19 and 20.



19. Describe the role of each structure labeled in this picture in the production of eggs or sperm.

20. Describe the process of pollination of this plant by insects.

21. Explain how a flower's appearance can indicate its method of pollination. Give three examples of flowers and the method of pollination for each.

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