Chapter 20

# The Endocrine System and Reproduction

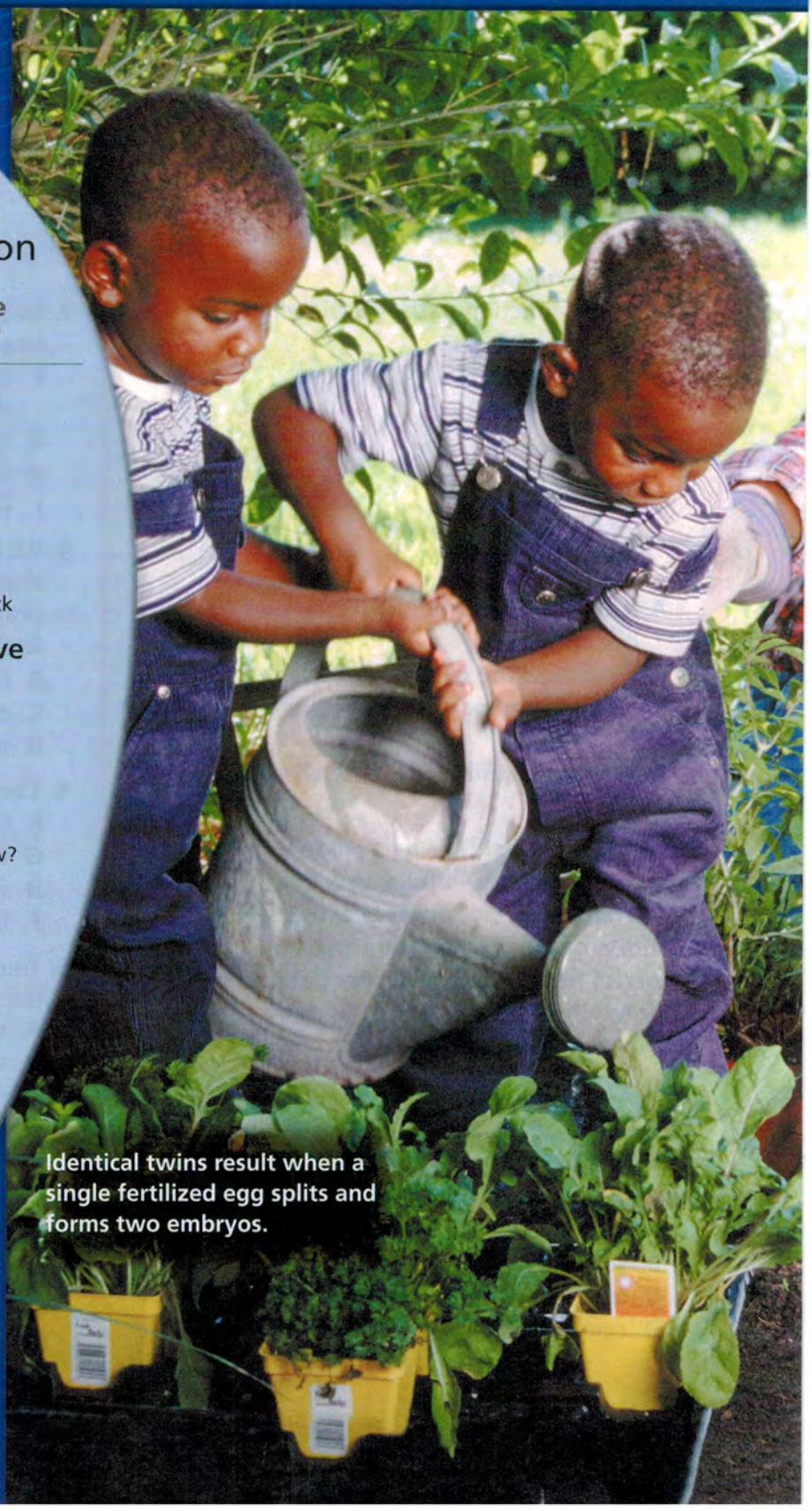
## The BIG Idea

Regulation and Reproduction

**What role does the endocrine system play in reproduction?**

### Chapter Preview



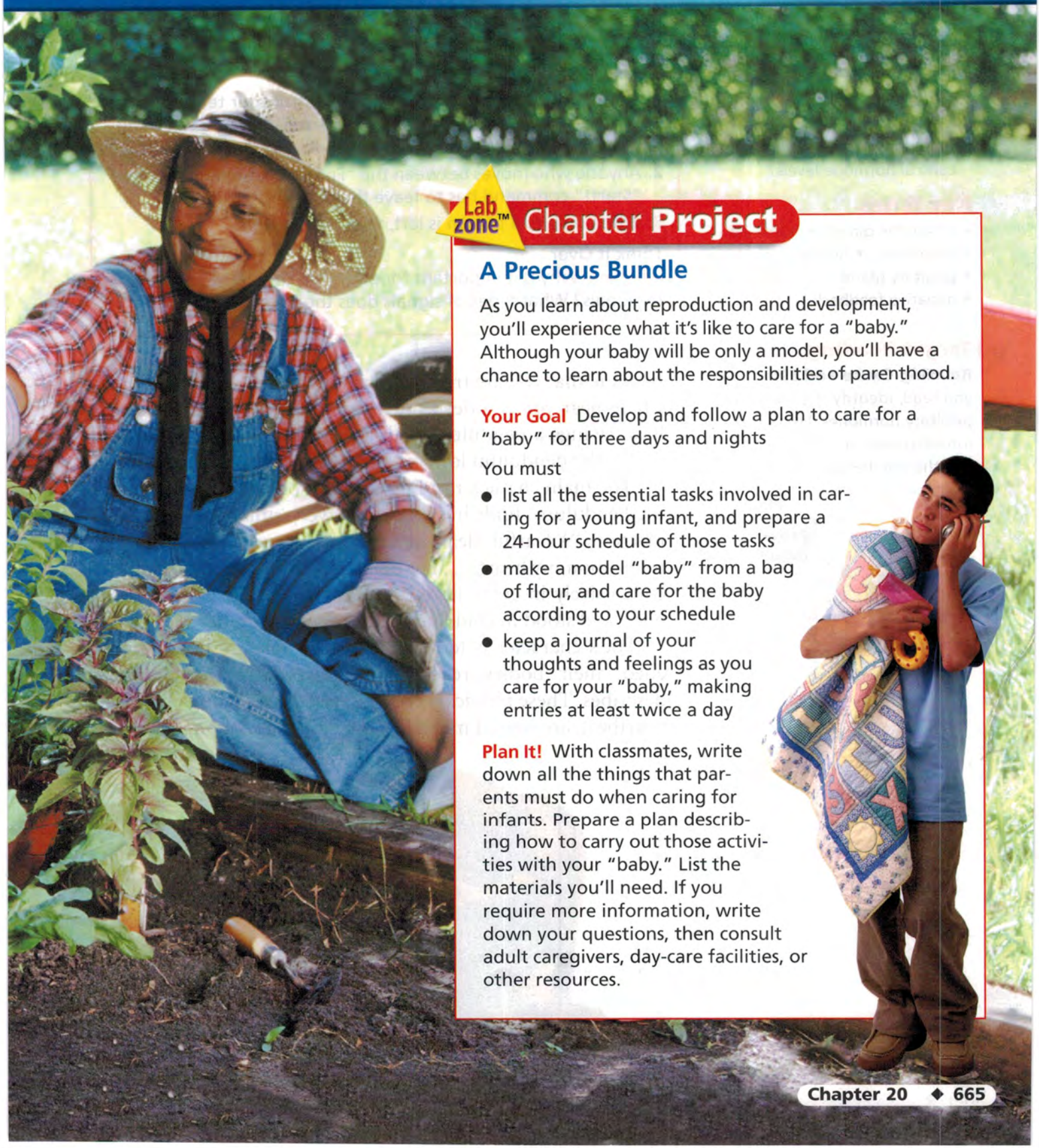


Identical twins result when a single fertilized egg splits and forms two embryos.

Discovery CHANNEL SCHOOL

*The Endocrine System and Reproduction*

- ▶ Video Preview
- Video Field Trip
- Video Assessment



Lab zone™ **Chapter Project**

## A Precious Bundle

As you learn about reproduction and development, you'll experience what it's like to care for a "baby." Although your baby will be only a model, you'll have a chance to learn about the responsibilities of parenthood.

**Your Goal** Develop and follow a plan to care for a "baby" for three days and nights

You must

- list all the essential tasks involved in caring for a young infant, and prepare a 24-hour schedule of those tasks
- make a model "baby" from a bag of flour, and care for the baby according to your schedule
- keep a journal of your thoughts and feelings as you care for your "baby," making entries at least twice a day

**Plan It!** With classmates, write down all the things that parents must do when caring for infants. Prepare a plan describing how to carry out those activities with your "baby." List the materials you'll need. If you require more information, write down your questions, then consult adult caregivers, day-care facilities, or other resources.

Section 1

# The Endocrine System

## Reading Preview

### Key Concepts

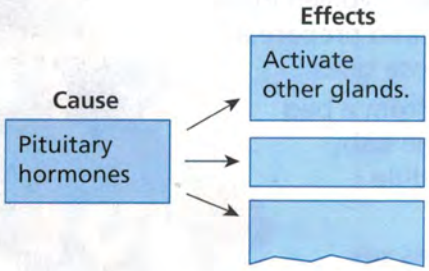
- How does the endocrine system control body processes?
- What are the endocrine glands?
- How does negative feedback control hormone levels?

### Key Terms

- endocrine gland
- hormone
- target cell
- hypothalamus
- pituitary gland
- negative feedback

### Target Reading Skill

**Relating Cause and Effect** As you read, identify the effects of pituitary hormones. Write the information in a graphic organizer like the one below.




## Lab zone Discover Activity

### What's the Signal?

1. Stand up and move around the room until your teacher says "Freeze!" Then, stop moving immediately. Stay perfectly still until your teacher says "Start!" Then, begin moving again.
2. Anyone who moves between the "Freeze!" command and the "Start!" command has to leave the game.
3. When only one person is left, that person wins.

**Think it Over**

**Inferring** Why is it important for players in this game to respond to signals? What types of signals does the human body use?

Imagine that you are trapped in a damp, dark dungeon. Somewhere near you is a deep pit with water at the bottom. Overhead swings a pendulum with a razor-sharp edge. With each swing, the pendulum lowers closer and closer to your body.

The main character in Edgar Allan Poe's story "The Pit and the Pendulum" finds himself in that very situation. Here is his reaction: "A fearful idea now suddenly drove the blood in torrents upon my heart. . . . I at once started to my feet, trembling convulsively in every fibre. . . . Perspiration burst from every pore, and stood in cold, big beads upon my forehead."

Poe's character is terrified. When people are badly frightened, their bodies react in the ways that the character describes. These physical reactions, such as sweating and rapid heartbeat, are caused mainly by the body's endocrine system.

## Hormones and the Endocrine System

The human body has two systems that regulate its activities, the nervous system and the endocrine system. The nervous system regulates most activities by sending nerve impulses throughout the body. **The endocrine system produces chemicals that control many of the body's daily activities. The endocrine system also regulates long-term changes such as growth and development.**

The endocrine system is made up of glands. A gland is an organ that produces or releases a chemical. Some glands, such as those that produce saliva and sweat, release their chemicals into tiny tubes. The tubes deliver the chemicals to a specific location within the body or to the skin's surface.

Unlike sweat glands, the glands of the endocrine system do not have delivery tubes. **Endocrine glands** (EN duh krin) produce and release their chemical products directly into the bloodstream. The blood then carries those chemicals throughout the body.

**Hormones** The chemical product of an endocrine gland is called a **hormone.** Hormones turn on, turn off, speed up, or slow down the activities of different organs and tissues. You can think of a hormone as a chemical messenger. Hormones are carried throughout the body by the blood. Therefore, hormones can regulate activities in tissues and organs that are not close to the glands that produce them.

**FIGURE 1**
**Endocrine Control**
The endocrine system controls the body's response to an exciting situation such as a roller-coaster ride. Endocrine glands also regulate the changes that occur as a baby grows.
**Applying Concepts** *What are the substances produced by endocrine glands called?*

**Hormone Production** What causes the release of hormones? Often, nerve impulses from the brain make that happen. Suppose, for example, a person sees a deadly, knife-edged pendulum. Nerve impulses travel from the person's eyes to the brain. The brain interprets the information and then sends an impulse to an endocrine gland. That gland, in turn, releases the hormone adrenaline into the bloodstream. Adrenaline immediately makes the heart rate and breathing rate increase.

**Hormone Action** In contrast to the body's response to a nerve impulse, hormones usually cause a slower, but longer-lasting, response. For example, the brain sends a signal to an endocrine gland to release adrenaline into the bloodstream. When the adrenaline reaches the heart, it makes the heart beat more rapidly. The heart continues to race until the amount of adrenaline in the blood drops to a normal level.

**Target Cells** When a hormone enters the bloodstream, it affects some organs but not others. Why? The answer lies in the hormone's chemical structure. A hormone interacts only with specific target cells. **Target cells** are cells that recognize the hormone's chemical structure. A hormone and its target cell fit together the way a key fits into a lock. Hormones will travel through the bloodstream until they find the "lock"—or particular cell type—that they fit.

Reading Checkpoint **What is a target cell?**

Lab zone Skills Activity

### Making Models

Make a model that shows a hormone and a target cell that the hormone affects. Your model should show how the structures of the hormone and target cell enable the two to fit together. Make your model from materials such as construction paper, pipe cleaners, or modeling clay. When you have finished your model, write an explanation of how it shows the relationship between a hormone and its target cell.

## Functions of Endocrine Glands

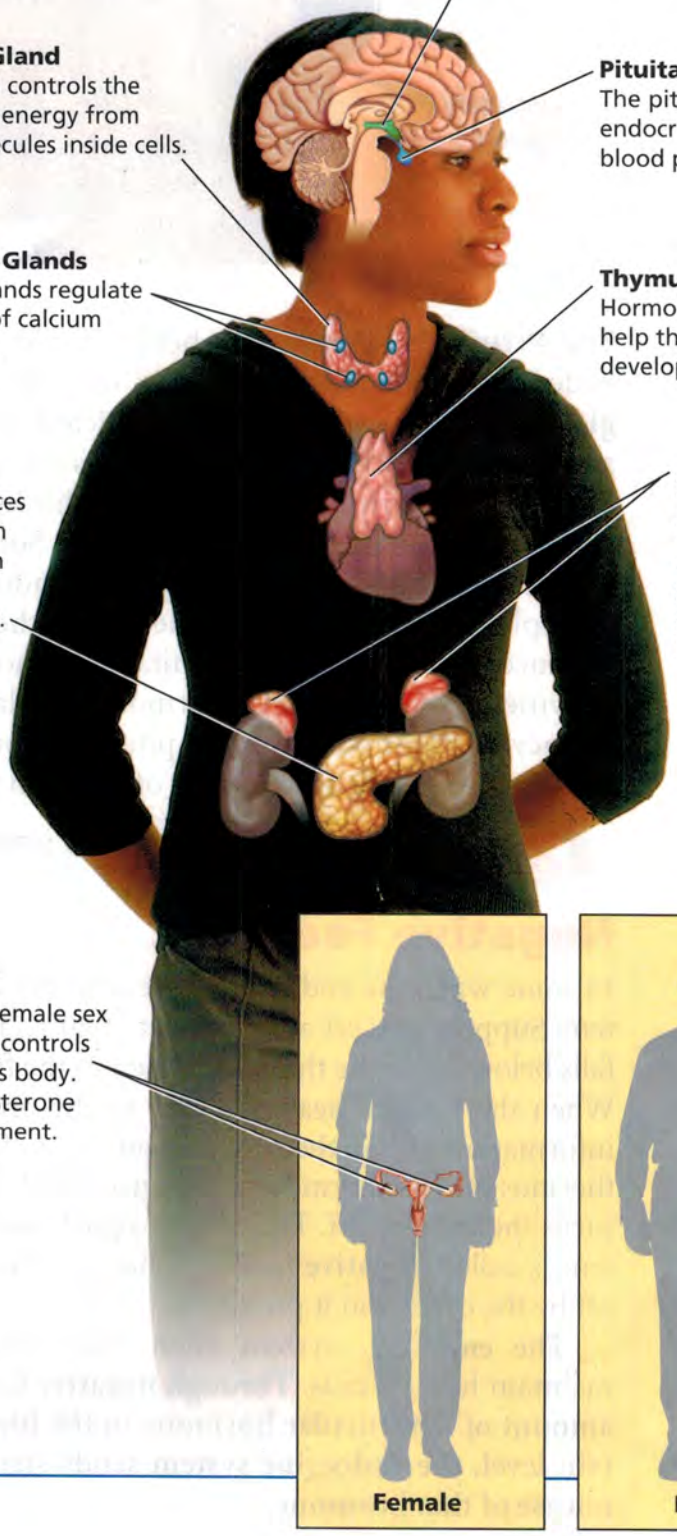
Each endocrine gland releases different hormones and thus controls different processes. **The endocrine glands include the hypothalamus, pituitary, thyroid, parathyroid, adrenal, thymus, and pancreas. They also include the ovaries in females and testes in males.** Figure 2 shows the locations of the endocrine glands and describes some activities they control.

**The Hypothalamus** The nervous system and the endocrine system work together. The **hypothalamus** (hy poh THAL uh mus), a tiny part of the brain near the middle of your head, is the link between the two systems. Nerve messages controlling sleep, hunger, and other basic body processes come from the hypothalamus. The hypothalamus also produces hormones that control other endocrine glands and organs. The hypothalamus plays a major role in maintaining homeostasis because of the nerve impulses and hormones it produces.

FIGURE 2

## Glands of the Endocrine System

Each of the endocrine glands has an important regulatory role in the body. Note the location of each gland and the functions of the hormones it produces.




**Hypothalamus**
The hypothalamus links the nervous and endocrine systems and controls the pituitary gland.

**Thyroid Gland**
This gland controls the release of energy from food molecules inside cells.

**Pituitary Gland**
The pituitary gland controls other endocrine glands and regulates growth, blood pressure, and water balance.

**Parathyroid Glands**
These tiny glands regulate the amount of calcium in the blood.

**Thymus Gland**
Hormones from this gland help the immune system develop during childhood.

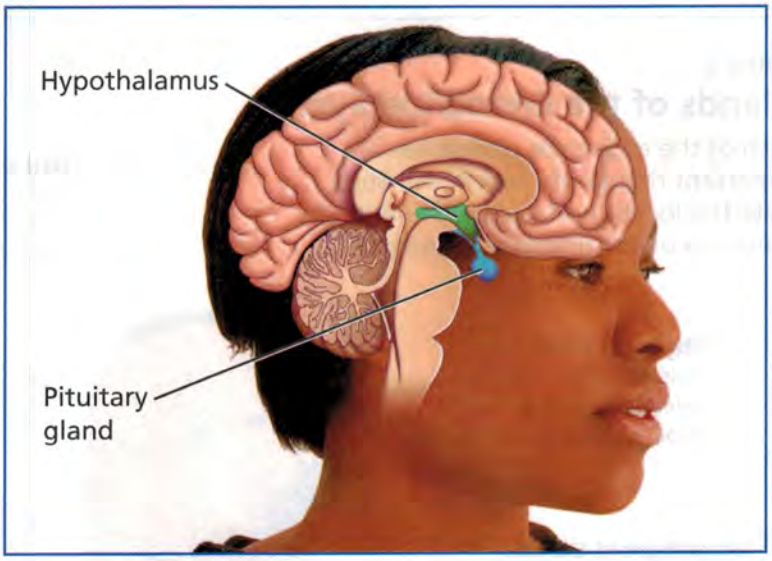
**Pancreas**
The pancreas produces the hormones insulin and glucagon, which control the level of glucose in the blood.

**Adrenal Glands**
These glands release several hormones. Adrenaline triggers the body's response to emergency situations. Other hormones affect salt and water balance in the kidneys and sugar in the blood.

**Ovaries**
The ovaries release female sex hormones. Estrogen controls changes in a female's body. Estrogen and progesterone trigger egg development.

**Testes**
The testes release the sex hormone testosterone, which controls changes in a male's body and regulates sperm production.

**FIGURE 3**
**The Pituitary Gland**
The pituitary gland is located below the hypothalamus. The pituitary controls several important body functions either directly or indirectly by signaling other endocrine glands.




**The Pituitary Gland** Just below the hypothalamus is an endocrine gland about the size of a pea. The **pituitary gland** (pih TOO ih tehr ee) communicates with the hypothalamus to control many body activities. In response to nerve impulses or hormone signals from the hypothalamus, the pituitary gland releases its hormones. Some of those hormones act as an "on" switch for other endocrine glands. For example, one pituitary hormone signals the thyroid gland to produce hormones. Other pituitary hormones control body activities directly. Growth hormone regulates growth from infancy to adulthood. Another pituitary hormone directs the kidneys to regulate the amount of water in the blood.

**Reading Checkpoint** **What causes the pituitary gland to release hormones?**

## Negative Feedback

In some ways, the endocrine system works like a heating system. Suppose you set a thermostat at 20°C. If the temperature falls below 20°C, the thermostat signals the furnace to turn on. When the furnace heats the area to the proper temperature, information about the warm conditions "feeds back" to the thermostat. The thermostat then gives the furnace a signal that turns the furnace off. The type of signal used in a heating system is called **negative feedback** because the system is turned off by the condition it produces.

The endocrine system often uses negative feedback to maintain homeostasis. **Through negative feedback, when the amount of a particular hormone in the blood reaches a certain level, the endocrine system sends signals that stop the release of that hormone.**

Lab zone

# Technology Lab

• Tech & Design •

# Modeling Negative Feedback

## Problem

How can you model negative feedback?

## Skills Focus

observing, making models, evaluating the design

## Materials

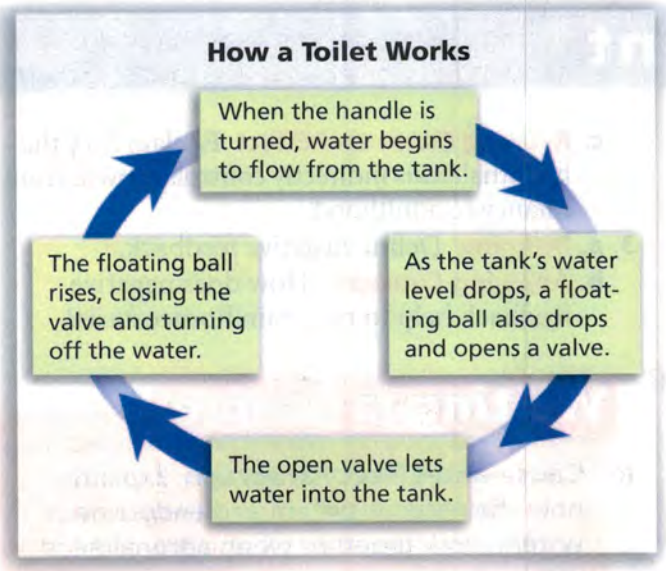
- duct tape
- round balloon
- scissors
- rubber stopper
- string, 40 cm
- large plastic soda bottle (2 L) with bottom removed
- small plastic soda bottle (1 L)
- plastic tray
- water

## Procedure

### PART 1 Research and Investigate

1. Figure 1 shows how a flush toilet uses negative feedback to regulate the water level. In your notebook, describe which part of the process involves negative feedback.

FIGURE 1



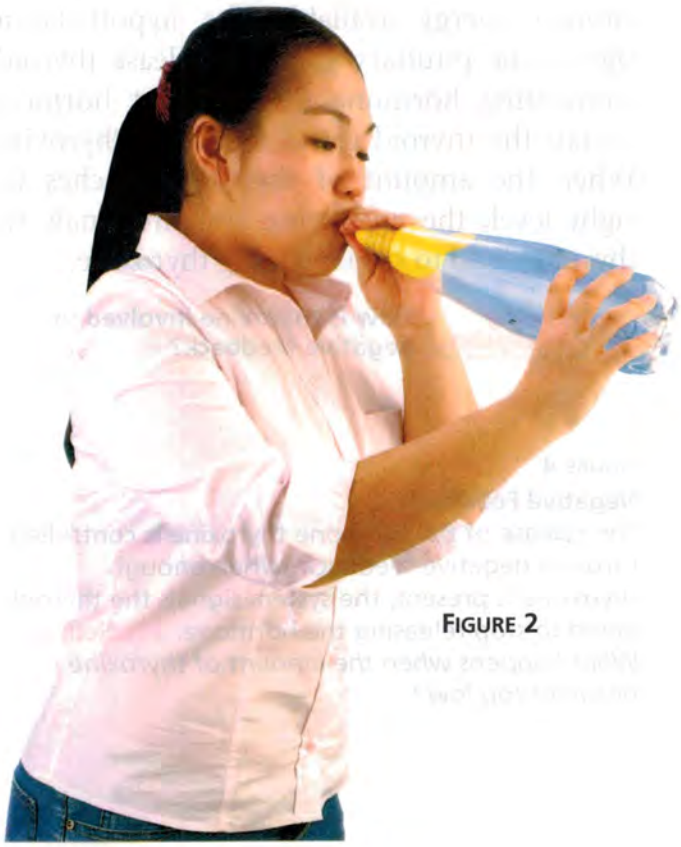



FIGURE 2

### PART 2 Design and Build

2. As you hold the open end of a balloon, push its closed end through the mouth of a small plastic bottle. Do not push the open end of the balloon into the bottle. Then, slide a straw partway into the bottle so that the air inside the bottle can escape as you blow up the balloon.
3. Partially blow up the balloon inside the bottle as shown in Figure 2. The partially inflated balloon should be about the size of a tennis ball. Remove the straw. Tie the balloon tightly, then push it into the bottle.
4. Place the large plastic bottle mouth to mouth with the small bottle. Tape the two bottles together. Make sure that the seal is waterproof.

You can see an example of negative feedback in Figure 4. Like a thermostat in a cool room, the endocrine system senses when there's not enough thyroxine in the blood. Thyroxine is a thyroid hormone that controls how much energy is available to cells. When there's not enough energy available, the hypothalamus signals the pituitary gland to release thyroid-stimulating hormone (TSH). That hormone signals the thyroid gland to release thyroxine. When the amount of thyroxine reaches the right level, the endocrine system signals the thyroid gland to stop releasing thyroxine.

**Reading Checkpoint** **How is thyroxine involved in negative feedback?**

**Go Online active art**

**For:** Negative Feedback activity
**Visit:** PHSchool.com
**Web Code:** cep-4071

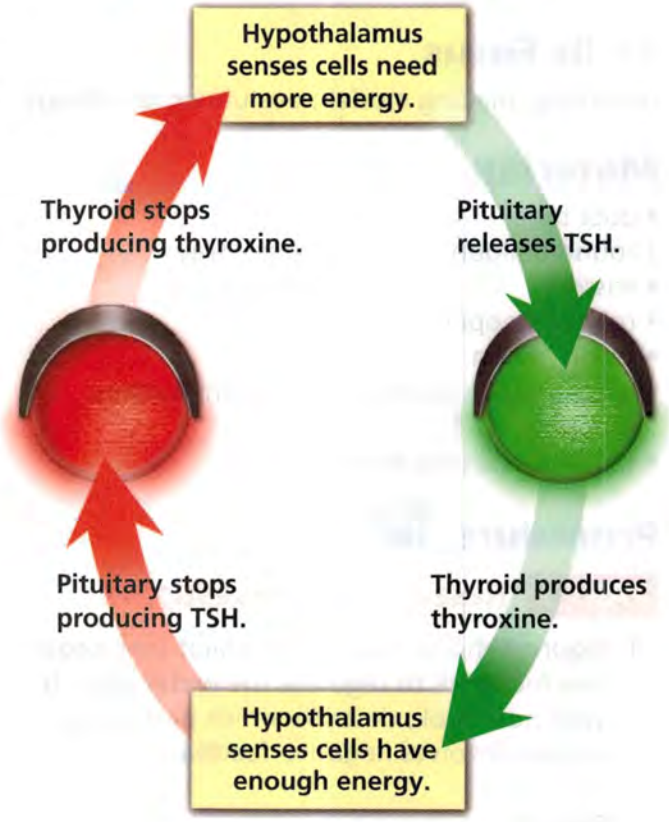



**FIGURE 4**
**Negative Feedback**
The release of the hormone thyroxine is controlled through negative feedback. When enough thyroxine is present, the system signals the thyroid gland to stop releasing the hormone. **Predicting** *What happens when the amount of thyroxine becomes too low?*

## Section 1 Assessment

### Target Reading Skill

**Relating Cause and Effect** For Question 2, refer to your graphic organizer about the pituitary gland.

### Reviewing Key Concepts

1. a. **Identifying** What is the role of the endocrine system?
   b. **Explaining** How does adrenaline affect the heart?
   c. **Predicting** What could happen if your body continued to release adrenaline into your bloodstream, and the amount of adrenaline did not return to normal?
2. a. **Listing** List the endocrine glands.
   b. **Summarizing** How do the hypothalamus and the pituitary gland interact?
   c. **Relating Cause and Effect** Explain how the hypothalamus indirectly controls growth from infancy to adulthood.
3. a. **Defining** Define negative feedback.
   b. **Applying Concepts** How does negative feedback help to maintain homeostasis?

### Writing in Science

**Cause-and-Effect Paragraph** Explain how the nervous system and endocrine system work together when adrenaline is released.

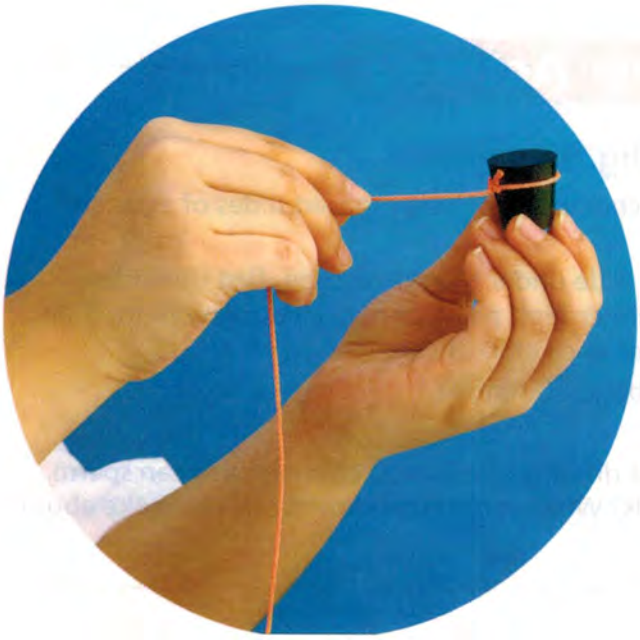


FIGURE 3

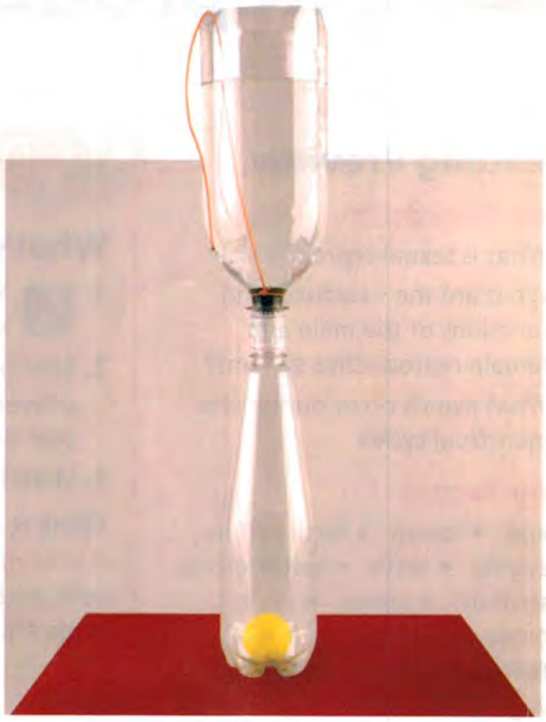


FIGURE 4

5. Tie one end of a piece of string around the top of a rubber stopper as shown in Figure 3.
6. Place the attached bottles on the tray with the smaller bottle on the bottom. Place the stopper loosely into the mouth of the larger bottle as shown in Figure 4.
7. While one partner holds the bottles upright, add water to the large bottle until it is about three fourths full. Then gently pull the string to remove the stopper. Watch what happens. Pay close attention to the following: What does the balloon do as water rises in the small bottle? Does the small bottle completely fill with water? Record your observations.
8. In your notebook, record which part of your device models negative feedback.

## PART 3 Evaluate and Redesign

9. In the human endocrine system, negative feedback occurs as part of a cycle. With your partner, think of one or more ways that you could modify the model from Part 2 to show a cycle.

## Analyze and Conclude

1. **Inferring** Summarize your research from Part 1 by describing an example of negative feedback.
2. **Observing** Describe the events you observed in Step 7.
3. **Making Models** In Step 7, which part of the process involves negative feedback? Explain your answer.
4. **Evaluating the Design** In a short paragraph, summarize the ideas you and your partner thought of in Step 9 to show that negative feedback can be part of a cycle.

## Communicating

Suppose you are a TV health reporter preparing a program on human hormones. You need to do a 30-second segment on hormones and negative feedback. Write a script for your presentation. Include references to a model to help viewers understand how negative feedback works in the endocrine system.

Section 2

# The Male and Female Reproductive Systems

## Reading Preview

### Key Concepts

- What is sexual reproduction?
- What are the structures and functions of the male and female reproductive systems?
- What events occur during the menstrual cycle?

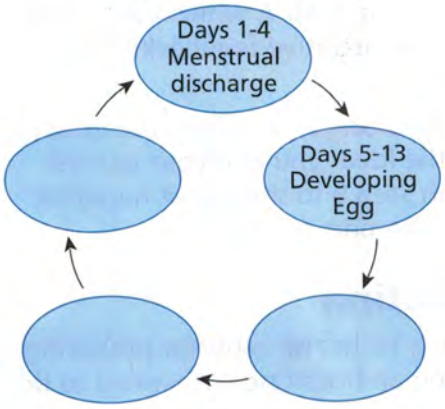
### Key Terms

- egg • sperm • fertilization
- zygote • testis • testosterone
- scrotum • semen • penis
- ovary • estrogen
- fallopian tube • uterus
- vagina • menstrual cycle
- ovulation • menstruation

### Target Reading Skill

**Sequencing** As you read, make a cycle diagram like the one below that shows the menstrual cycle. Write each event of the process in a separate circle.

**The Menstrual Cycle**




## Lab zone Discover Activity

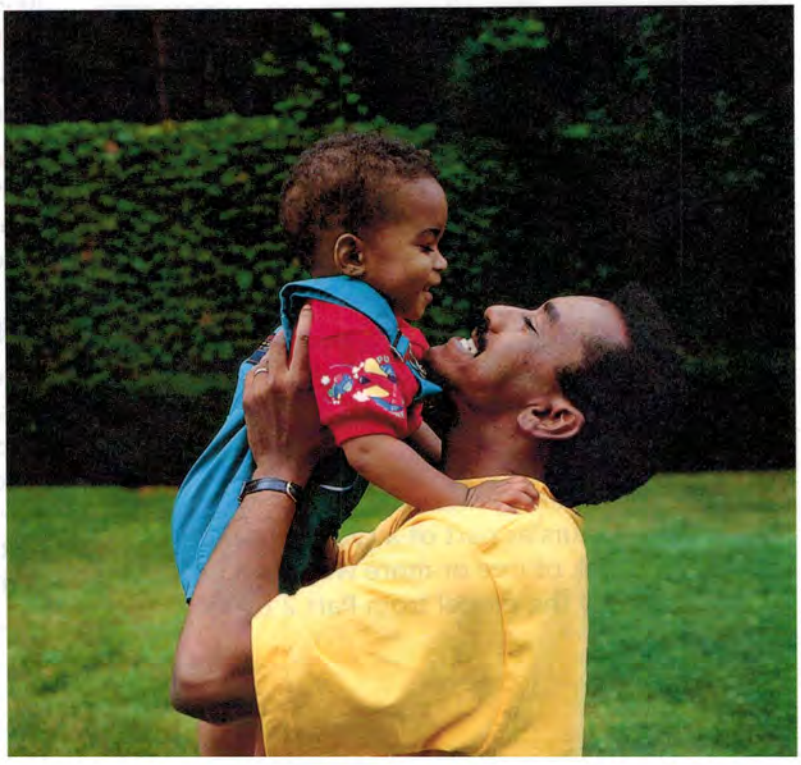
### What's the Big Difference?

1. Your teacher will provide prepared slides of eggs and sperm.
2. Examine each slide under the microscope, first under low power, then under high power. Be sure you view more than one example of each kind of cell.
3. Sketch and label each sample.

**Think It Over**

**Observing** What differences did you observe between sperm cells and egg cells? What general statement can you make about eggs and sperm?

Many differences between an adult animal and its young are controlled by the endocrine system. In humans, two endocrine glands—the ovaries and the testes—control many of the changes that occur as a child matures. These glands release hormones that cause the body to develop as a person grows older. They also produce sex cells that are part of sexual reproduction.



**Hormones control growth and development.**

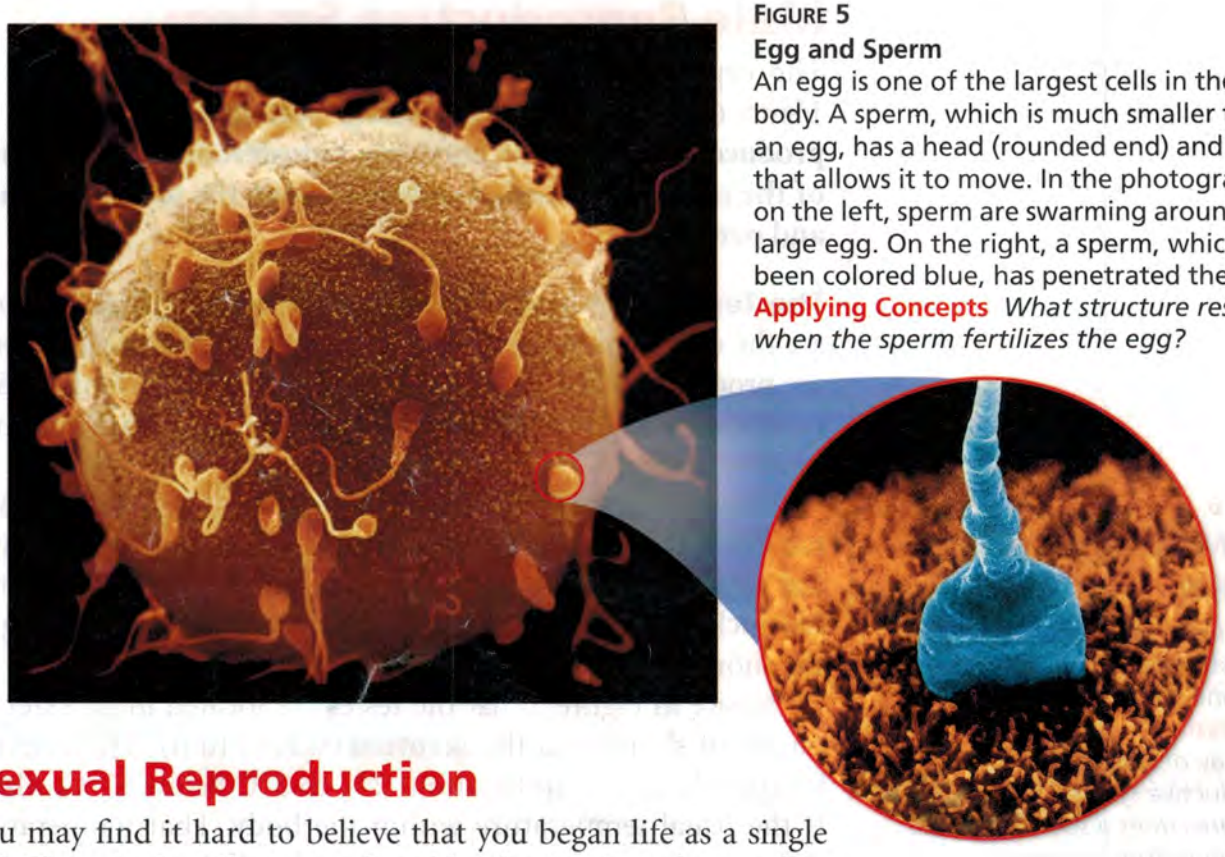


**FIGURE 5**
**Egg and Sperm**
An egg is one of the largest cells in the body. A sperm, which is much smaller than an egg, has a head (rounded end) and a tail that allows it to move. In the photograph on the left, sperm are swarming around the large egg. On the right, a sperm, which has been colored blue, has penetrated the egg.
**Applying Concepts** *What structure results when the sperm fertilizes the egg?*

## Sexual Reproduction

You may find it hard to believe that you began life as a single cell. That single cell was produced by the joining of two other cells, an egg and a sperm. An **egg** is the female sex cell. A **sperm** is the male sex cell.

The joining of a sperm and an egg is called **fertilization.** Fertilization is an important part of sexual reproduction, the process by which male and female living things produce new individuals. **Sexual reproduction involves the production of eggs by the female and sperm by the male. The egg and sperm join together during fertilization.** When fertilization occurs, a fertilized egg, or **zygote,** is produced. Every one of the trillions of cells in your body is descended from the single cell that formed during fertilization.

Like other cells in the body, sex cells contain rod-shaped structures called chromosomes. Chromosomes (KROH muh sohmz) carry the information that controls inherited characteristics, such as eye color and blood type. Every cell in the human body that has a nucleus, except the sex cells, contains 46 chromosomes. Each sex cell contains half that number, or 23 chromosomes. During fertilization, the 23 chromosomes in a sperm join the 23 chromosomes in an egg. The result is a zygote with 46 chromosomes. The zygote contains all of the information needed to produce a new human being.

**Reading Checkpoint** **What happens to the number of chromosomes when a male sex cell and a female sex cell join?**

# Male Reproductive System

The organs of the male reproductive system are shown in Figure 6. **The male reproductive system is specialized to produce sperm and the hormone testosterone. The structures of the male reproductive system include the testes, scrotum, and penis.**

**The Testes** The oval-shaped **testes** (TES teez) (singular *testis*) are the organs of the male reproductive system in which sperm are produced. The testes consist of clusters of hundreds of tiny coiled tubes and the cells between the tubes. Sperm are formed inside the tubes.

The testes also produce testosterone. **Testosterone** (tes TAHS tuh rohn) is a hormone that controls the development of physical characteristics in mature men. Some of those characteristics include facial hair, deepening of the voice, broadening of the shoulders, and the ability to produce sperm.

Notice in Figure 6 that the testes are located in an external pouch of skin called the **scrotum** (SKROH tum). The external location keeps the testes about 2°C to 3°C below 37°C, which is the usual temperature within the body. That temperature difference is important. Sperm need the slightly cooler conditions to develop normally.

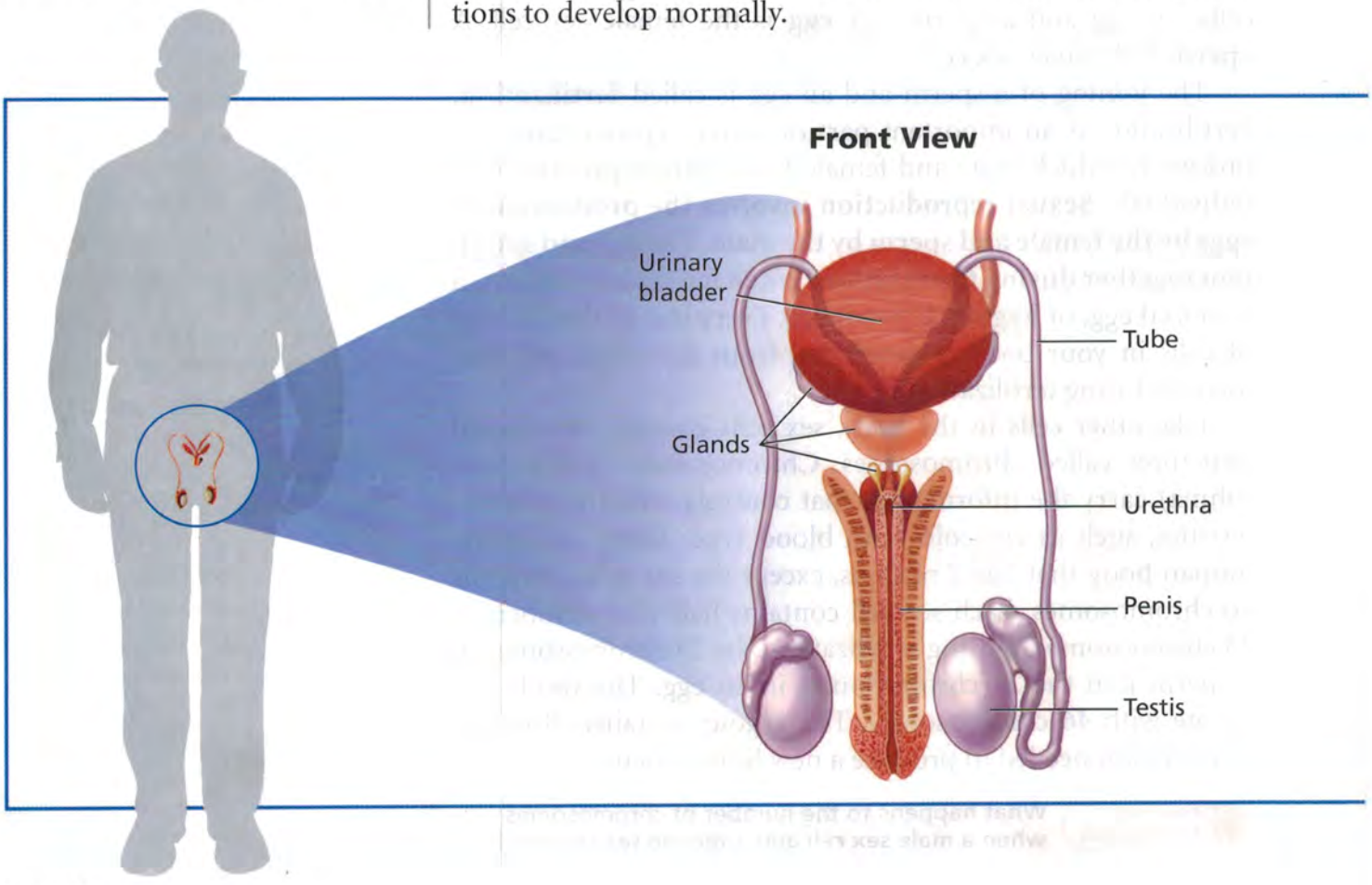



**FIGURE 6**

## The Male Reproductive System

In the male reproductive system, the testes produce sperm and the hormone testosterone.

**Interpreting Diagrams** *Trace the pathway of sperm in the male reproductive system. What structures does a sperm cell pass through before exiting the body?*

**Sperm Production** The production of sperm cells begins in males at some point during the teenage years. Each sperm cell is composed of a head that contains chromosomes and a long, whiplike tail. Basically, a sperm cell is a tiny package of chromosomes that can swim.

**The Path of Sperm Cells** Once sperm cells form in the testes, they travel through other structures in the male reproductive system. During this passage, sperm mix with fluids produced by nearby glands. This mixture of sperm cells and fluids is called **semen** (SEE mun). Semen contains a huge number of sperm—about 5 to 10 million per drop! The fluids in semen provide an environment in which sperm are able to swim. Semen also contains nutrients that the moving sperm use as a source of energy.

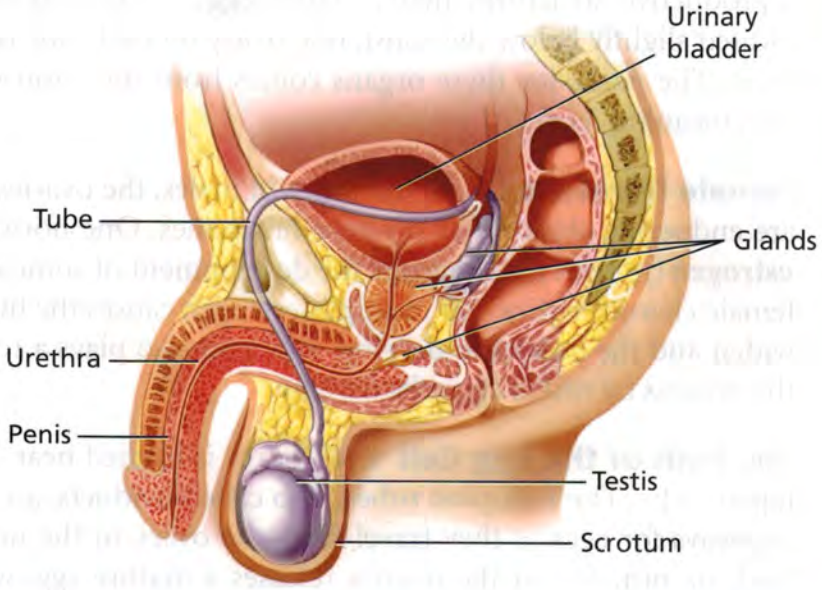
Semen leaves the body through an organ called the **penis.** The tube in the penis through which the semen travels is called the urethra. Urine also leaves the body through the urethra. When semen passes through the urethra, however, muscles near the bladder contract. Those muscles prevent urine and semen from mixing.

**Reading Checkpoint** **What is the pouch of skin in which the testes are located?**

Go Online
SCILINKS NSTA

**For:** Links on the reproductive system
**Visit:** www.SciLinks.org
**Web Code:** scn-0472

**Side View**



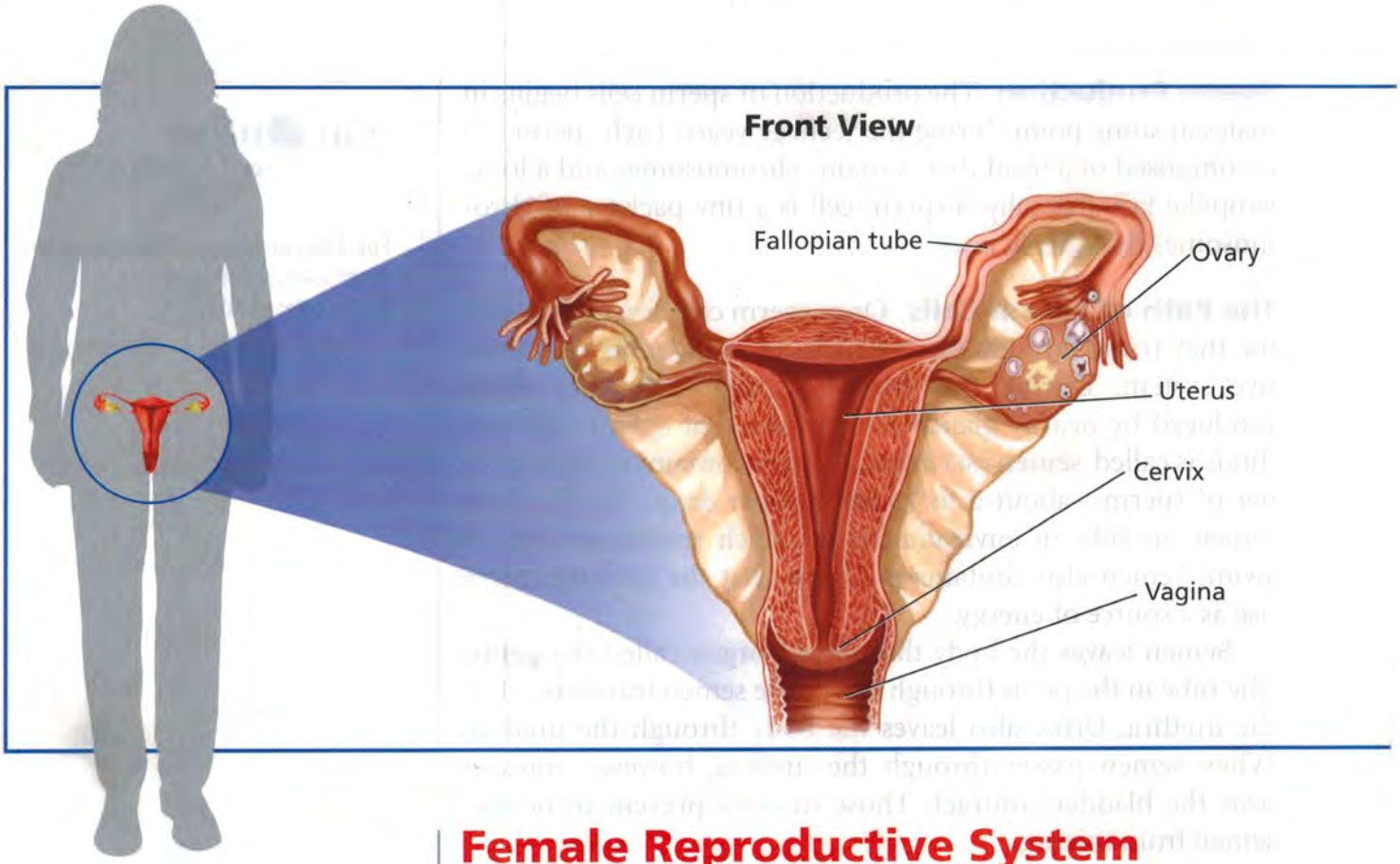



FIGURE 7

**Female Reproductive System**

In the female reproductive system, the two ovaries produce eggs and hormones such as estrogen.

**Relating Cause and Effect** *What changes does estrogen produce in a female's body?*

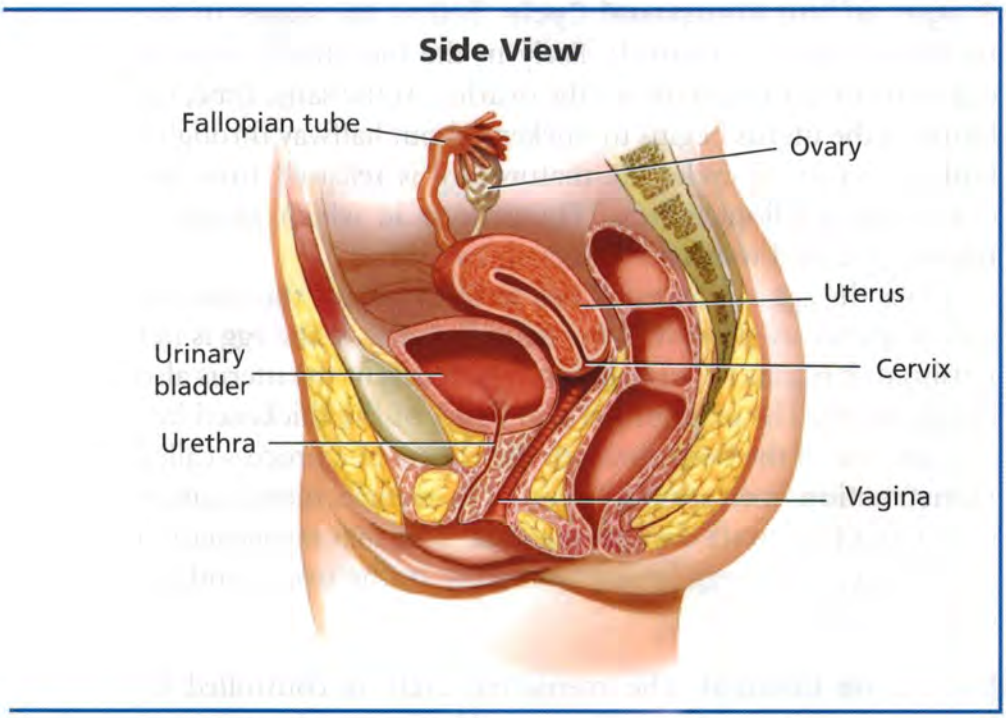
# Female Reproductive System

Figure 7 shows the female reproductive system. **The role of the female reproductive system is to produce eggs and, if an egg is fertilized, to nourish a developing baby until birth. The organs of the female reproductive system include the ovaries, fallopian tubes, uterus, and vagina.**

**The Ovaries** The **ovaries** (OH vuh reez) are the female reproductive structures that produce eggs. The ovaries are located slightly below the waist, one ovary on each side of the body. The name for these organs comes from the Latin word *ova*, meaning "eggs."

**Female Hormones** Like the testes in males, the ovaries also are endocrine glands that produce hormones. One hormone, **estrogen** (ES truh jun), triggers the development of some adult female characteristics. For example, estrogen causes the hips to widen and the breasts to develop. Estrogen also plays a role in the process by which egg cells develop.

**The Path of the Egg Cell** Each ovary is located near a fallopian tube. The **fallopian tubes,** also called oviducts, are passageways for eggs as they travel from the ovary to the uterus. Each month, one of the ovaries releases a mature egg, which enters the nearest fallopian tube. Fertilization usually occurs within a fallopian tube.




The egg moves through the fallopian tube, which leads to the uterus. The **uterus** (YOO tur us) is a hollow muscular organ about the size of a pear. If an egg has been fertilized, it becomes attached to the wall of the uterus.

An egg that has not been fertilized starts to break down in the uterus. It leaves the uterus through an opening at the base of the uterus, called the cervix. The egg then enters the vagina. The **vagina** (vuh JY nuh) is a muscular passageway leading to the outside of the body. The vagina, or birth canal, is the passageway through which a baby leaves the mother's body.

**Reading Checkpoint** **What is the role of the fallopian tube?**

## The Menstrual Cycle

When the female reproductive system becomes mature, usually during the teenage years, there are about 400,000 undeveloped eggs in the ovaries. However, only about 500 of those eggs will actually leave the ovaries and reach the uterus. An egg is released about once a month in a mature woman's body. The monthly cycle of changes that occur in the female reproductive system is called the **menstrual cycle** (MEN stroo ul).

**During the menstrual cycle, an egg develops in an ovary. At the same time, the uterus prepares for the arrival of an embryo.** In this way, the menstrual cycle prepares the woman's body for pregnancy, which begins after fertilization.

**Lab zone Skills Activity**

### Calculating

An egg is about 0.1 mm in diameter. In contrast, the head of a sperm is about 0.005 mm. Calculate how much bigger an egg is than a sperm.

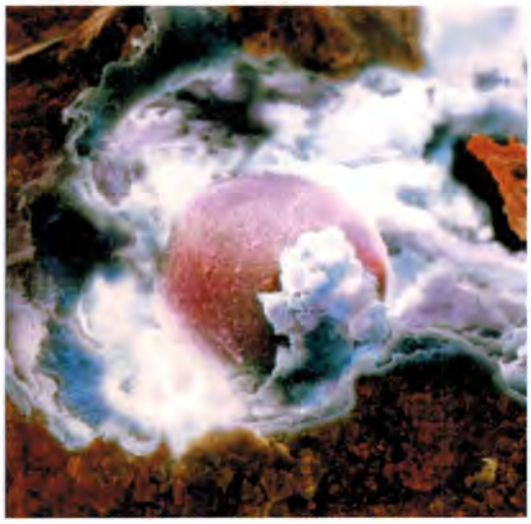


**FIGURE 8**
**Release of an Egg**
The ovary releases an egg, shown here in pink. The egg will then travel down the fallopian tube to the uterus. **Applying Concepts** *Through what opening does an unfertilized egg pass when leaving the uterus?*

**Stages of the Menstrual Cycle** Follow the stages of the menstrual cycle in Figure 9. Early in the menstrual cycle, an egg starts to mature in one of the ovaries. At the same time, the lining of the uterus begins to thicken. About halfway through a typical menstrual cycle, the mature egg is released from the ovary into a fallopian tube. The process in which an egg is released is called **ovulation** (ahv yuh LAY shun).

Once the egg is released, it can be fertilized for the next few days if sperm are present in the fallopian tube. If the egg is not fertilized, it begins to break down. The lining of the uterus also breaks down. The extra blood and tissue of the thickened lining pass out of the body through the vagina in a process called **menstruation** (men stroo AY shun). On average, menstruation lasts about four to six days. At the same time that menstruation takes place, a new egg begins to mature in the ovary, and the cycle continues.

**Endocrine Control** The menstrual cycle is controlled by hormones of the endocrine system. Hormones also trigger a girl's first menstruation. Many girls begin menstruation sometime between the ages of 10 and 14 years. Some girls start earlier, while others start later. Women continue to menstruate until about the age of 50. At around that age, the production of sex hormones drops. As a result, the ovaries stop releasing mature egg cells.

**Reading Checkpoint** **How often is an egg released from an ovary?**

## Math Analyzing Data

### Changing Hormone Levels

A woman's hormone levels change throughout the menstrual cycle. The graph shows the levels of one female hormone, known as LH, during the menstrual cycle.

1. **Reading Graphs** What does the *y*-axis show?
2. **Interpreting Data** What is the level of LH on day 1? On day 17? On day 21?
3. **Calculating** What is the difference between LH levels on days 9 and 13?
4. **Drawing Conclusions** On what day does LH reach its highest level? What event takes place at about the same time?

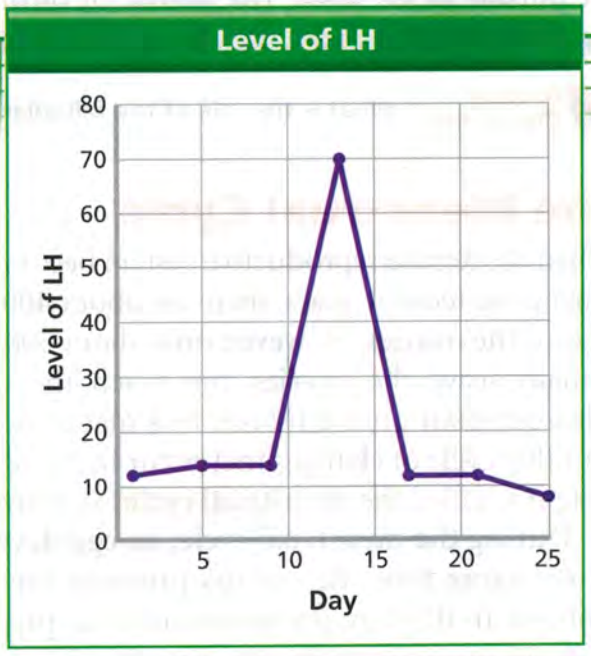
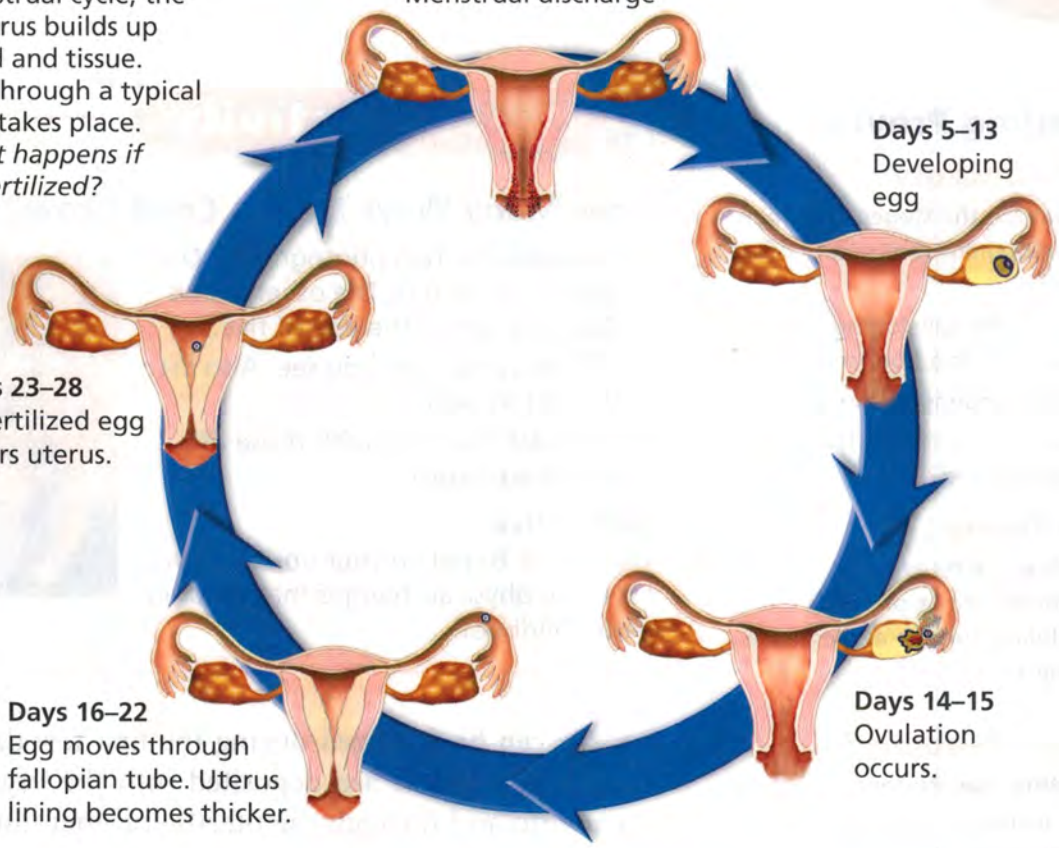


FIGURE 9

## The Menstrual Cycle

During the menstrual cycle, the lining of the uterus builds up with extra blood and tissue. About halfway through a typical cycle, ovulation takes place.
**Predicting** *What happens if the egg is not fertilized?*




## Section 2 Assessment

**Target Reading Skill** **Sequencing** Refer to your cycle diagram about the menstrual cycle as you answer Question 3.

### Reviewing Key Concepts

1. a. **Reviewing** What is fertilization?
   b. **Explaining** Explain how fertilization produces a new individual.
   c. **Comparing and Contrasting** Contrast the number of chromosomes in sex cells and in a zygote. Explain why the zygote has the number of chromosomes that it does.
2. a. **Listing** List the structures of the male and female reproductive systems.
   b. **Describing** Describe the functions of the structures you named in Question 2a.
   c. **Comparing and Contrasting** In what ways are the functions of the ovaries and the testes similar? How do their functions differ?
3. a. **Defining** What is the menstrual cycle?
   b. **Sequencing Events** At what point in the menstrual cycle does ovulation occur?

### Writing in Science

**Explanatory Paragraph** Write a paragraph explaining why the ovaries and testes are part of both the endocrine system and the reproductive system.

Section 3

Integrating Health

# The Human Life Cycle

## Reading Preview

### Key Concepts

- What are the stages of human development that occur before birth?
- How is the developing embryo protected and nourished?
- What happens during childbirth?
- What changes occur from infancy to adulthood?

### Key Terms

- embryo • fetus
- amniotic sac • placenta
- umbilical cord • adolescence
- puberty

## Target Reading Skill

**Building Vocabulary** After you read Section 3, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write sentences using each Key Term.

## Lab zone Discover Activity

### How Many Ways Does a Child Grow?

1. Compare the two photographs. One shows a baby girl. The other shows the same girl at the age of five.
2. List the similarities you see. Also list the differences.
3. Compare your lists with those of your classmates.

**Think It Over**

**Observing** Based on your observations, list three physical changes that occur in early childhood.

An egg can be fertilized during the first few days after ovulation. When sperm are deposited into the vagina, the sperm move into and through the uterus and then into the fallopian tubes. If a sperm fertilizes an egg, pregnancy can occur. Then, the amazing process of human development begins.

## Development Before Birth

A fertilized egg, or zygote, is no larger than the period at the end of this sentence. Yet after fertilization, the zygote undergoes changes that result in the formation of a new human. **The zygote develops first into an embryo and then into a fetus.** About nine months after fertilization, a baby is born.

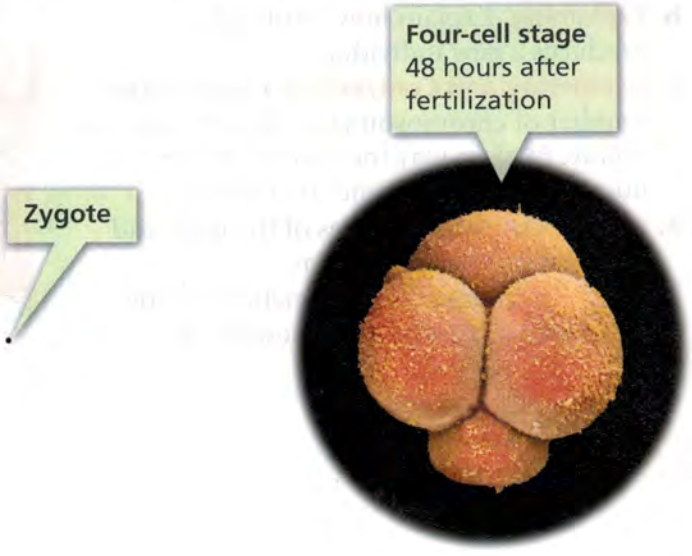



**FIGURE 10**
**Development of the Fetus**
As a fetus grows and develops, it gains mass, increases in length, and develops all its body systems.
**Applying Concepts** *How large is a zygote?*

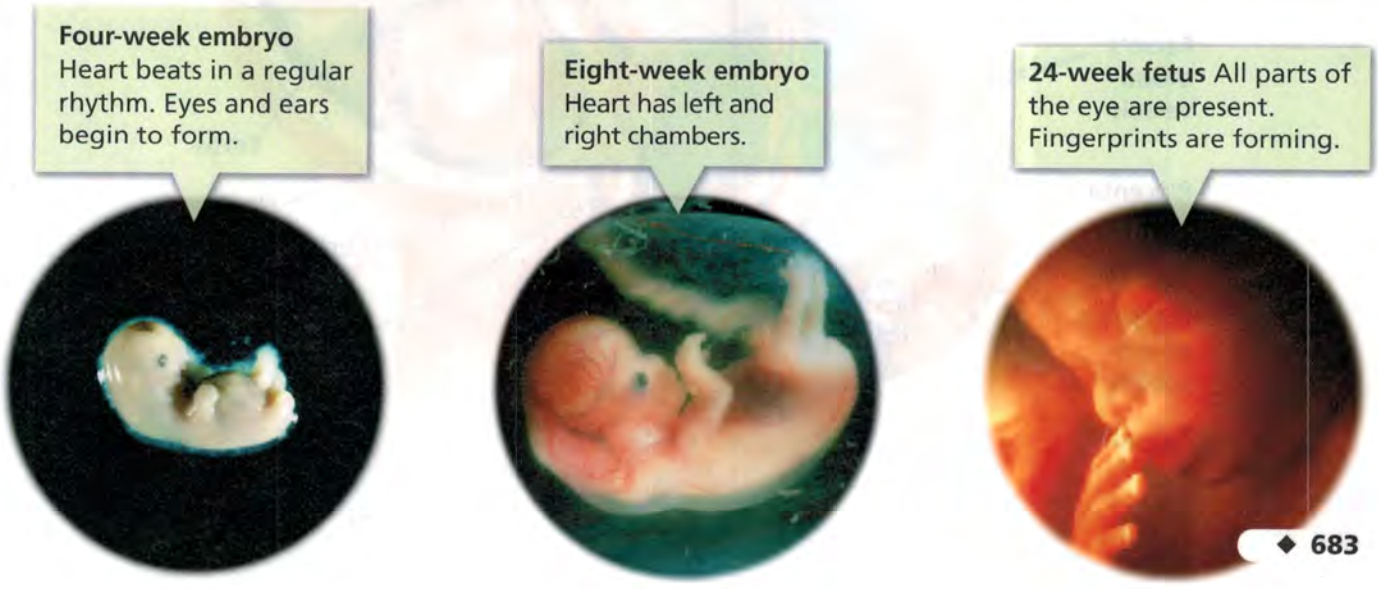
**Zygote and Embryo** After an egg and sperm join, the zygote moves down the fallopian tube toward the uterus. During this trip, which takes about four days, the zygote begins to divide. The original cell divides to make two cells. These two cells divide to make four, and so on. Eventually, the growing mass of hundreds of cells forms a hollow ball. The ball attaches to the lining of the uterus. From the two-cell stage through the eighth week of development, the developing human is called an **embryo** (EM bree oh).

**Fetus** From about the ninth week of development until birth, the developing human is called a **fetus** (FEE tus). Although at first the fetus is only the size of a whole walnut shell, it now looks more like a baby. Many internal organs have developed. The head is about half the body's total size. The fetus's brain is developing rapidly. The fetus also has dark eye patches, fingers, and toes. By the end of the third month, the fetus is about 9 centimeters long and has a mass of about 26 grams.

Between the fourth and sixth months, bones become distinct. A heartbeat can be heard with a stethoscope. A layer of soft hair grows over the skin. The arms and legs develop more completely. The fetus begins to move and kick, a sign that its muscles are growing. At the end of the sixth month, the mass of the fetus is approaching 700 grams. Its body is about 30 centimeters long.

The final three months prepare the fetus to survive outside the mother's body. The brain surface develops grooves and ridges. The lungs become ready to carry out the exchange of oxygen and carbon dioxide. The eyelids can open. The fetus doubles in length. Its mass may reach 3 kilograms or more.

**Reading Checkpoint** **At what point during development can a heartbeat be detected in a fetus?**



## Protection and Nourishment

Just like you, the embryo and fetus need nourishment and protection to develop properly. Soon after the embryo attaches to the uterus, many changes take place. The hollow ball of cells grows inward. New membranes form. **The membranes and other structures that form during development protect and nourish the developing embryo, and later the fetus.**

**Amniotic Sac** One membrane surrounds the embryo and develops into a fluid-filled sac called the **amniotic sac** (am NEE aht ik). Locate the amniotic sac in Figure 11. The fluid in the amniotic sac cushions and protects the developing baby.

**Placenta** Another membrane also forms, which helps to form the placenta. The **placenta** (pluh SEN tuh) is the link between the embryo and the mother. In the placenta, the embryo's blood vessels are located next to the mother's blood vessels. Blood from the two systems does not mix, but many substances are exchanged between the two blood supplies. The embryo receives nutrients, oxygen, and other substances from the mother. It gives off carbon dioxide and other wastes.

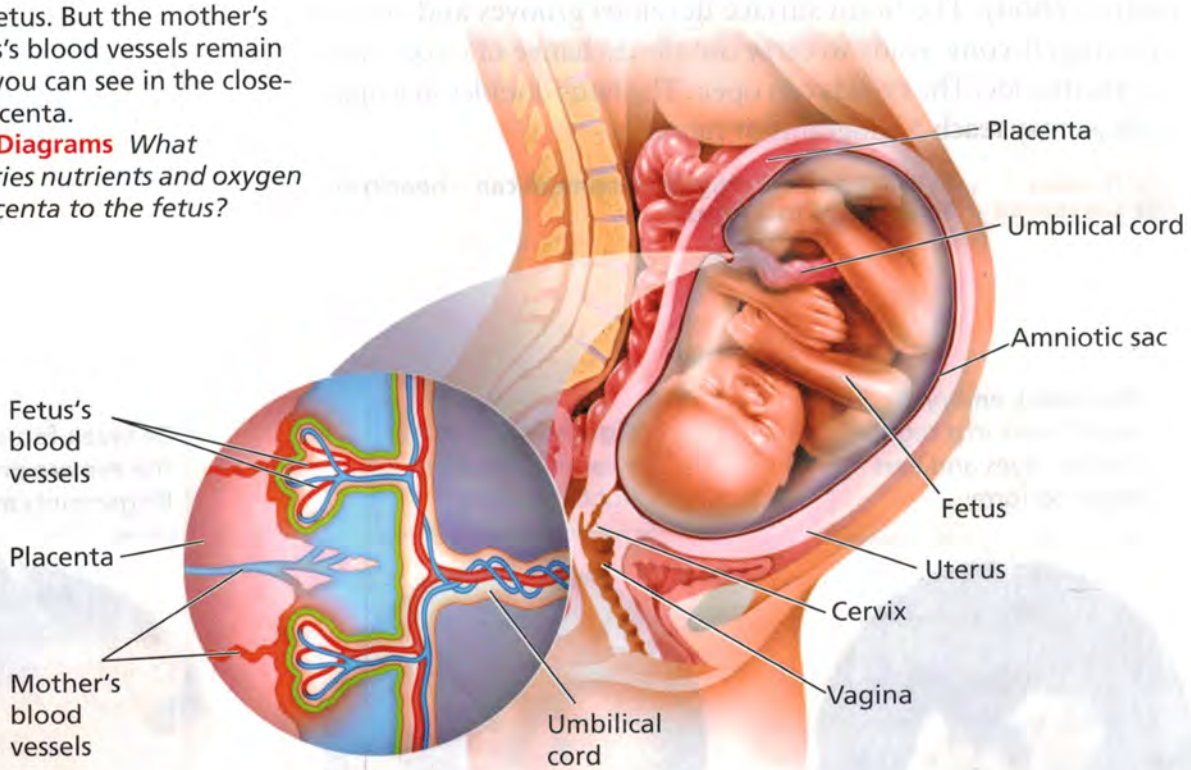



**FIGURE 11**
**The Placenta**
The placenta provides a connection between the mother and the developing fetus. But the mother's and the fetus's blood vessels remain separate, as you can see in the close-up of the placenta.
**Interpreting Diagrams** *What structure carries nutrients and oxygen from the placenta to the fetus?*


**FIGURE 12**
**Eight-Month Fetus**
This eight-month fetus is capable of surviving outside the mother. However, the fetus will remain protected within the uterus until birth, at approximately nine months.

**Umbilical Cord** A ropelike structure called the **umbilical cord** forms between the fetus and the placenta. It contains blood vessels that link the fetus to the mother. However, the two circulatory systems remain separated by a thin barrier.

The barrier that separates the fetus's and mother's blood prevents some diseases from spreading from the mother to the fetus. However, substances such as alcohol, chemicals in tobacco, and many other drugs can pass through the barrier to the fetus. For this reason, pregnant women should not smoke, drink alcohol, or take any drug without a doctor's approval.

**Reading Checkpoint** **How does a fetus obtain oxygen?**

## Birth

After about nine months of development inside the uterus, the baby is ready to be born. **The birth of a baby takes place in three stages—labor, delivery, and afterbirth.**

**Labor** During the first stage of birth, strong muscular contractions of the uterus begin. These contractions are called labor. The contractions cause the cervix to enlarge, eventually allowing the baby to fit through the opening. Labor may last from about 2 hours to more than 20 hours.

**Lab zone Try This Activity**

### Way to Grow!

The table lists the average mass of a developing baby at different months of pregnancy.

| Month of Pregnancy | Mass (grams) |
|---|---|
| 1 | 0.02 |
| 2 | 2.0 |
| 3 | 26 |
| 4 | 150 |
| 5 | 460 |
| 6 | 640 |
| 7 | 1,500 |
| 8 | 2,300 |
| 9 | 3,200 |

1. Use a balance to identify an everyday object with a mass approximately equal to each mass listed in the table. You may need to use different balances to cover the range of masses listed.
2. Arrange the objects in order by month.

**Making Models** What did you learn by gathering these physical models?

**FIGURE 13**
**Birth**
After about nine months of growth and development inside the uterus, a baby is born. You can see where the umbilical cord of this newborn was tied and cut.

**Delivery** The second stage of birth is called delivery. During normal delivery, the baby is pushed completely out of the uterus, through the vagina, and out of the mother's body. The head usually comes out first. At this time, the baby is still connected to the placenta by the umbilical cord. Delivery of the baby usually takes less time than labor does—from several minutes to an hour or so.

Shortly after delivery, the umbilical cord is clamped, then cut about 5 centimeters from the baby's abdomen. Within seven to ten days, the remainder of the umbilical cord dries up and falls off, leaving a scar called the navel, or belly button.

**Afterbirth** About 15 minutes after delivery, the third stage of the birth process begins. Contractions of the uterus push the placenta and other membranes out of the uterus through the vagina. This stage, called afterbirth, is usually completed in less than an hour.

**Birth and the Baby** The birth process is stressful for both the baby and the mother. The baby is pushed and squeezed as it travels out of the mother's body. Muscle contractions put pressure on the placenta and umbilical cord. This pressure briefly decreases the baby's supply of oxygen.

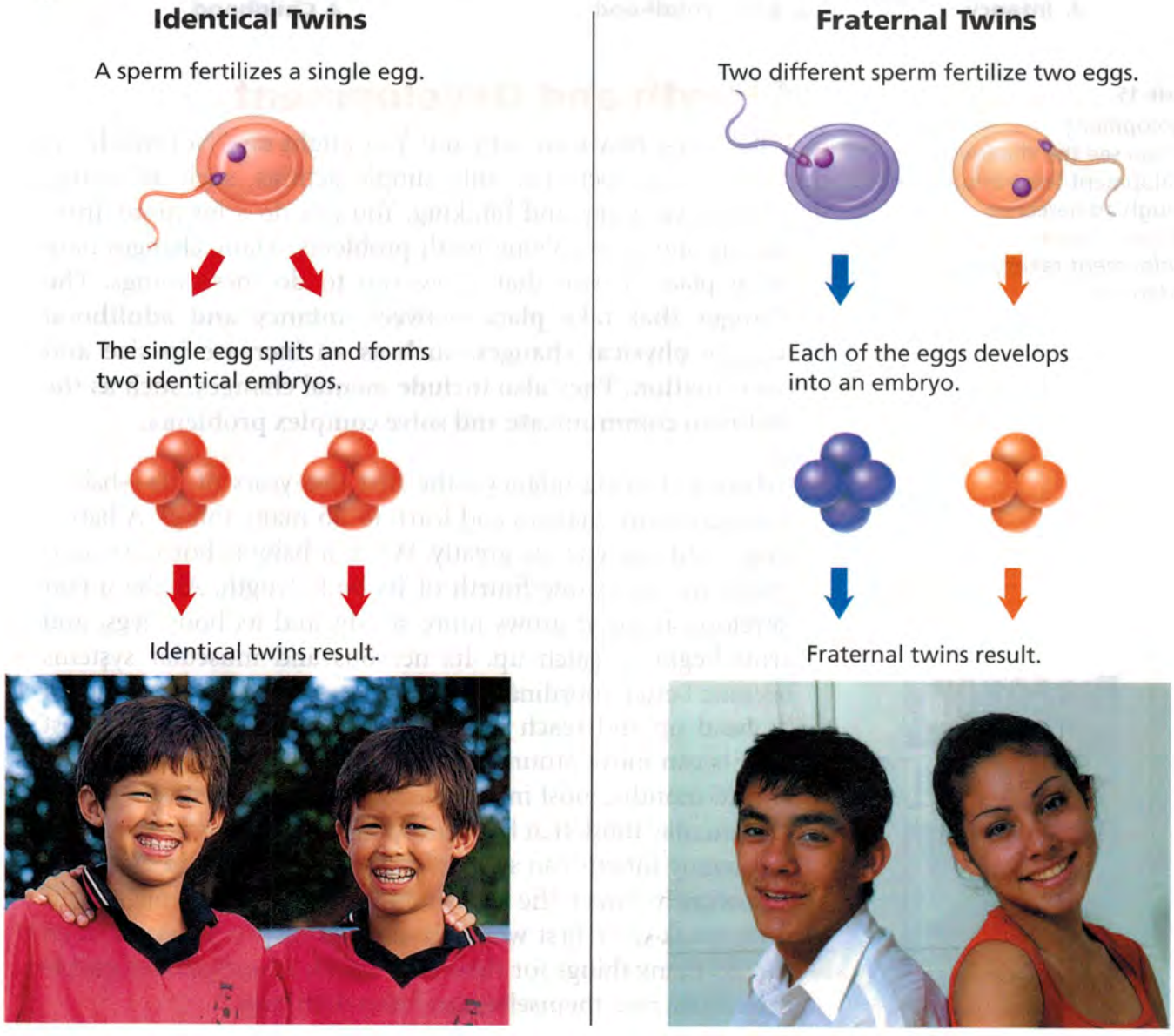
In response to the changes, the baby's endocrine system releases adrenaline. The baby's heart rate increases. Within a few seconds of delivery, the baby begins breathing with a cry or a cough. This action helps rid the lungs of fluid and fills them with air. The newborn's heart rate then slows to a steady pace. Blood travels to the lungs and picks up oxygen from the air that the baby breathes in. The newborn's cry helps it adjust to the changes in its surroundings.

**Multiple Births** The delivery of more than one baby from a single pregnancy is called a multiple birth. In the United States, about 1 out of every 30 babies born each year is a twin. Multiple births of more than two babies, such as triplets and quadruplets, occur less frequently than do twin births.

There are two types of twins: identical twins and fraternal twins. Identical twins develop from a single fertilized egg, or zygote. Early in development, the embryo splits into two identical embryos. The two embryos have identical inherited traits and are the same sex. Fraternal twins develop when two eggs are released from the ovary and are fertilized by two different sperm. Fraternal twins are no more alike than any other brothers or sisters. Fraternal twins may or may not be the same sex.

**Reading Checkpoint** **What are the two types of twins?**

FIGURE 14
## Twins
Identical twins (left) develop from the same fertilized egg. They share identical characteristics. Fraternal twins (right) develop from two different fertilized eggs. **Applying Concepts** *Why can fraternal twins be different sexes while identical twins cannot?*



▲ Infancy ▲ Early childhood ▲ Childhood

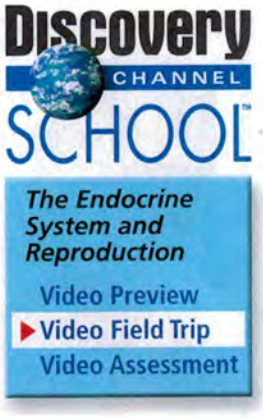
**FIGURE 15**
**Development**
You can see the changes in development from infancy through adolescence.
**Applying Concepts** *What mental development takes place during childhood?*

## Growth and Development

What can a newborn baby do? You might say "Not much!" A newborn can perform only simple actions, such as crying, sucking, yawning, and blinking. You can do a lot more, from playing sports to solving math problems. Many changes have taken place in you that allow you to do these things. **The changes that take place between infancy and adulthood include physical changes, such as an increase in size and coordination. They also include mental changes, such as the ability to communicate and solve complex problems.**

**Infancy** During infancy—the first two years of life—babies undergo many changes and learn to do many things. A baby's shape and size change greatly. When a baby is born, its head makes up about one fourth of its body length. As the infant develops, its head grows more slowly, and its body, legs, and arms begin to catch up. Its nervous and muscular systems become better coordinated. After about 3 months, it can hold its head up and reach for objects. At about 7 months, most infants can move around by crawling. Somewhere between 10 and 16 months, most infants begin to walk by themselves.

You may think that babies display feelings mostly by crying. But young infants can show pleasure by smiling and laughing. Sometime between the ages of one and three years, many children speak their first word. By the end of two years, children can do many things for themselves, such as understand simple directions, feed themselves, and play with toys.



▲ Early adolescence

▲ Adolescence

**Childhood** Infancy ends and childhood begins at about two years of age. Throughout childhood, children continue to grow. They become taller and heavier as their bones and muscles increase in size. They become more coordinated as they practice skills such as walking, using a pencil, and playing games.

As they develop, children show a growing curiosity and increasing mental abilities. Language skills improve rapidly. For example, most four-year-olds can carry on conversations. With the help of family members and teachers, children learn to read and to solve problems. Over time, children learn to make friends, care about others, and behave responsibly.

**Adolescence** The stage of development during which children become adults physically and mentally is called **adolescence** (ad ul ES uns). Adolescents gradually become able to think like adults and take on adult responsibilities. The bodies of adolescents also undergo specific physical changes.

Sometime between the ages of about 9 and 15 years, girls and boys enter puberty. **Puberty** (PYOO bur tee) is the period of sexual development in which the body becomes able to reproduce. In girls, hormones produced by the pituitary gland and the ovaries control the physical changes of puberty. The sex organs develop. Ovulation and menstruation begin. The breasts enlarge, and the hips start to widen. In boys, hormones from the testes and the pituitary gland govern the changes. The sex organs develop, and sperm production begins. The voice deepens. Hair appears on the face and chest.

Lab zone **Try This Activity**

### Teenagers in Ads

In this activity, you will examine an ad taken from a teen magazine.

1. Examine an ad that shows one or more teenagers. Read the words and examine the pictures.
2. Think about how the ad portrays teenagers. How do they look and act? How accurate is this "picture" of teenagers?

**Drawing Conclusions** How does this ad try to influence people your age? Do you think the ad is effective? Explain your opinion.

FIGURE 16
**Adulthood**
Young adults often enjoy helping older adults.

**Adulthood** The mental and emotional growth of adolescence continues after puberty ends. It is difficult to say when adolescence ends and adulthood begins. And adults, like adolescents, continue to learn new things.

After about the age of 30, a process known as aging begins. As people age, the skin becomes wrinkled and muscle strength decreases. The eyes may lose their ability to focus on close objects, and hair may lose its coloring. Aging becomes more noticeable between the ages of 40 and 65. During this period, women stop menstruating and ovulating. Men usually continue to produce sperm throughout their lives. However, as men become older, the number of sperm they produce decreases.

The effects of aging can be slowed if people follow sensible diets and good exercise plans. With the help of such healthy behaviors, more and more adults remain active throughout their lives. In addition, older people have learned a lot from their experiences. Because of this learning, many older people have a great deal of wisdom. Older adults can share their knowledge and experience with younger people.

Reading Checkpoint **What are the physical effects of aging?**

## Section 3 Assessment

**Target Reading Skill** **Building Vocabulary** Use your sentences to help answer the questions.

### Reviewing Key Concepts

1. a. **Identifying** What three steps of development does a fertilized egg go through before birth?
   b. **Describing** What happens to the fetus during the final three months of development?
   c. **Relating Cause and Effect** Explain why a baby born before the seventh month of development needs special care to survive.
2. a. **Reviewing** What is the general function of the membranes that surround a fetus?
   b. **Explaining** What is the specific function of the placenta?
   c. **Relating Cause and Effect** Why is it dangerous for a pregnant woman to drink alcohol or to smoke cigarettes?
3. a. **Listing** What are the three stages of birth?
   b. **Summarizing** What happens during labor?
4. a. **Identifying** Identify two general kinds of change that occur between infancy and adulthood. Give an example of each.
   b. **Describing** Describe what happens during puberty.
   c. **Making Judgments** Is puberty the most important process that occurs during adolescence? Explain your answer.

### Lab zone At-Home Activity

**Parenting Skills** Interview a family member about what is involved in being a parent. Ask the following questions: What skills do parents need? What are some of the rewards of parenthood? What are some of the challenges?

Lab zone **Skills Lab**

# Growing Up

## Problem

How do the proportions of the human body change during development?

## Skills Focus

calculating, predicting

## Procedure

1. Examine the diagram below. Notice that the figures are drawn against a graph showing percentages. You can use this diagram to determine how the lengths of major body parts compare to each figure's height. Make a data table in which to record information about each figure's head size and leg length.
2. Look at Figure D. You can use the graph to estimate that the head is about 15 percent of the figure's full height. Record that number in your data table.
3. Examine Figures A through C. Determine the percentage of the total height that the head makes up. Record your results.
4. Next, compare the length of the legs to the total body height for Figures A through D. Record your results. (*Hint*: Figure A shows the legs folded. You will need to estimate the data for that figure.)

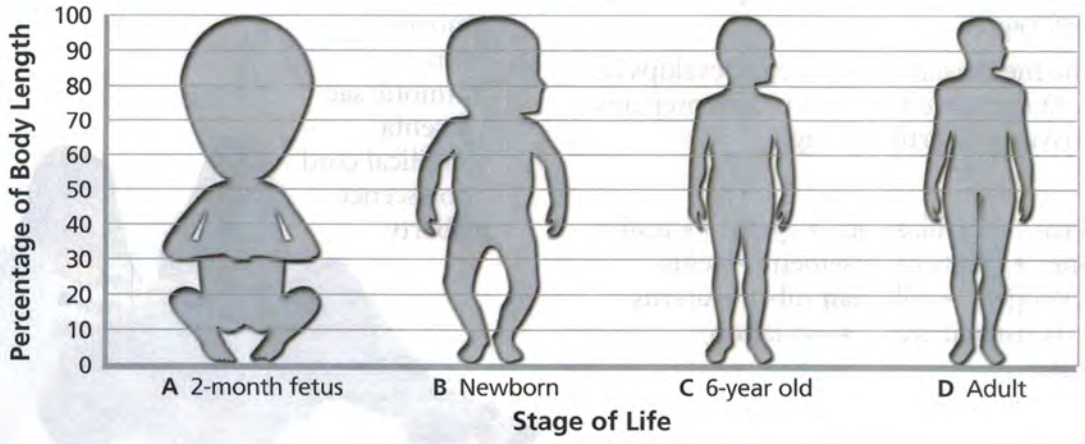
## Analyze and Conclude

1. **Calculating** How do the percentages for head size and leg length change from infancy to adulthood?
2. **Predicting** If you made a line graph using the data in the diagram, what would be on the horizontal axis? On the vertical axis? What additional information could you gain from this line graph?
3. **Communicating** What can you infer about the rate at which different parts of the body grow? Write a paragraph in which you discuss the answer to this question.

## Design an Experiment

Make a prediction about the relationship between the circumference of the head compared with body height. Then, design an experiment to test your prediction, using people for test subjects. *Obtain your teacher's permission before carrying out your investigation.*

**Body Proportions During Development**



# Chapter 20 Study Guide

**The BIG Idea** **Regulation and Reproduction** The endocrine system releases hormones necessary for the development of male and female sex cells, which are needed for reproduction.

## 1 The Endocrine System

### Key Concepts

- The endocrine system produces chemicals that control many of the body's daily activities as well as growth and development.
- The endocrine glands include the pituitary, hypothalamus, thyroid, parathyroid, adrenal, thymus, and pancreas. They include ovaries in females and testes in males.
- Through negative feedback, when the amount of a particular hormone in the blood reaches a certain level, the endocrine system sends signals that stop the release of that hormone.

### Key Terms

• endocrine gland • hormone • target cell
• hypothalamus • pituitary gland
• negative feedback

## 2 The Male and Female Reproductive Systems

### Key Concepts

- Sexual reproduction involves the production of eggs by the female and sperm by the male. The egg and sperm join during fertilization.
- The male reproductive system produces sperm and the hormone testosterone. Its structures include the testes, scrotum, and penis.
- The female reproductive system produces eggs and nourishes a developing baby until birth. Its structures include the ovaries, fallopian tubes, uterus, and vagina.
- During the menstrual cycle, an egg develops in an ovary. At the same time, the uterus prepares for the arrival of a fertilized egg.

### Key Terms

• egg • sperm • fertilization • zygote • testis
• testosterone • scrotum • semen • penis
• ovary • estrogen • fallopian tube • uterus
• vagina • menstrual cycle • ovulation
• menstruation

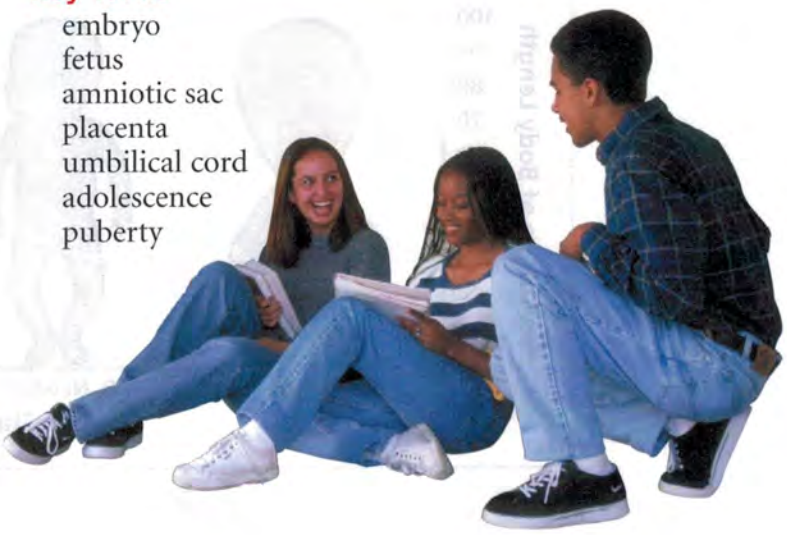
## 3 The Human Life Cycle

### Key Concepts

- The zygote develops first into an embryo and then into a fetus.
- The membranes and other structures that form during development protect and nourish the developing embryo and then the fetus.
- The birth of a baby takes place in three stages—labor, delivery, and afterbirth.
- The changes that take place between infancy and adulthood include physical changes, such as an increase in size and coordination, and mental changes, such as the ability to communicate and solve complex problems.

### Key Terms

embryo
fetus
amniotic sac
placenta
umbilical cord
adolescence
puberty

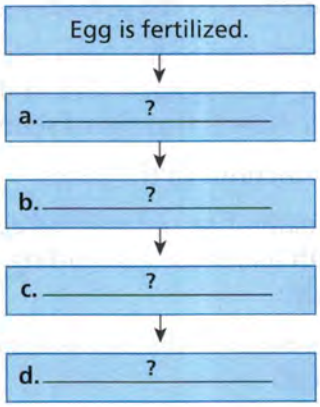


# Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cea-4070

## Organizing Information

**Sequencing** Copy the flowchart showing the main stages that occur between fertilization and birth onto a sheet of paper. Then, complete it and add a title. (For more on Sequencing, see the Skills Handbook.)




## Reviewing Key Terms

**Choose the letter of the best answer.**

1. The structure that links the nervous system and the endocrine system is the
   **a.** thyroid gland.
   **b.** target cell.
   **c.** umbilical cord.
   **d.** hypothalamus.
2. The male sex cell is called the
   **a.** testis.
   **b.** sperm.
   **c.** egg.
   **d.** ovary.
3. The release of an egg from an ovary is known as
   **a.** ovulation.
   **b.** fertilization.
   **c.** menstruation.
   **d.** negative feedback.
4. The structure that protects and cushions the embryo is called the
   **a.** umbilical cord.
   **b.** scrotum.
   **c.** amniotic sac.
   **d.** ovary.
5. Sex organs develop rapidly during
   **a.** fertilization.
   **b.** ovulation.
   **c.** puberty.
   **d.** menstruation.

**If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.**

6. A target cell recognizes a hormone's chemical structure.
7. The joining of a sperm and an egg is called menstruation.
8. A fluid that contains sperm is testosterone.
9. A fallopian tube is the passageway through which an egg travels from the ovary to the uterus.
10. The amniotic sac contains blood vessels that link the fetus to the mother.

## Writing in Science

**Creative Writing** Imagine you just found out that you have an identical twin who was raised in another country. Write a description of what you think your twin would be like. Be sure to include information about what your twin looks like, his or her interests, and unique characteristics of your twin.

Discovery CHANNEL SCHOOL

*The Endocrine System and Reproduction*
Video Preview
Video Field Trip
▶ Video Assessment

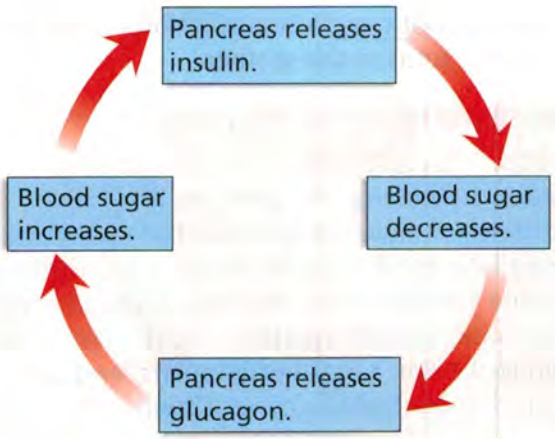
# Review and Assessment

## Checking Concepts

11. What is the function of the pituitary gland?
12. When enough thyroxine has been released into the blood, what signal is sent to the thyroid gland? How is that signal sent?
13. Identify two functions of the testes.
14. Describe the path of an unfertilized egg, beginning with its release and ending when it leaves the body.
15. What changes occur in the uterus during the menstrual cycle?
16. How does a zygote form? What happens to the zygote about four days after it forms?
17. Describe how a fetus receives food and oxygen and gets rid of wastes.
18. List five changes that a 10-year-old boy should expect to happen during the next five years. Include physical and mental changes.

## Thinking Critically

19. **Inferring** Study the diagram below. Then, suggest how the two hormones, glucagon and insulin, might work together to maintain homeostasis in the body.




20. **Calculating** The average menstrual cycle is 28 days in length but can vary from 24 to 32 days. Ovulation usually occurs 14 days before the end of the cycle. How long after the start of a 24-day cycle will ovulation occur? A 32-day cycle?
21. **Comparing and Contrasting** Contrast the ways in which identical twins and fraternal twins form.
22. **Relating Cause and Effect** How can playing games help children develop important skills?

## Applying Skills

**Use the table to answer Questions 23–25.**

*The data table below shows how the length of a developing baby changes during pregnancy.*

**Length of Fetus**

| Week of Pregnancy | Average Length (mm) | Week of Pregnancy | Average Length (mm) |
|---|---|---|---|
| 4 | 4 | 24 | 300 |
| 8 | 30 | 28 | 350 |
| 12 | 75 | 32 | 410 |
| 16 | 180 | 36 | 450 |
| 20 | 250 | 38 | 500 |

23. **Measuring** Use a metric ruler to mark each length on a piece of paper. During which four-week period did the greatest increase in length occur?
24. **Graphing** Graph the data by plotting time on the *x*-axis and length on the *y*-axis.
25. **Interpreting Data** At the twelfth week, a developing baby measures about 75 mm. By which week has the fetus grown to four times that length? Six times that length?

## Lab zone Chapter Project

**Performance Assessment** Explain what you learned as you cared for your "baby." What did you learn about parenting that you didn't know before? Consider reading passages from your journal to the class.

# Standardized Test Prep

### Test-Taking Tip

**Eliminating Incorrect Answers**

When you answer a multiple-choice question, you often can eliminate some of the answer choices because they are clearly incorrect. For example, in the sample question below, two of the choices are incorrect and can be eliminated. Read the question and determine which two choices are clearly wrong. Then, choose the correct answer from the remaining choices.

***Sample Question***

By the end of the third month, a human fetus

**A** is about 20 cm long and weighs about 700 g.
**B** is breathing air.
**C** has fingers and toes.
**D** has eyelids that can open.

***Answer***

You can eliminate choices **A** and **B** because they are clearly incorrect. Choice **A** gives the size of a 6-month fetus. Choice **B** is incorrect because a fetus does not breathe before birth. You have now narrowed your choices to two, **C** and **D**. Choice **C** is correct. The fetus's fingers and toes have developed by 3 months. Choice **D** is incorrect because at 3 months, the eyelids cannot yet open.

**Choose the letter of the best answer.**

**1.** You are riding your bike when a small child suddenly darts out in front of you. Which of your endocrine glands is most likely to release a hormone in response to this situation?

**A** pituitary gland
**B** adrenal glands
**C** thyroid gland
**D** parathyroid gland

**2.** On day 10 of a woman's menstrual cycle, the egg is most likely

**F** moving through the fallopian tube.
**G** in the uterus.
**H** in the ovary.
**J** leaving the body.

*Use the table below and your knowledge of science to answer Questions 3 and 4.*

**Number of Chromosomes in Body Cells of Various Animals**

| Organism | Chromosome Number |
|---|---|
| Roundworm | 2 |
| Fruit Fly | 8 |
| Cricket | 22 |
| Mouse | 40 |
| Human | 46 |
| Pigeon | 80 |

**3.** An egg cell produced by a female mouse probably contains

**A** 20 chromosomes.
**B** 40 chromosomes.
**C** 60 chromosomes.
**D** 80 chromosomes.

**4.** How many chromosomes will a pigeon zygote have?

**F** 20
**G** 40
**H** 60
**J** 80

**5.** A woman gives birth to twins that developed from a single fertilized egg that split early in development. Which of the following is a reasonable prediction that you can make about the twins?

**A** They will be the same sex.
**B** They will be different sexes.
**C** They will not look alike.
**D** They will have different inherited traits.

## Constructed Response

**6.** What is negative feedback? Choose an example of a hormone, and describe in a general way how negative feedback regulates its release.

# Interdisciplinary Exploration

# African Rain Forests

## What forest—

- contains a frog that's 30 cm long?
- is home to gorillas, pottos, and pygmy hippos?
- is preserving diversity?

It's an African rain forest. Thousands of plants and animals live here, from colorful orchids to fruit bats to elephants.

The rain forests of Africa grow near the equator. About 70 percent of the rain forests are in central Africa, in the vast basin of the great Congo River. Some parts of the central African rain forest are so dense and hard to reach that explorers have never visited them. East Africa, which is drier, has only scattered areas of rain forest.


**Golden Potto**
This golden potto eats insects and fruits in the African rain forest.

# Rain Forest Layers

The rain forest is really many forests in one—like different levels in an apartment building. Each layer varies in climate and is home to different plants and animals. The four layers are the emergent layer, the canopy, the understory, and the forest floor.

Over time, plants and animals have developed unusual adaptations to life at different layers of the rain forest. Some monkeys living in the canopy have long, muscular legs so they can run and leap through branches. Others have strong teeth and jaws that allow them to crunch fruits, nuts, and seeds. Some monkeys that live mainly on the forest floor have shorter tails but longer front legs.

**Emergent Layer** **40–70 Meters**
This layer is formed by a few taller trees that poke through the canopy. The emergent layer captures the most rain, sunlight, heat, and wind. Colobus monkeys and vast numbers of birds live at this level.

**Black and White Colobus Monkey**

**Canopy** **10–40 Meters**
The canopy is the dense "roof" of the rainforest. The crowns of trees capture sunlight to use in photosynthesis. Rain and sunlight filter through thick vegetation. Epiphytic orchids grow to the top of the canopy.

**Epiphytic Orchid**

**Paradise Flycatcher**

**Understory** **0–10 Meters**
The understory has trees and plants that need little light. Pythons lurk in the vegetation. Some small animals such as squirrels glide from branch to branch.

**Forest Floor** **0 Meters**
The forest floor is dark, humid, and still. Some animals, including frogs and insects, grow to gigantic sizes. Others are little, like the pygmy hippo.

**Pygmy Hippo**

## Science Activity

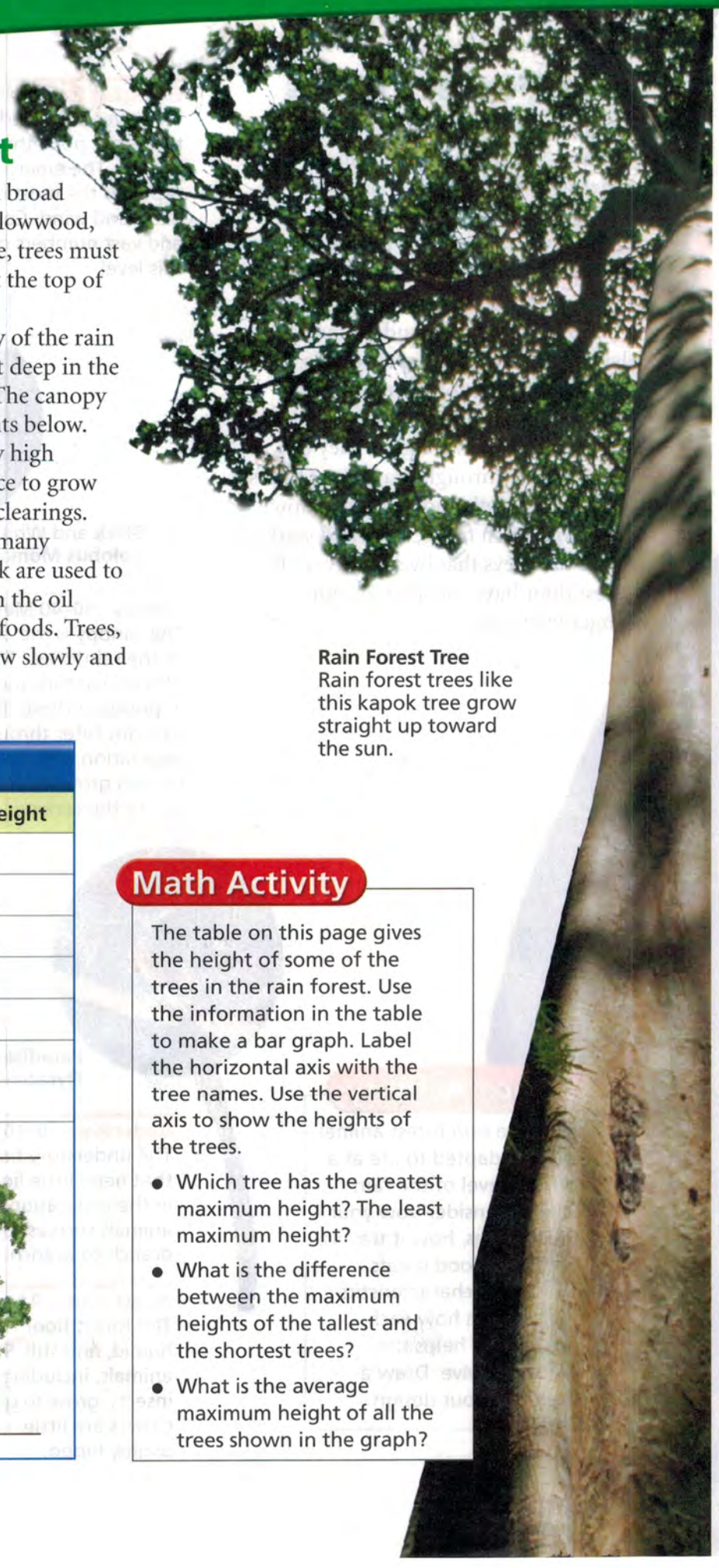
Design a rain forest animal that is adapted to life at a certain level of the rain forest. Consider how your animal lives, how it travels, and what food it eats. Outline its characteristics and explain how each adaptation helps the animal survive. Draw a sketch of your design.

## Reaching for Sunlight

Most rain forest trees are evergreens with broad leathery leaves. Some, like the African yellowwood, are conifers. Because the forest is so dense, trees must grow tall and straight to reach sunlight at the top of the canopy.

Along rivers, the floor and understory of the rain forest are a tangle of thick vegetation. But deep in the rain forest the floor is surprisingly bare. The canopy trees prevent sunlight from reaching plants below. Water drips from the leaves of the canopy high overhead. Young trees have the best chance to grow when older trees fall and open up sunny clearings.

West Africa's tropical forests contain many valuable trees. African mahogany and teak are used to make furniture, tools, and boats. Oil from the oil palm is used in soaps, candles, and some foods. Trees, such as ebony, that can tolerate shade grow slowly and develop dark, hard, long-lasting wood.



**Rain Forest Tree**
Rain forest trees like this kapok tree grow straight up toward the sun.

**Trees of the Rain Forest**

| Tree | Maximum Height |
|---|---|
| African oil palm | 18 m |
| African yellowwood | 20 m |
| Cape fig | 7 m |
| Ebony | 30 m |
| Kapok | 70 m |
| Raffia palm | 12 m |
| Teak | 46 m |


### Math Activity

The table on this page gives the height of some of the trees in the rain forest. Use the information in the table to make a bar graph. Label the horizontal axis with the tree names. Use the vertical axis to show the heights of the trees.

- Which tree has the greatest maximum height? The least maximum height?
- What is the difference between the maximum heights of the tallest and the shortest trees?
- What is the average maximum height of all the trees shown in the graph?

**Bark Cloth**
Traditional Mbuti clothing is made of bark cloth.

## Ituri Forest People

The native peoples of the African rain forest live as they have for thousands of years—by hunting and gathering. The forest supplies them with everything they need—food, water, firewood, building materials, and medicines.

One group of rain forest dwellers is the Mbuti people. The Mbuti live in the Ituri forest of the Democratic Republic of the Congo. Many of the Mbuti are quite small. The men hunt game, such as gazelle and antelope. The women gather wild fruits, nuts, and greens. Their traditional Mbuti clothing is made of tree bark and is wrapped around the waist. The bark is beaten to make it soft. Then it's decorated with geometric designs.

Most Mbuti live as nomads, with no settled home. Every few months they set up new hunting grounds. They build temporary dome-shaped huts of branches and leaves. Hunting groups of about 10 to 25 families live together.

Modern Africa has brought changes to the forest people, especially for those who live near the edges of the rain forest. For a few months of the year, some Mbuti work as laborers for farmers who live in villages at the edge of the forest. When their work is finished, the Mbuti return to the Ituri forest. Most forest people prefer not to cultivate their own land. Since the farmers don't hunt, they trade their goods for meat. In exchange for meat, the Mbuti receive goods such as iron tools, cooking pots, clothes, bananas, and other farm produce.

**The Mbuti**
The Mbuti hunt and fish along the Congo River.

### Social Studies Activity

List the goods that forest people and farmers might have to trade. Assume that no modern conveniences, such as tractors and stoves, are available. In writing, explain how goods might be exchanged. Assign a value to the farmers' goods and the Mbuti goods, depending upon each group's needs. How would the trading process change if money were exchanged?

# Climbing the Canopy

Much of the rain forest is still a mystery because it's so difficult for scientists to study the canopy. Native forest people sometimes climb these tall trees using strong, thick vines called lianas as support. But rain forest scientists have had to find different methods. Naturalist Gerald Durrell, working in the African rain forest, was lucky enough to find another way to observe the canopy. He describes it here.

**Gerald Durrell**
British conservationist Gerald Durrell wrote about his adventures with wildlife around the world. In this photo, Durrell holds an anteater.

While the canopy is one of the most richly inhabited regions of the forest it is also the one that causes the naturalist the greatest frustration. There he is, down in the gloom among the giant tree trunks, hearing the noises of animal life high above him and having half-eaten fruit, flowers, or seeds rained on him by legions of animals high in their sunlit domain—all of which he cannot see. Under these circumstances the naturalist develops a very bad temper and a permanent crick in the neck.

However, there was one occasion when I managed to transport myself into the forest canopy, and it was a magical experience. It happened in West Africa when I was camped on the thickly forested lower slopes of a mountain called N'da Ali. Walking through the forest one day I found I was walking along the edge of a great step cut out of the mountain. The cliff face, covered with creepers, dropped away for about 50 yards, so that although I was walking through forest, just next to me and slightly below was the canopy of the forest growing up from the base of the cliff. This cliff was over half a mile in length and provided me with a natural balcony from which I could observe the treetop life simply by lying on the cliff edge, concealed in the low undergrowth.

Over a period of about a week I spent hours up there and a whole pageant of wildlife passed by. The numbers of birds were incredible, ranging from minute glittering sunbirds in rainbow coloring, zooming like helicopters from blossom to blossom as they fed on the nectar, to the flocks of huge black hornbills with their monstrous yellow beaks who flew in such an ungainly manner and made such a noise over their choice of forest fruits.

From early morning to evening when it grew too dark to see, I watched this parade of creatures. Troops of monkeys swept past, followed by attendant flocks of birds who fed eagerly on the insects that the monkeys disturbed during their noisy crashing through the trees. Squirrels chased each other, or hotly pursued lizards, or simply lay spread-eagled on branches high up in the trees, enjoying the sun.

African Eagle

## Language Arts Activity

Besides being an experienced naturalist and writer, Gerald Durrell was also a careful observer. In this selection, he describes in detail the "magical experience" of being in the canopy. Reread Durrell's description. Now work with a partner to write and design a pamphlet that will persuade visitors to come to an African rain forest. For your pamphlet, write strong, lively descriptions of what you might see, hear, and experience. Be persuasive.

## Tie It **Together**

### Celebrate Diversity

Rain forests have the greatest biodiversity—variety of plant and animal life—of any ecosystem on Earth. Many species have yet to be discovered! Plan a display for your school to celebrate biodiversity in the rain forests. Include drawings, photos, and detailed captions.

- On a large map, locate and label Earth's tropical rain forests. Divide into groups to choose one rain forest region to research, such as Africa, Brazil, Costa Rica, Hawaii, or Borneo.
- With your group, study several animal and plant species in your chosen rain forest. You might choose monkeys, butterflies, birds, orchids, or medicinal plants.
- For each species, describe its appearance, where it occurs in the rain forest, its role in the ecosystem, and how it is useful to humans.

Grass Frog

Comet Moth

Mandrill

Chapter

# 21 Populations and Communities

## The BIG Idea

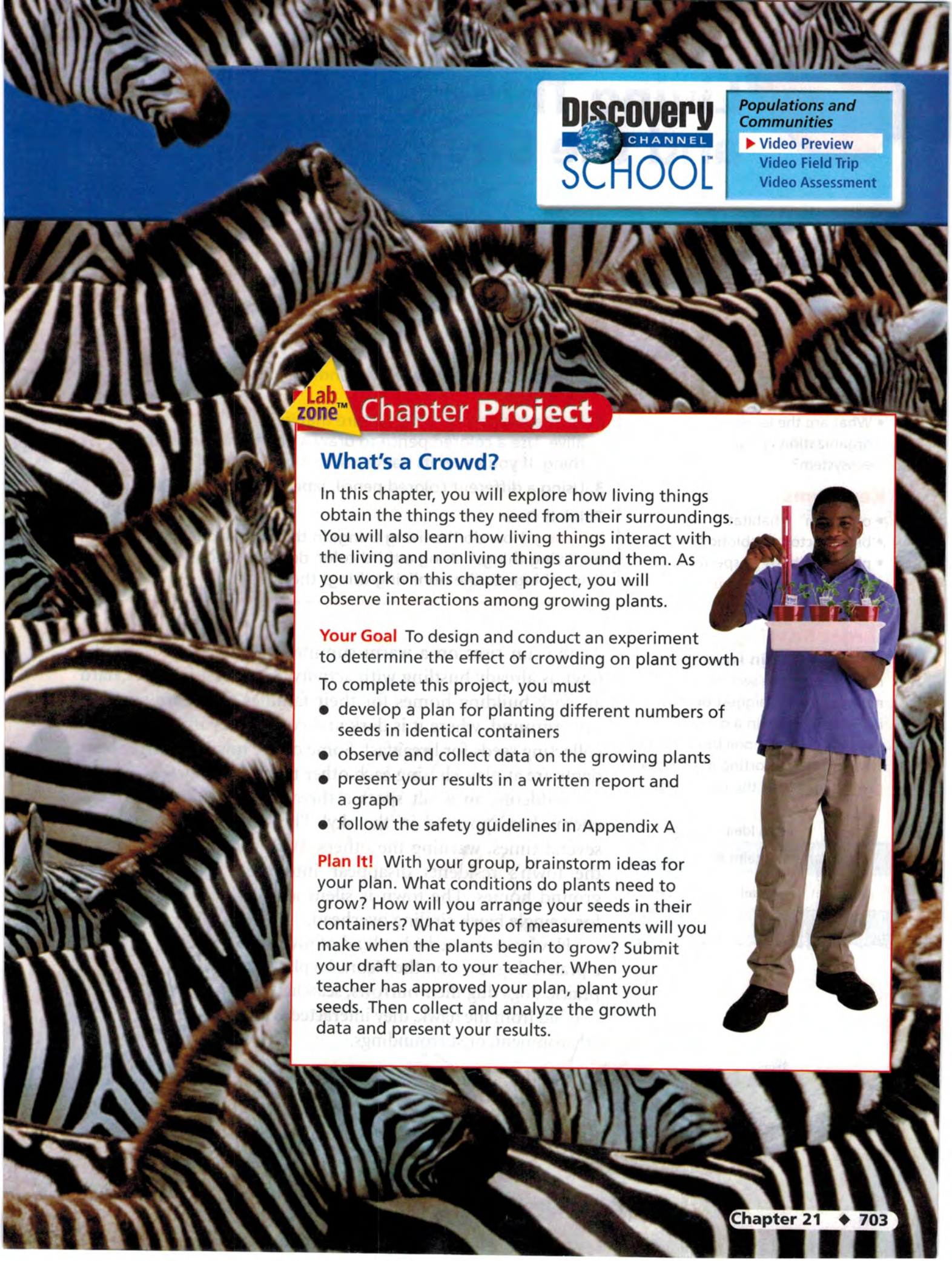
Populations and Ecosystems

**How do the living and nonliving parts of an ecosystem interact?**

### Chapter Preview



A population of Grant's zebras roams on the Masai Mara Reserve in Kenya. ▶



Discovery CHANNEL SCHOOL

*Populations and Communities*
- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ Chapter **Project**

## What's a Crowd?

In this chapter, you will explore how living things obtain the things they need from their surroundings. You will also learn how living things interact with the living and nonliving things around them. As you work on this chapter project, you will observe interactions among growing plants.



**Your Goal** To design and conduct an experiment to determine the effect of crowding on plant growth

To complete this project, you must

- develop a plan for planting different numbers of seeds in identical containers
- observe and collect data on the growing plants
- present your results in a written report and a graph
- follow the safety guidelines in Appendix A

**Plan It!** With your group, brainstorm ideas for your plan. What conditions do plants need to grow? How will you arrange your seeds in their containers? What types of measurements will you make when the plants begin to grow? Submit your draft plan to your teacher. When your teacher has approved your plan, plant your seeds. Then collect and analyze the growth data and present your results.

Section 1

# Living Things and the Environment

## Reading Preview

### Key Concepts

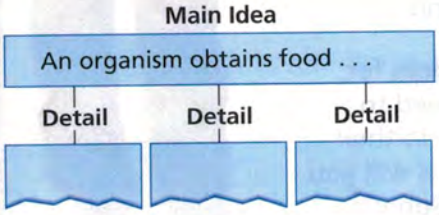
- What needs are met by an organism's environment?
- What are the two parts of an organism's habitat with which it interacts?
- What are the levels of organization within an ecosystem?

### Key Terms

- organism • habitat
- biotic factor • abiotic factor
- photosynthesis • species
- population • community
- ecosystem • ecology

### Target Reading Skill

**Identifying Main Ideas** As you read the Habitats section, write the main idea—the biggest or most important idea—in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.




## Lab zone Discover Activity

### What's in the Scene?

1. Choose a magazine picture of a nature scene. Paste the picture onto a sheet of paper, leaving space all around the picture.
2. Locate everything in the picture that is alive. Use a colored pencil to draw a line from each living thing. If you know its name, write it on the line.
3. Using a different colored pencil, label each nonliving thing.

**Think It Over**

**Inferring** How do the living things in the picture depend on the nonliving things? Using a third color, draw lines connecting the living things to the nonliving things they need.

As the sun rises on a warm summer morning, the Nebraska town is already bustling with activity. Some residents are hard at work building homes for their families. They are working underground, where it is dark and cool. Other inhabitants are collecting seeds for breakfast. Some of the town's younger residents are at play, chasing each other through the grass.

Suddenly, an adult spots a threatening shadow—an enemy has appeared in the sky! The adult cries out several times, warning the others. Within moments, the town's residents disappear into their underground homes. The town is silent and still, except for a single hawk circling overhead.

Have you guessed what kind of town this is? It is a prairie dog town on the Nebraska plains. As these prairie dogs dug their burrows, searched for food, and hid from the hawk, they interacted with their environment, or surroundings.

Black-Tailed Prairie Dog ▶

FIGURE 1
**An Organism in Its Habitat**
Like all organisms, this red-tailed hawk obtains food, water, and shelter from its habitat. Prairie dogs are a major source of food for the red-tailed hawk.

## Habitats

A prairie dog is one type of **organism,** or living thing. Different types of organisms must live in different types of environments. **An organism obtains food, water, shelter, and other things it needs to live, grow, and reproduce from its environment.** An environment that provides the things the organism needs to live, grow, and reproduce is called its **habitat.**

One area may contain many habitats. For example, in a forest, mushrooms grow in the damp soil, salamanders live on the forest floor, and woodpeckers build nests in tree trunks.

Organisms live in different habitats because they have different requirements for survival. A prairie dog obtains the food and shelter it needs from its habitat. It could not survive in a tropical rain forest or on the rocky ocean shore. Likewise, the prairie would not meet the needs of a spider monkey or hermit crab.

**Reading Checkpoint** **Why do different organisms live in different habitats?**

## Biotic Factors

To meet its needs, a prairie dog must interact with more than just the other prairie dogs around it. **An organism interacts with both the living and nonliving parts of its habitat.** The living parts of a habitat are called **biotic factors** (by AHT ik). Biotic factors in the prairie dogs' habitat include the grass and plants that provide seeds and berries. The hawks, ferrets, badgers, and eagles that hunt the prairie dogs are also biotic factors. In addition, worms, fungi, and bacteria are biotic factors that live in the soil underneath the prairie grass.

**Reading Checkpoint** **Name a biotic factor in your environment.**

FIGURE 2
**Abiotic Factors**
The nonliving things in an organism's habitat are abiotic factors. **Applying Concepts** *Name three abiotic factors you interact with each day.*

▲ This orangutan is enjoying a drink of water.

▲ Sunlight enables this plant to make its own food.

▲ This banjo frog burrows in the soil to stay cool.

# Abiotic Factors

**Abiotic factors** (ay by AHT ik) are the nonliving parts of an organism's habitat. They include water, sunlight, oxygen, temperature, and soil.

**Water** All living things require water to carry out their life processes. Water also makes up a large part of the bodies of most organisms. Your body, for example, is about 65 percent water. Plants and algae need water, along with sunlight and carbon dioxide, to make their own food in a process called **photosynthesis** (foh toh SIN thuh sis). Other living things depend on plants and algae for food.

**Sunlight** Because sunlight is needed for photosynthesis, it is an important abiotic factor for most living things. In places that do not receive sunlight, such as dark caves, plants and algae cannot grow. Because there are no plants or algae to provide food, few other organisms can live in such places.

**Oxygen** Most living things require oxygen to carry out their life processes. Oxygen is so important to the functioning of the human body that you can live only a few minutes without it. Organisms that live on land obtain oxygen from air, which is about 20 percent oxygen. Fish and other water organisms obtain oxygen that is dissolved in the water around them.

**Temperature** The temperatures that are typical of an area determine the types of organisms that can live there. For example, if you took a trip to a warm tropical island, you might see colorful orchid flowers and tiny lizards. These organisms could not survive on the frozen plains of Siberia.

Some animals alter their environments so they can survive very hot or very cold temperatures. Prairie dogs, for example, dig underground dens to find shelter from the hot summer sun and cold winter winds.

**Soil** Soil is a mixture of rock fragments, nutrients, air, water, and the decaying remains of living things. Soil in different areas consists of varying amounts of these materials. The type of soil in an area influences the kinds of plants that can grow there. Many animals, such as the prairie dogs, use the soil itself as a home. Billions of microscopic organisms such as bacteria also live in the soil.

**Reading Checkpoint** **How do abiotic factors differ from biotic factors?**

FIGURE 3
**A Population**
All these garter snakes make up a population.

## Levels of Organization

Of course, organisms do not live all alone in their habitat. Instead, organisms live together in populations and communities, and with abiotic factors in their ecosystems.

**Populations** In 1900, travelers saw a prairie dog town in Texas that covered an area twice the size of the city of Dallas. The town contained more than 400 million prairie dogs! These prairie dogs were all members of one species, or single kind, of organism. A **species** (SPEE sheez) is a group of organisms that are physically similar and can mate with each other and produce offspring that can also mate and reproduce.

All the members of one species in a particular area are referred to as a **population.** The 400 million prairie dogs in the Texas town are one example of a population. All the pigeons in New York City make up a population, as do all the bees that live in a hive. In contrast, all the trees in a forest do not make up a population, because they do not all belong to the same species. There may be pines, maples, birches, and many other tree species in the forest.

**Communities** A particular area usually contains more than one species of organism. The prairie, for instance, includes prairie dogs, hawks, grasses, badgers, and snakes, along with many other organisms. All the different populations that live together in an area make up a **community.**

To be considered a community, the different populations must live close enough together to interact. One way the populations in a community may interact is by using the same resources, such as food and shelter. For example, the tunnels dug by prairie dogs also serve as homes for burrowing owls and black-footed ferrets. The prairie dogs share the grass with other animals. Meanwhile, prairie dogs themselves serve as food for many species.

Lab zone **Try This Activity**

### With or Without Salt?

In this activity you will explore salt as an abiotic factor.

1. Label four 600-mL beakers A, B, C, and D. Fill each with 500 mL of room-temperature spring water.
2. Set beaker A aside. Add 2.5 grams of noniodized salt to beaker B, 7.5 grams of salt to beaker C, and 15 grams of salt to beaker D. Stir each beaker.
3. Add $\frac{1}{8}$ spoonful of brine shrimp eggs to each beaker.
4. Cover each beaker with a square of paper. Keep them away from direct light or heat. Wash your hands.
5. Observe the beakers daily for three days.

**Drawing Conclusions** In which beakers did the eggs hatch? What can you conclude about the amount of salt in the shrimps' natural habitat?

Go Online
SCILINKS NSTA
**For:** Links on biotic and abiotic factors
**Visit:** www.SciLinks.org
**Web Code:** scn-0511

**Ecosystems** The community of organisms that live in a particular area, along with their nonliving surroundings, make up an **ecosystem.** A prairie is just one of the many different ecosystems found on Earth. Other ecosystems in which living things make their homes include mountain streams, deep oceans, and evergreen forests.

Figure 4 shows the levels of organization in a prairie ecosystem. **The smallest level of organization is a single organism, which belongs to a population that includes other members of its species. The population belongs to a community of different species. The community and abiotic factors together form an ecosystem.**

Because the populations in an ecosystem interact with one another, any change affects all the different populations that live there. The study of how living things interact with each other and with their environment is called **ecology.** Ecologists are scientists who study ecology. As part of their work, ecologists study how organisms react to changes in their environment. An ecologist, for example, may look at how a fire affects a prairie ecosystem.

Reading Checkpoint **What is ecology?**

## Section 1 Assessment

**Target Reading Skill** **Identifying Main Ideas** Use your graphic organizer to help you answer Question 1 below.

### Reviewing Key Concepts

1. a. **Listing** What basic needs are provided by an organism's habitat?
   b. **Predicting** What might happen to an organism if its habitat could not meet one of its needs?
2. a. **Defining** Define the terms *biotic factors* and *abiotic factors.*
   b. **Interpreting Illustrations** List all the biotic and abiotic factors in Figure 4.
   c. **Making Generalizations** Explain why water and sunlight are two abiotic factors that are important to most organisms.
3. a. **Sequencing** List these terms in order from the smallest level to the largest: *population, organism, ecosystem, community.*
   b. **Classifying** Would all the different kinds of organisms in a forest be considered a population or a community? Explain.
   c. **Relating Cause and Effect** How might a change in one population affect other populations in a community?

### Writing in Science

**Descriptive Paragraph** What habitat do you live in? Write a one-paragraph description of your habitat. Describe how you obtain the food, water, and shelter you need from your habitat. How does this habitat meet your needs in ways that another would not?

FIGURE 4

## Ecological Organization

The smallest level of organization is the organism. The largest is the entire ecosystem.

**Organism:** Prairie dog

**Population:** Prairie dog town

**Community:** All the living things that interact on the prairie

**Ecosystem:** All the living and nonliving things that interact on the prairie

Lab zone **Skills Lab**

# A World in a Bottle

## Problem

How do organisms survive in a closed ecosystem?

## Skills Focus

making models, observing

## Materials

- gravel • soil • moss plants • plastic spoon
- charcoal • spray bottle • large rubber band
- 2 vascular plants • plastic wrap
- pre-cut, clear plastic bottle

## Procedure

1. In this lab, you will place plants in moist soil in a bottle that then will be sealed. This setup is called a terrarium. Predict whether the plants can survive in this habitat.
2. Spread about 2.5 cm of gravel on the bottom of a pre-cut bottle. Then sprinkle a spoonful or two of charcoal over the gravel.
3. Use the spoon to layer about 8 cm of soil over the gravel and charcoal. After you add the soil, tap it down to pack it.
4. Scoop out two holes in the soil. Remove the vascular plants from their pots. Gently place their roots in the holes. Then pack the loose soil firmly around the plants' stems.
5. Fill the spray bottle with water. Spray the soil until you see water collecting in the gravel.
6. Cover the soil with the moss plants, including the areas around the stems of the vascular plants. Lightly spray the mosses with water.
7. Tightly cover your terrarium with plastic wrap. Secure the cover with a rubber band. Place the terrarium in bright, indirect light.
8. Observe your terrarium daily for two weeks. Record your observations in your notebook. If its sides fog, move the terrarium to an area with a different amount of light. You may need to move it a few times. Note any changes you make in your terrarium's location.

## Analyze and Conclude

1. **Making Models** List all of the biotic factors and abiotic factors that are part of your ecosystem model.
2. **Observing** Were any biotic or abiotic factors able to enter the terrarium? If so, which ones?
3. **Inferring** Draw a diagram showing the interactions between the terrarium's biotic and abiotic factors?
4. **Predicting** Suppose a plant-eating insect were added to the terrarium. Predict whether it would be able to survive. Explain your prediction.
5. **Communicating** Write a paragraph that explains how your terrarium models an ecosystem on Earth. How does your model differ from that ecosystem?

## Design an Experiment

Plan an experiment that would model a freshwater ecosystem. How would this model be different from the land ecosystem? *Obtain your teacher's approval before carrying out your plan.*

Section 2

Integrating Mathematics

# Studying Populations

## Reading Preview

### Key Concepts

- How do ecologists determine the size of a population?
- What causes populations to change in size?
- What factors limit population growth?

### Key Terms

- estimate
- birth rate
- death rate
- immigration
- emigration
- population density
- limiting factor
- carrying capacity

### Target Reading Skill

**Asking Questions** Before you read, preview the red headings. In a graphic organizer like the one below, ask a question for each heading. As you read, write the answers to your questions.

**Studying Populations**

| Question | Answer |
|---|---|
| How do you determine population size? | Some methods of determining population size are . . . |
| | |

## Lab zone Discover Activity

### What's the Population of Beans in a Jar?

1. Fill a plastic jar with dried beans. This is your model population.
2. Your goal is to determine the bean population size, but you will not have time to count every bean. You may use any of the following to help you: a ruler, a small beaker, another large jar. Set a timer for two minutes when you are ready to begin.
3. After two minutes, record your answer. Then count the beans. How close was your answer?

**Think It Over**

**Forming Operational Definitions** In this activity, you came up with an estimate of the size of the bean population. Write a definition of the term *estimate* based on what you did.

How would you like to be an ecologist today? Your assignment is to study the albatross population on an island. One question you might ask is how the size of the albatross population has changed over time. Is the number of albatrosses on the island more than, less than, or the same as it was 50 years ago? To answer this question, you must first determine the current size of the albatross population.

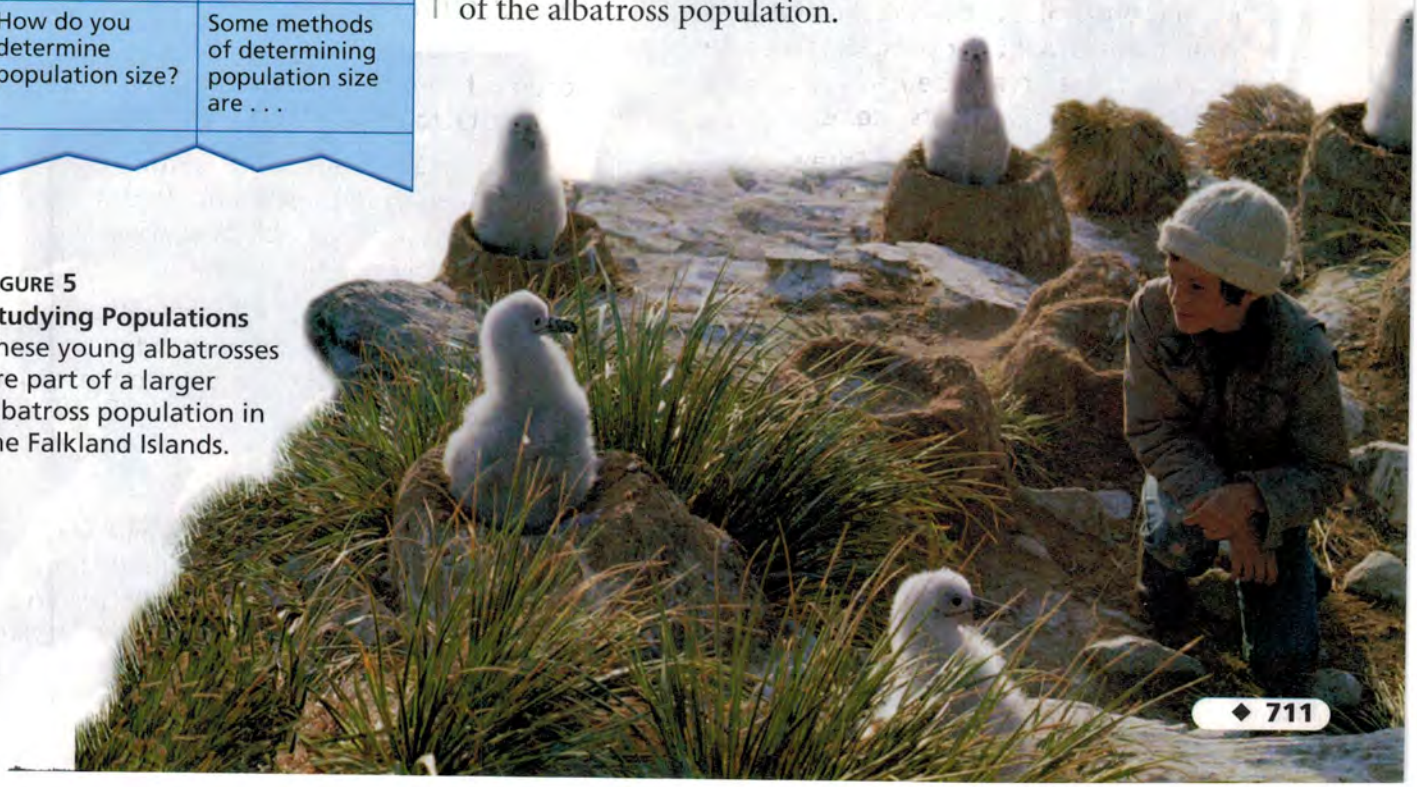


**FIGURE 5**
**Studying Populations**
These young albatrosses are part of a larger albatross population in the Falkland Islands.

## Determining Population Size

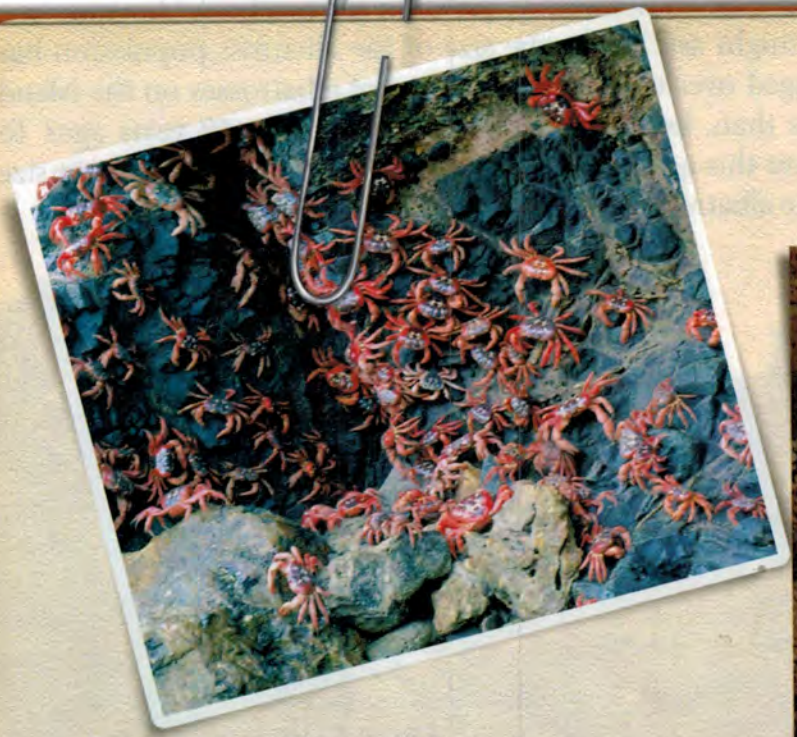
**Some methods of determining the size of a population are direct and indirect observations, sampling, and mark-and-recapture studies.**

**Direct Observation** The most obvious way to determine the size of a population is to count all of its members. For example, you could try to count all the crabs in a tide pool.

**Indirect Observation** Sometimes it may be easier to observe signs of organisms rather than the organisms themselves. Look at the mud nests built by cliff swallows in Figure 6. Each nest has one entrance hole. By counting the entrance holes, you can determine the number of swallow nests in this area. Suppose that the average number of swallows per nest is four: two parents and two offspring. If there are 120 nests, you can multiply 120 by 4 to determine that there are 480 swallows.

**Sampling** In many cases, it is not even possible to count signs of every member of a population. The population may be very large or spread over a wide area. In such cases, ecologists usually make an estimate. An **estimate** is an approximation of a number, based on reasonable assumptions.

FIGURE 6
**Determining Population Size**
Scientists use a variety of methods to determine the size of a population.



**Direct Observation**
Counting these crabs one by one is an example of direct observation.

**Indirect Observation**
One way to determine this cliff swallow population is to count their cone-shaped nests.

One way to estimate the size of a population is to count the number of organisms in a small area (a sample), and then multiply to find the number in a larger area. To get the most accurate estimate, your sample area should be typical of the larger area. Suppose you count 8 birch trees in 100 square meters of a forest. If the entire forest were 100 times that size, you would multiply your count by 100 to estimate the total population, or 800 birch trees.

**Mark-and-Recapture Studies** Another estimating method is called "mark and recapture." Here's an example showing how mark and recapture works. First, turtles in a bay are caught in a way that does not harm them. Ecologists count the turtles and mark each turtle's shell with a dot of paint before releasing it. Two weeks later, the researchers return and capture turtles again. They count how many turtles have marks, showing that they have been recaptured, and how many are unmarked. Using a mathematical formula, the ecologists can estimate the total population of turtles in the bay. You can try this technique for yourself in the Skills Lab at the end of this section.

**Reading Checkpoint** **When might an ecologist use indirect observation to estimate a population?**

**Lab zone Skills Activity**

## Calculating

An oyster bed is 100 meters long and 50 meters wide. In a 1-square-meter area you count 20 oysters. Estimate the population of oysters in the bed. (*Hint:* Drawing a diagram may help you set up your calculation.)

**Sampling**
To estimate the birch tree population in a forest, count the birches in a small area. Then multiply to find the number in the larger area.

**Mark and Recapture**
This researcher is releasing a marked turtle as part of a mark-and-recapture study.

## Changes in Population Size

By returning to a location often and using one of the methods described on the previous pages, ecologists can monitor the size of a population over time. **Populations can change in size when new members join the population or when members leave the population.**

**Births and Deaths** The main way in which new individuals join a population is by being born into it. The **birth rate** of a population is the number of births in a population in a certain amount of time. For example, suppose that a population of 100 cottontail rabbits produces 600 young in a year. The birth rate in this population would be 600 young per year.

The main way that individuals leave a population is by dying. The **death rate** is the number of deaths in a population in a certain amount of time. If 400 rabbits die in a year in the population, the death rate would be 400 rabbits per year.

**The Population Statement** When the birth rate in a population is greater than the death rate, the population will generally increase. This can be written as a mathematical statement using the "is greater than" sign:

**If birth rate > death rate, population size increases.**

However, if the death rate in a population is greater than the birth rate, the population size will generally decrease. This can also be written as a mathematical statement:

**If death rate > birth rate, population size decreases.**

**Immigration and Emigration** The size of a population also can change when individuals move into or out of the population, just as the population of your town changes when families move into town or move away. **Immigration** (im ih GRAY shun) means moving into a population. **Emigration** (em ih GRAY shun) means leaving a population. For instance, if food is scarce, some members of an antelope herd may wander off in search of better grassland. If they become permanently separated from the original herd, they will no longer be part of that population.

**Graphing Changes in Population** Changes in a population's size can be displayed on a line graph. Figure 7 shows a graph of the changes in a rabbit population. The vertical axis shows the numbers of rabbits in the population, while the horizontal axis shows time. The graph shows the size of the population over a ten-year period.

**Math Skills**

### Inequalities

The population statement is an example of an inequality. An inequality is a mathematical statement that compares two expressions. Two signs that represent inequalities are

**< (is less than)**

**> (is greater than)**

For example, an inequality comparing the fraction to the decimal 0.75 would be written

$$\frac{1}{2} < 0.75$$

**Practice Problems** Write an inequality comparing each pair of expressions below.

1. $5 \blacksquare -6$
2. $0.4 \blacksquare \frac{3}{5}$
3. $-2 - (-8) \blacksquare 7 - 1.5$

**FIGURE 7**
This line graph shows how the size of a rabbit population changed over a ten-year period. **Interpreting Graphs** *In what year did the rabbit population reach its highest point? What was the size of the population in that year?*

**Go Online**
**active art**
**For:** Changes in Population activity
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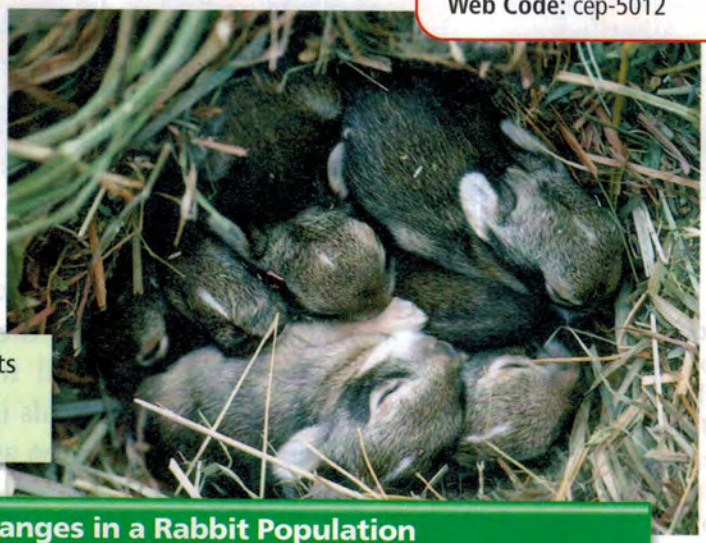
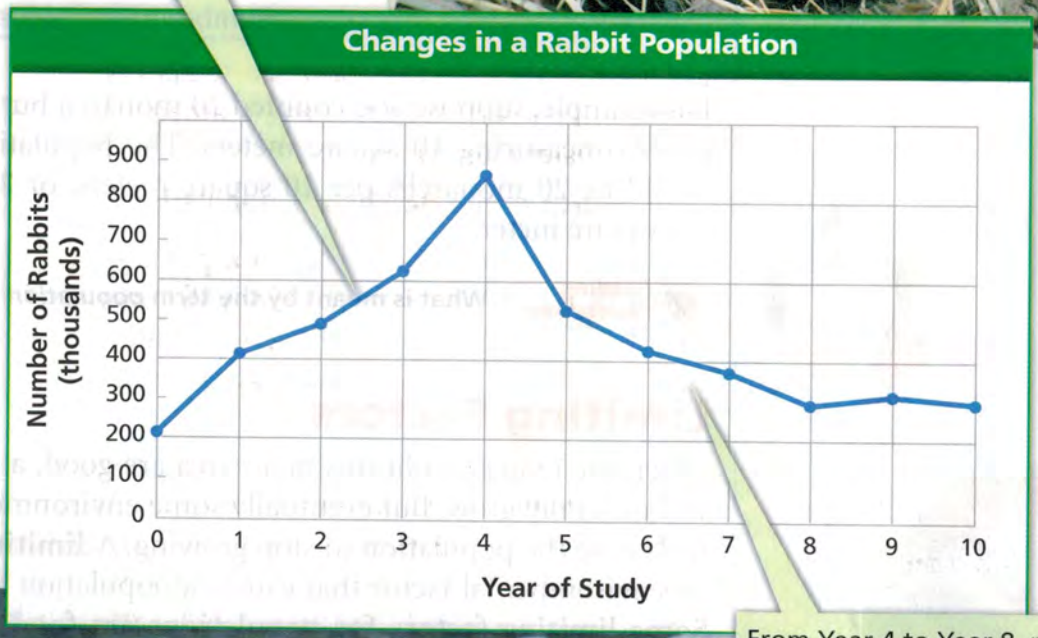
▼ Young cottontail rabbits in a nest



From Year 0 to Year 4, more rabbits joined the population than left it, so the population increased.




From Year 4 to Year 8, more rabbits left the population than joined it, so the population decreased.

◀ Cottontail rabbit caught by a fox

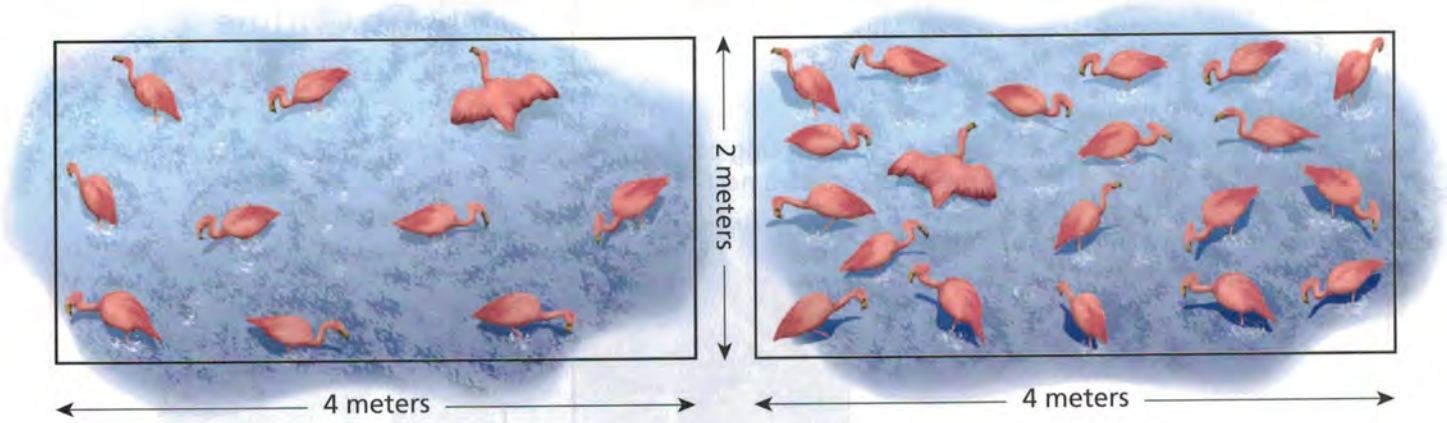



**FIGURE 8**
**Population Density**
In the pond on the top left, there are ten flamingos in 8 square meters. The population density is 1.25 flamingos per square meter.
**Calculating** *What is the population density of the flamingos in the pond on the top right?*

**Population Density** Sometimes an ecologist may need to know more than just the total size of a population. In many situations, it is helpful to know the **population density**—the number of individuals in an area of a specific size. Population density can be written as an equation:

$$\text{Population density} = \frac{\text{Number of individuals}}{\text{Unit area}}$$

For example, suppose you counted 20 monarch butterflies in a garden measuring 10 square meters. The population density would be 20 monarchs per 10 square meters, or 2 monarchs per square meter.

**Reading Checkpoint** **What is meant by the term *population density*?**

## Limiting Factors

When the living conditions in an area are good, a population will generally grow. But eventually some environmental factor will cause the population to stop growing. A **limiting factor** is an environmental factor that causes a population to decrease. **Some limiting factors for populations are food and water, space, and weather conditions.**

**Food and Water** Organisms require food and water to survive. Since food and water are often in limited supply, they are often limiting factors. Suppose a giraffe must eat 10 kilograms of leaves each day to survive. The trees in an area can provide 100 kilograms of leaves a day while remaining healthy. Five giraffes could live easily in this area, since they would only require a total of 50 kilograms of food. But 15 giraffes could not all survive—there would not be enough food. No matter how much shelter, water, and other resources there were, the population would not grow much larger than 10 giraffes.

◀ Greater flamingo

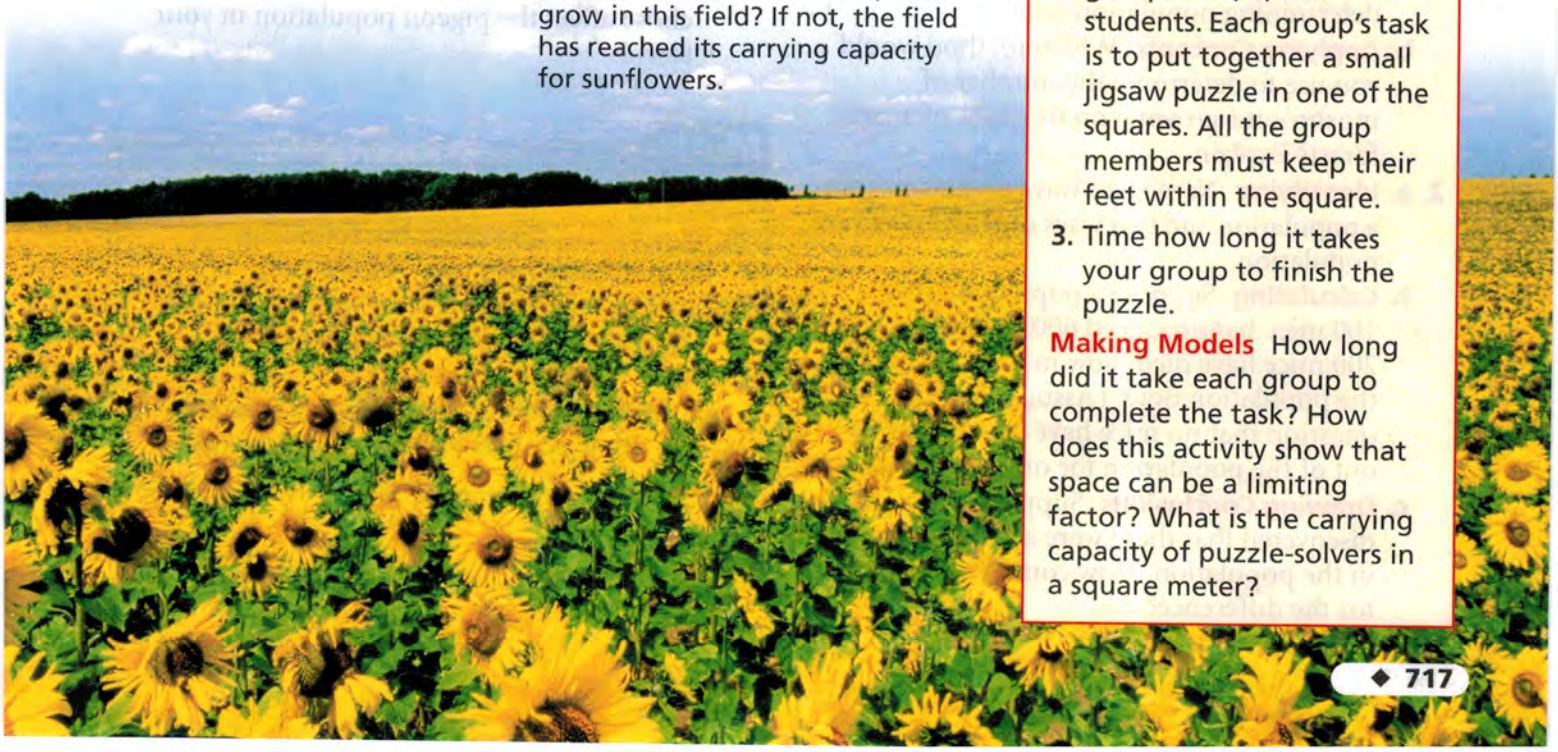
The largest population that an area can support is called its **carrying capacity.** The carrying capacity of this giraffe habitat would be 10 giraffes. A population usually stays near its carrying capacity because of the limiting factors in its habitat.

FIGURE 9
**Food as a Limiting Factor**
These jackals are fighting over the limited food available to them.

**Space** Space is another limiting factor for populations. Gannets are seabirds that are usually seen flying over the ocean. They come to land only to nest on rocky shores. But the nesting shores get very crowded. If a pair does not find room to nest, they will not be able to add any offspring to the gannet population. So nesting space on the shore is a limiting factor for gannets. If there were more nesting space, more gannets would be able to nest, and the population would increase.

Space is also a limiting factor for plants. The amount of space in which a plant grows determines whether the plant can obtain the sunlight, water, and soil nutrients it needs. For example, many pine seedlings sprout each year in a forest. But as the seedlings grow, the roots of those that are too close together run out of space. Branches from other trees may block the sunlight the seedlings need. Some of the seedlings then die, limiting the size of the pine population.

FIGURE 10
**Space as a Limiting Factor**
Could any more sunflower plants grow in this field? If not, the field has reached its carrying capacity for sunflowers.



Lab zone **Try This Activity**

## Elbow Room

1. Using masking tape, mark off several one-meter squares on the floor of your classroom.
2. Your teacher will set up groups of 2, 4, and 6 students. Each group's task is to put together a small jigsaw puzzle in one of the squares. All the group members must keep their feet within the square.
3. Time how long it takes your group to finish the puzzle.

**Making Models** How long did it take each group to complete the task? How does this activity show that space can be a limiting factor? What is the carrying capacity of puzzle-solvers in a square meter?

**FIGURE 11**
**Weather as a Limiting Factor**
A snowstorm can limit the size of an orange crop.
**Applying Concepts** *What other weather conditions can limit population growth?*

**Weather** Weather conditions such as temperature and the amount of rainfall can also limit population growth. A cold snap in late spring can kill the young of many species of organisms, including birds and mammals. A hurricane or flood can wash away nests and burrows. Such unusual events can have long-lasting effects on population size.

**Reading Checkpoint** **What is one weather condition that can limit the growth of a population?**

## Section 2 Assessment

**Target Reading Skill** **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

### Reviewing Key Concepts

1. a. **Listing** What are four methods of determining population size?
   b. **Applying Concepts** Which method would you use to determine the number of mushrooms growing on the floor of a large forest? Explain.
2. a. **Identifying** Name two ways organisms join a population and two ways organisms leave a population.
   b. **Calculating** Suppose a population of 100 mice has produced 600 young. If 200 mice have died, how many mice are in the population now? (Assume for this question that no mice have moved into or out of the population for other reasons.)
   c. **Drawing Conclusions** Suppose that you discovered that there were actually 750 mice in the population. How could you account for the difference?
3. a. **Reviewing** Name three limiting factors for populations.
   b. **Describing** Choose one of the limiting factors and describe how it limits population growth.
   c. **Inferring** How might the limiting factor you chose affect the pigeon population in your town?

**Math Practice**

4. **Inequalities** Complete the following inequality showing the relationship between carrying capacity and population size. Then explain why the inequality is true.

**If population size ■ carrying capacity, then population size will decrease.**

Lab zone **Skills Lab**

# Counting Turtles

## Problem

How can the mark-and-recapture method help ecologists monitor the size of a population?

## Skills Focus

calculating, graphing, predicting

## Materials

- model paper turtle population
- calculator
- graph paper

## Procedure

1. The data table shows the results from the first three years of a population study to determine the number of snapping turtles in a pond. Copy the table into your notebook.

Data Table

| Year | Number Marked | Total Number Captured | Number Recaptured (With Marks) | Estimated Total Population |
|---|---|---|---|---|
| 1 | 32 | 28 | 15 | |
| 2 | 25 | 21 | 11 | |
| 3 | 23 | 19 | 11 | |
| 4 | 15 | | | |

2. Your teacher will give you a box representing the pond. Fifteen of the turtles have been marked, as shown in the data table for Year 4.
3. Capture a member of the population by randomly selecting one turtle. Set it aside.
4. Repeat Step 3 nine times. Record the total number of turtles you captured.
5. Examine each turtle to see whether it has a mark. Count the number of recaptured (marked) turtles. Record this number in your data table.

## Analyze and Conclude

1. **Calculating** Use the equation below to estimate the turtle population for each year. The first year is done for you as a sample. If your answer is a decimal, round it to the nearest whole number. Record the population for each year in the last column of the data table.

$$\text{Total population} = \frac{\text{Number marked} \times \text{Total number captured}}{\text{Number recaptured (with marks)}}$$

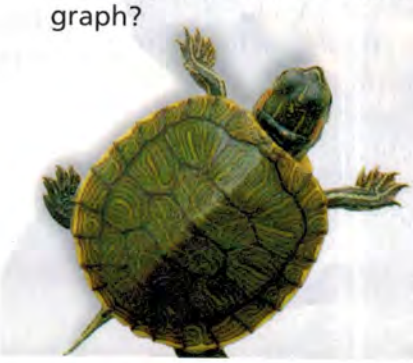
Sample (Year 1):

$$\frac{32 \times 28}{15} = 59.7 \text{ or } 60 \text{ turtles}$$

2. **Graphing** Graph the estimated total populations for the four years. Mark years on the horizontal axis. Mark population size on the vertical axis.
3. **Interpreting Data** Describe how the turtle population has changed over the four years of the study. Suggest three possible causes for the changes.
4. **Predicting** Use your graph to predict what the turtle population will be in Year 5. Explain your prediction.
5. **Communicating** Write a paragraph that explains why the mark-and-recapture method is a useful tool for ecologists. When is this technique most useful for estimating a population's size?

## More to Explore

Suppose that only six turtles had been recaptured in Year 2. How would this change your graph?



# Animal Overpopulation: How Can People Help?

**White-Tailed Deer**
To obtain food, deer are moving into people's yards.

Populations of white-tailed deer are growing rapidly in many parts of the United States. As populations soar, food becomes a limiting factor. Many deer die of starvation. Others grow up small and unhealthy. In search of food, hungry deer move closer to where humans live. There they eat farm crops, garden vegetables, shrubs, and even trees. In addition, increased numbers of deer near roads can cause automobile accidents.

People admire the grace and swiftness of deer. Most people don't want these animals to suffer from starvation or illness. Should people take action to limit growing deer populations?

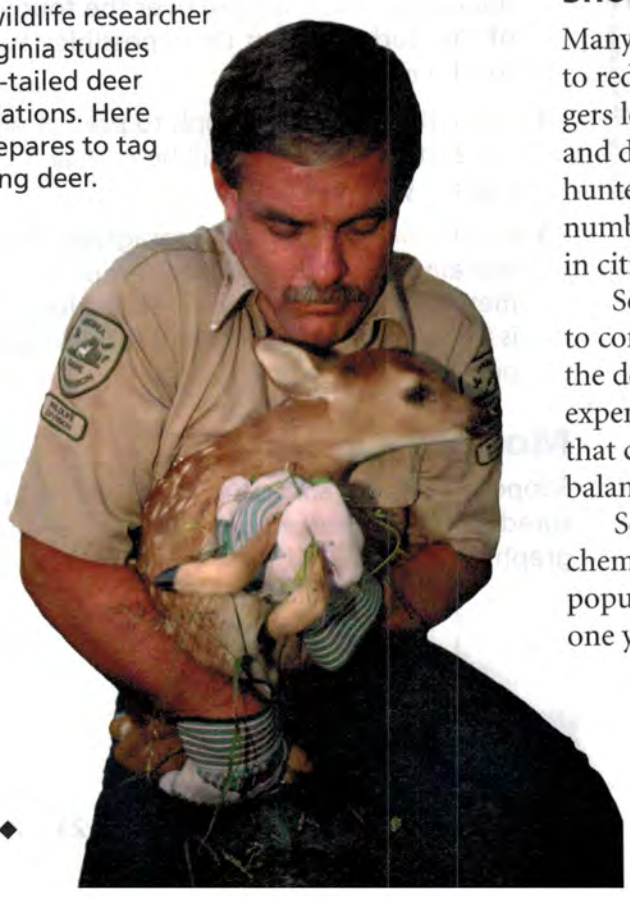
## The Issues

### Should People Take Direct Action?

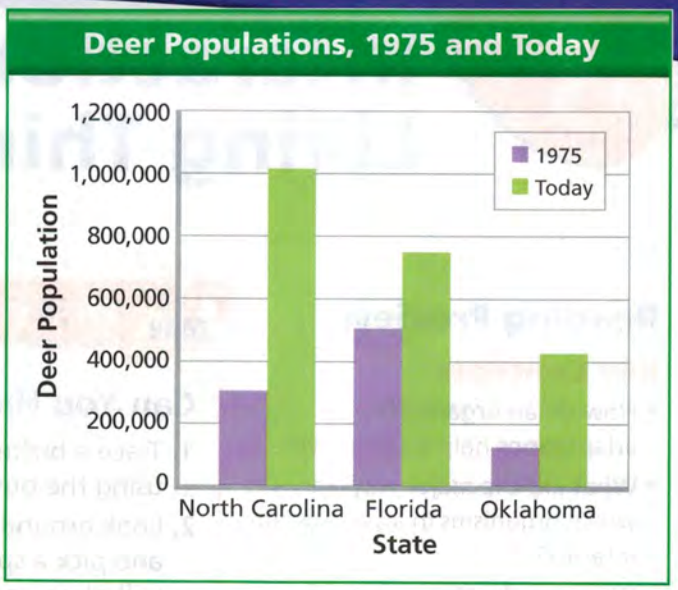
Many people argue that hunting is the best way to reduce animal populations. Wildlife managers look at the supply of resources in an area and determine its carrying capacity. Then hunters are issued licenses to help reduce the number of deer. Hunting is usually not allowed in cities or suburbs, however.

Some people favor nonhunting approaches to control deer populations. One plan is to trap the deer and relocate them. But this method is expensive and requires finding another location that can accept the deer without upsetting the balance of its own ecosystem.

Scientists are also working to develop chemicals to reduce the birth rate in deer populations. But this plan is effective for only one year at a time.



**Wildlife Technician**
This wildlife researcher in Virginia studies white-tailed deer populations. Here he prepares to tag a young deer.




**White-Tailed Deer Populations**
This graph shows how the deer populations have grown in North Carolina, Florida, and Oklahoma.

## Should People Take Indirect Action?

Some suggest bringing in natural predators of deer, such as wolves, mountain lions, and bears, to areas with too many deer. But these animals could also attack cattle, dogs, cats, and even humans. Other communities have built tall fences around areas to keep out the deer. However, this solution is impractical for farmers or ranchers.

## Should People Do Nothing?

Some people oppose any kind of action. They support leaving the deer alone and allowing nature to take its course. Animal populations in an area naturally cycle up and down over time. Doing nothing means that some deer will die of starvation or disease. But eventually, the population will be reduced to a size within the carrying capacity of the environment.

## You Decide

### 1. Identify the Problem

In your own words, explain the problem created by the overpopulation of white-tailed deer.

### 2. Analyze the Options

List the ways that people can deal with the overpopulation of white-tailed deer. State the positive and negative points of each method.

### 3. Find a Solution

Suppose you are an ecologist in an area that has twice as many deer as it can support. Propose a way for the community to deal with the problem.

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Section 3

# Interactions Among Living Things

## Reading Preview

### Key Concepts

- How do an organism's adaptations help it to survive?
- What are the major ways in which organisms in an ecosystem interact?
- What are the three types of symbiotic relationships?

### Key Terms

- natural selection
- adaptations • niche
- competition • predation
- predator • prey • symbiosis
- mutualism • commensalism
- parasitism • parasite • host

### Target Reading Skill

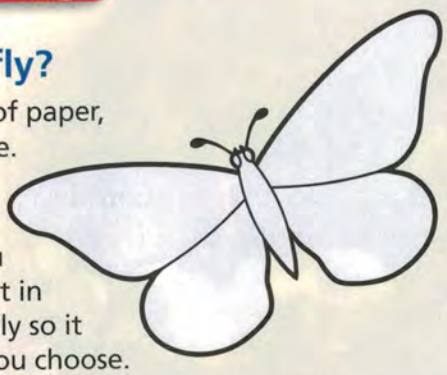
**Using Prior Knowledge** Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about how living things interact in a graphic organizer like the one below. As you read, continue to write in what you learn.

| What You Know |
| --- |
| 1. Organisms interact in different ways.<br>2. |

| What You Learned |
| --- |
| 1.<br>2. |

### Lab zone Discover Activity

#### Can You Hide a Butterfly?



1. Trace a butterfly on a piece of paper, using the outline shown here.
2. Look around the classroom and pick a spot where you will place your butterfly. You must place your butterfly out in the open. Color your butterfly so it will blend in with the spot you choose.
3. Tape your butterfly down. Someone will now have one minute to find the butterflies. Will your butterfly be found?

**Think It Over**

**Predicting** Over time, do you think the population size of butterflies that blend in with their surroundings would increase or decrease?

Can you imagine living in a cactus like the one in Figure 12? Ouch! You probably wouldn't want to live in a house covered with sharp spines. But many species live in, on, and around saguaro cactuses.

As day breaks, a twittering sound comes from a nest tucked in one of the saguaro's arms. Two young red-tailed hawks are preparing to fly for the first time. Farther down the stem, a tiny elf owl peeks out of its nest in a small hole. This owl is so small it could fit in your palm! A rattlesnake slithers around the base of the saguaro, looking for lunch. Spying a shrew, the snake strikes it with its needle-like fangs. The shrew dies instantly.

Activity around the saguaro continues after sunset. Long-nosed bats come out to feed on the nectar from the saguaro's blossoms. The bats stick their faces into the flowers to feed, dusting their long snouts with white pollen. As they move from plant to plant, they carry the pollen to other saguaros. This enables the cactuses to reproduce.

## Adapting to the Environment

Each organism in the saguaro community has unique characteristics. These characteristics affect the individual's ability to survive in its environment.

**Natural Selection** A characteristic that makes an individual better suited to its environment may eventually become common in that species through a process called **natural selection.** Natural selection works like this: Individuals whose unique characteristics are best suited for their environment tend to survive and produce offspring. Offspring that inherit these characteristics also live to reproduce. In this way, natural selection results in **adaptations,** the behaviors and physical characteristics that allow organisms to live successfully in their environments.

Individuals with characteristics that are poorly suited to the environment are less likely to survive and reproduce. Over time, poorly suited characteristics may disappear from the species.

**Niche** **Every organism has a variety of adaptations that are suited to its specific living conditions.** The organisms in the saguaro community have adaptations that result in specific roles. The role of an organism in its habitat, or how it makes its living, is called its **niche.** A niche includes the type of food the organism eats, how it obtains this food, and which other organisms use the organism as food. A niche also includes when and how the organism reproduces and the physical conditions it requires to survive.

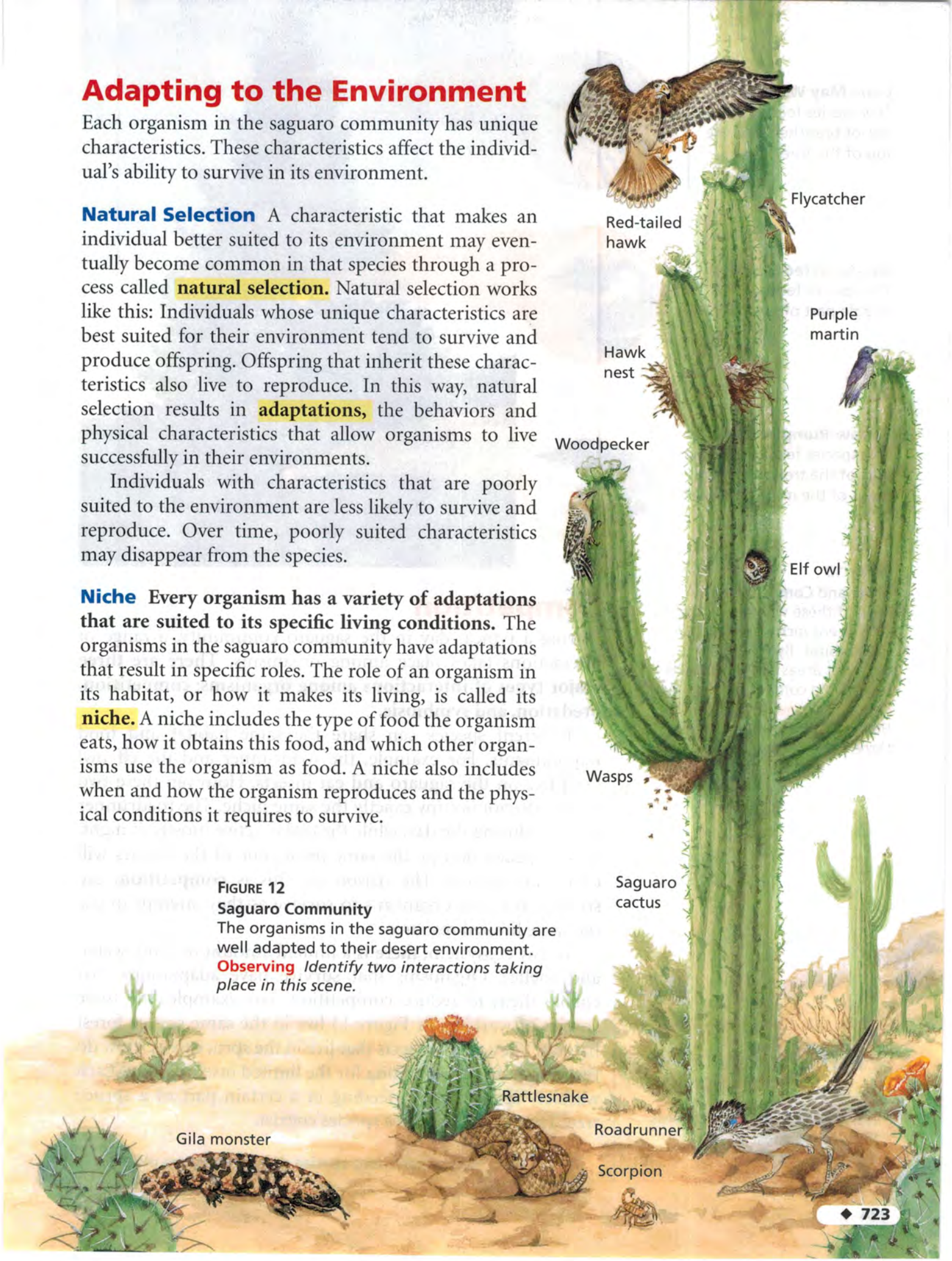



**FIGURE 12**
**Saguaro Community**
The organisms in the saguaro community are well adapted to their desert environment.
**Observing** *Identify two interactions taking place in this scene.*

**Cape May Warbler**
This species feeds at the tips of branches near the top of the tree.

**Bay-Breasted Warbler**
This species feeds in the middle part of the tree.

**Yellow-Rumped Warbler**
This species feeds in the lower part of the tree and at the bases of the middle branches.

**FIGURE 13**
**Niche and Competition**
Each of these warblers occupies a different niche in its spruce tree habitat. By feeding in different areas of the tree, the birds avoid competing for food.
**Comparing and Contrasting**
*How do the niches of these three warblers differ?*

## Competition

During a typical day in the saguaro community, a range of interactions takes place among organisms. **There are three major types of interactions among organisms: competition, predation, and symbiosis.**

Different species can share the same habitat and food requirements. For example, the roadrunner and the elf owl both live on the saguaro and eat insects. However, these two species do not occupy exactly the same niche. The roadrunner is active during the day, while the owl is active mostly at night. If two species occupy the same niche, one of the species will eventually die off. The reason for this is **competition,** the struggle between organisms to survive as they attempt to use the same limited resource.

In any ecosystem, there is a limited amount of food, water, and shelter. Organisms that survive have adaptations that enable them to reduce competition. For example, the three species of warblers in Figure 13 live in the same spruce forest habitat. They all eat insects that live in the spruce trees. How do these birds avoid competing for the limited insect supply? Each warbler "specializes" in feeding in a certain part of a spruce tree. This is how the three species coexist.

**Reading Checkpoint** **Why can't two species occupy the same niche?**

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**Web Code:** ced-5013

## Predation

A tiger shark lurks below the surface of the clear blue water, looking for shadows of albatross chicks floating above. The shark spots a chick and silently swims closer. Suddenly, the shark bursts through the water and seizes the albatross with one snap of its powerful jaw. This interaction between two organisms has an unfortunate ending for the albatross.

An interaction in which one organism kills another for food is called **predation.** The organism that does the killing, in this case the tiger shark, is the **predator.** The organism that is killed, in this case the albatross, is the **prey.**

**The Effect of Predation on Population Size** Predation can have a major effect on the size of a population. Recall from Section 2 that when the death rate exceeds the birth rate in a population, the size of that population usually decreases. So if there are many predators, the result is often a decrease in the size of the population of their prey. But a decrease in the number of prey results in less food for their predators. Without adequate food, the predator population starts to decline. So, generally, populations of predators and their prey rise and fall in related cycles.

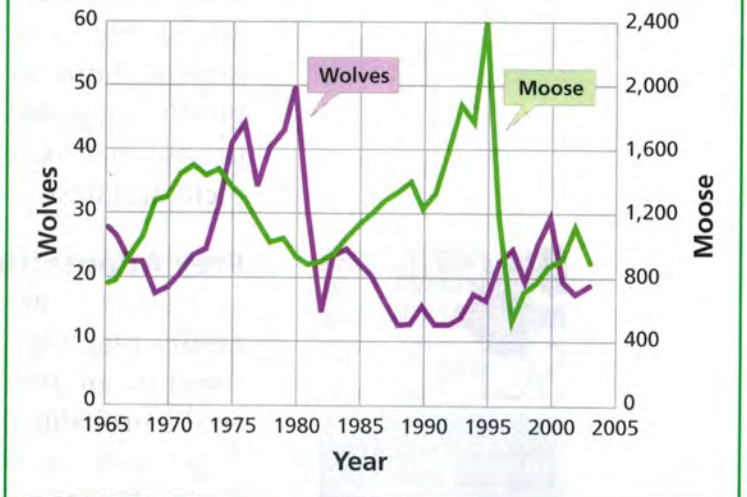
**FIGURE 14**
**Predation**
This green tree python and mouse are involved in a predator-prey interaction.

## Math Analyzing Data

### Predator-Prey Interactions

On Isle Royale, an island in Lake Superior, the populations of wolves (the predator) and moose (the prey) rise and fall in cycles. Use the graph to answer the questions.

**Wolf and Moose Populations on Isle Royale**




1. **Reading Graphs** What variable is plotted on the *x*-axis? What two variables are plotted on the *y*-axis?
2. **Interpreting Data** How did the moose population change between 1965 and 1972? What happened to the wolf population from 1973 through 1976?
3. **Inferring** How might the change in the moose population have led to the change in the wolf population?
4. **Drawing Conclusions** What is one likely cause of the dip in the moose population between 1974 and 1981?
5. **Predicting** How might a disease in the wolf population one year affect the moose population the next year?

**FIGURE 15**
**Predator Adaptations**
This greater horseshoe bat has adaptations that allow it to find prey in the dark. The bat produces pulses of sound and locates prey by interpreting the echoes.
**Inferring** *What other adaptations might contribute to the bat's success as a predator?*

**Predator Adaptations** Predators have adaptations that help them catch and kill their prey. For example, a cheetah can run very fast for a short time, enabling it to catch its prey. A jellyfish's tentacles contain a poisonous substance that paralyzes tiny water animals. Some plants, too, have adaptations for catching prey. The sundew is covered with sticky bulbs on stalks—when a fly lands on the plant, it remains snared in the sticky goo while the plant digests it.

Some predators have adaptations that enable them to hunt at night. For example, the big eyes of an owl let in as much light as possible to help it see in the dark. Insect-eating bats can hunt without seeing at all. Instead, they locate their prey by producing pulses of sound and listening for the echoes. This precise method enables a bat to catch a flying moth in complete darkness.



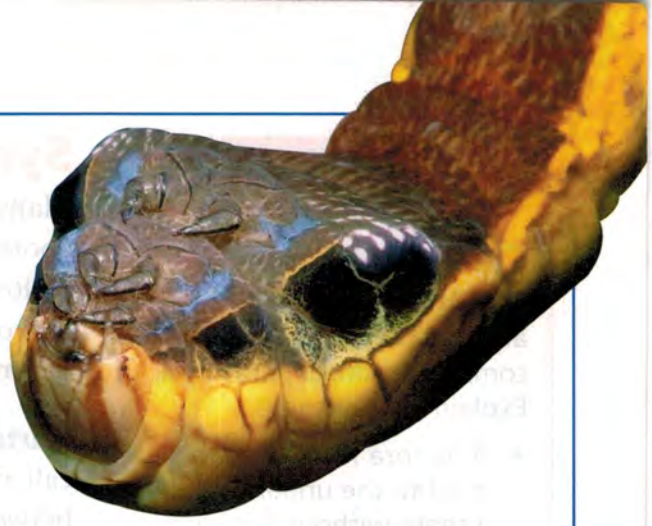
**Prey Adaptations** How do organisms avoid being killed by such effective predators? Organisms have many kinds of adaptations that help them avoid becoming prey. The alertness and speed of an antelope help protect it from its predators. And you're probably not surprised that the smelly spray of a skunk helps keep its predators at a distance. As you can see in Figure 16, other organisms also have some very effective ways to avoid becoming a predator's next meal.

**Reading Checkpoint** **What are two predator adaptations?**

FIGURE 16

## Defense Strategies

Organisms display a wide array of adaptations that help them avoid becoming prey.



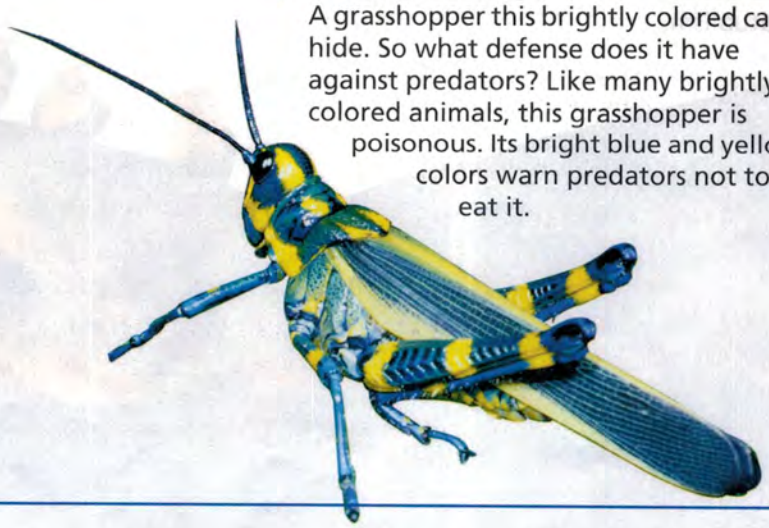
**Mimicry ▶**
If you're afraid of snakes, you'd probably be terrified to see this organism staring at you. But this caterpillar only looks like a snake. Its convincing resemblance to a viper tricks would-be predators into staying away.

**False Coloring ▲**
If you saw this moth in a dark forest, you might think you were looking into the eyes of a large mammal. The large false eyespots on the moth's wings scare potential predators away.

**Protective Covering ▼**
Have you ever seen a pine cone with a face? This organism is actually a pangolin, a small African mammal. When threatened, the pangolin protects itself by rolling up into a scaly ball.

**Camouflage ▲**
Is it a leaf? Actually, it's a walking leaf insect. But if you were a predator, you might be fooled into looking elsewhere for a meal.

**▼ Warning Coloring**
A grasshopper this brightly colored can't hide. So what defense does it have against predators? Like many brightly colored animals, this grasshopper is poisonous. Its bright blue and yellow colors warn predators not to eat it.



Lab zone Skills Activity

### Classifying

Classify each interaction as an example of mutualism, commensalism, or parasitism. Explain your answers.

- A remora fish attaches itself to the underside of a shark without harming the shark, and eats left-over bits of food from the shark's meals.
- A vampire bat drinks the blood of horses.
- Bacteria living in cows' stomachs help them break down the cellulose in grass.

## Symbiosis

Many of the interactions in the saguaro community you read about are examples of symbiosis. **Symbiosis** (sim bee OH sis) is a close relationship between two species that benefits at least one of the species. **The three types of symbiotic relationships are mutualism, commensalism, and parasitism.**

**Mutualism** A relationship in which both species benefit is called **mutualism** (MYOO choo uh liz um). The relationship between the saguaro and the long-eared bats is an example of mutualism. The bats benefit because the cactus flowers provide them with food. The saguaro benefits as its pollen is carried to another plant on the bat's nose.

In some cases of mutualism, two species are so dependent on each other that neither could live without the other. This is true for some species of acacia trees and stinging ants in Central and South America. The stinging ants nest only in the acacia tree, whose thorns discourage the ants' predators. The tree also provides the ants' only food. The ants, in turn, attack other animals that approach the tree and clear competing plants away from the base of the tree. To survive, each species needs the other.

**Commensalism** A relationship in which one species benefits and the other species is neither helped nor harmed is called **commensalism** (kuh MEN suh liz um). The red-tailed hawks' interaction with the saguaro is an example of commensalism. The hawks benefit by having a place to build their nest, while the cactus is not affected by the hawks.

Commensalism is not very common in nature because two species are usually either helped or harmed a little by any interaction. For example, by creating a small hole for its nest in the cactus stem, the elf owl slightly damages the cactus.

**FIGURE 17**
**Mutualism**
Three yellow-billed oxpeckers get a cruise and a snack aboard an obliging hippopotamus. The oxpeckers eat ticks living on the hippo's skin. Since both the birds and the hippo benefit from this interaction, it is an example of mutualism.

**Parasitism** Parasitism (PA ruh sit iz um) involves one organism living on or inside another organism and harming it. The organism that benefits is called a **parasite,** and the organism it lives on or in is called a **host.** The parasite is usually smaller than the host. In a parasitic relationship, the parasite benefits from the interaction while the host is harmed.

Some common parasites are fleas, ticks, and leeches. These parasites have adaptations that enable them to attach to their host and feed on its blood. Other parasites live inside the host's body, such as tapeworms that live inside the digestive systems of dogs, wolves, and some other mammals.

Unlike a predator, a parasite does not usually kill the organism it feeds on. If the host dies, the parasite loses its source of food. An interesting example of this rule is shown by a species of mite that lives in the ears of moths. The mites almost always live in just one of the moth's ears. If they live in both ears, the moth's hearing is so badly affected that it is likely to be quickly caught and eaten by its predator, a bat.

Reading Checkpoint **Why doesn't a parasite usually kill its host?**

FIGURE 18
**Parasitism**
Ticks feed on the blood of certain animals. **Classifying** *Which organism in this interaction is the parasite? Which organism is the host?*

## Section 3 Assessment

**Target Reading Skill** **Using Prior Knowledge** Review your graphic organizer and revise it based on what you just learned in the section.

### Reviewing Key Concepts

1. a. **Defining** What are adaptations?
   b. **Explaining** How are a snake's sharp fangs an adaptation that helps it survive in the saguaro community?
   c. **Developing Hypotheses** Explain how natural selection in snakes might have led to adaptations such as sharp fangs.
2. a. **Reviewing** What are three main ways in which organisms interact?
   b. **Classifying** Give one example of each type of interaction.
3. a. **Listing** List the three types of symbiotic relationships.
   b. **Comparing and Contrasting** For each type of symbiotic relationship, explain how the two organisms are affected.
   c. **Applying Concepts** Some of your classroom plants are dying. Others that you planted at the same time and cared for in the same way are growing well. When you look closely at the dying plants, you see tiny mites on them. Which symbiotic relationship is likely occurring between the plants and mites? Explain.

Lab zone **At-Home Activity**

**Feeding Frenzy** You and your family can observe interactions among organisms at a bird feeder. Fill a clean, dry, 2-liter bottle with birdseed. With paper clips, attach a plastic plate to the neck of the bottle. Then hang your feeder outside where you can see it easily. Observe the feeder at different times of the day. Keep a log of all the organisms you see near it and how they interact.

Section 4

# Changes in Communities

## Reading Preview

### Key Concept

- How do primary and secondary succession differ?

### Key Terms

- succession
- primary succession
- pioneer species
- secondary succession

### Target Reading Skill

**Comparing and Contrasting** As you read, compare and contrast primary and secondary succession by completing a table like the one below.

| Factors in Succession | Primary Succession | Secondary Succession |
|---|---|---|
| Possible cause | Volcanic eruption | |
| Type of area | | |
| Existing ecosystem? | | |

Lab zone

## Discover Activity

### What Happened Here?

1. The two photographs at the bottom of this page show the same area in Yellowstone National Park in Wyoming. The photograph on the left was taken soon after a major fire. The photograph on the right was taken a few years later. Observe the photographs carefully.
2. Make a list of all the differences you notice between the two scenes.

**Think It Over**

**Posing Questions** How would you describe what happened during the time between the two photographs? What questions do you have about this process?

In 1988, huge fires raged through the forests of Yellowstone National Park. The fires were so hot that they jumped from tree to tree without burning along the ground. Huge trees burst into flame from the intense heat. It took months for the fires to burn themselves out. All that remained were thousands of blackened tree trunks sticking out of the ground like charred toothpicks.

Could a forest community recover from such disastrous fires? It might seem unlikely. But within just a few months, signs of life had returned. First, tiny green shoots of new grass poked through the sooty ground. Then, small tree seedlings began to grow. The forest was coming back! After 15 years, young forests were flourishing in many areas.

Fires, floods, volcanoes, hurricanes, and other natural disasters can change communities very quickly. But even without disasters, communities change. The series of predictable changes that occur in a community over time is called **succession.**

**Changes in a Yellowstone community ▼**

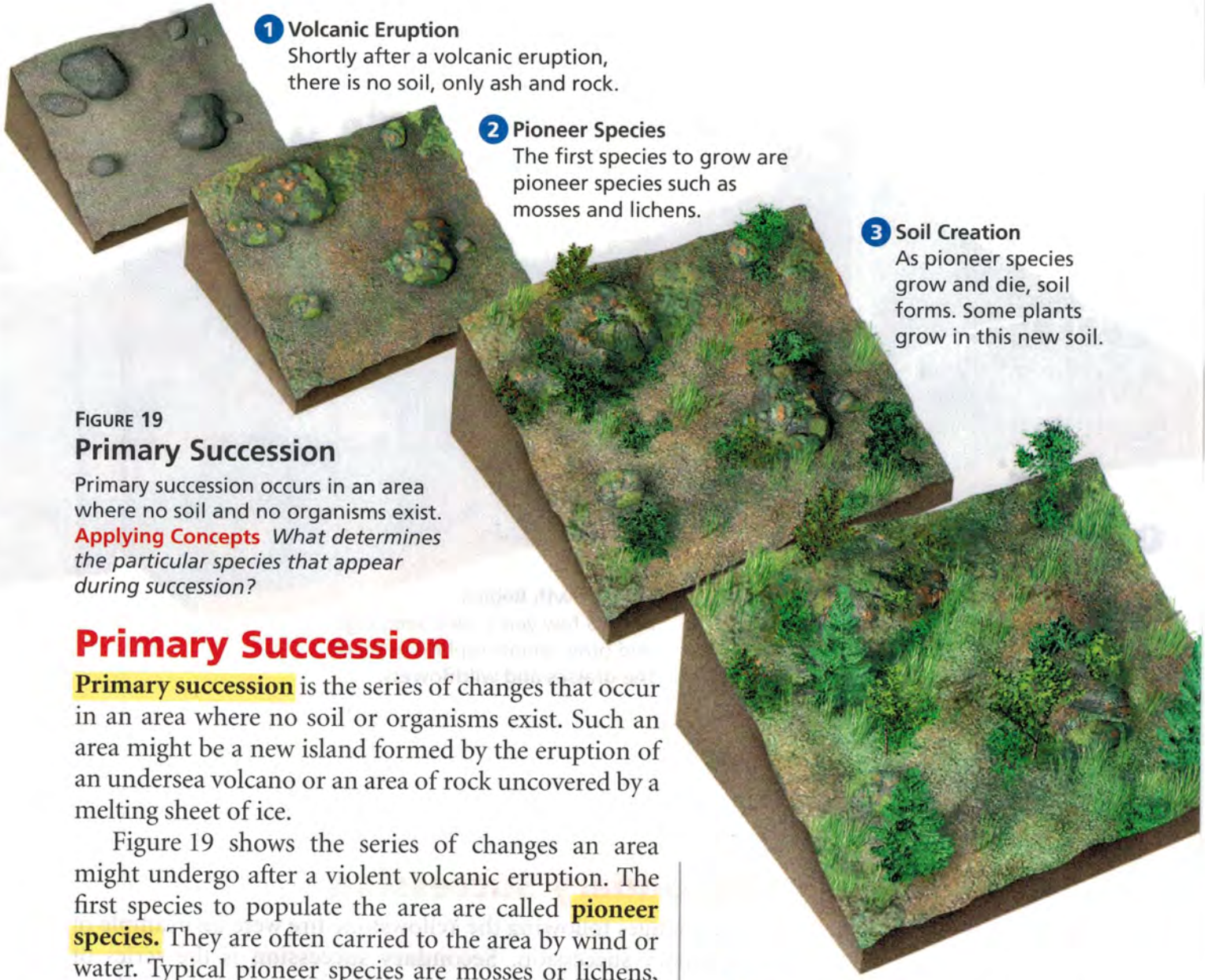



FIGURE 19
**Primary Succession**
Primary succession occurs in an area where no soil and no organisms exist. **Applying Concepts** *What determines the particular species that appear during succession?*

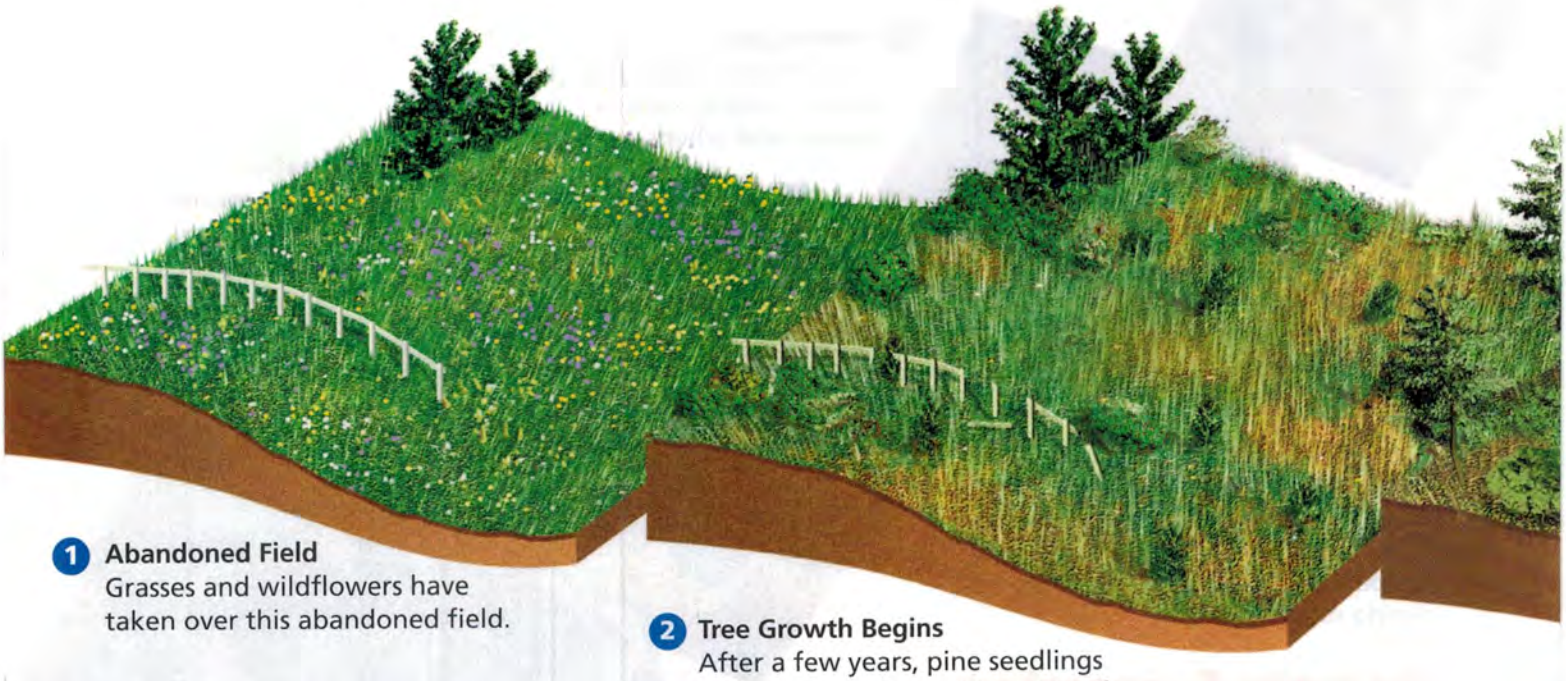
## Primary Succession

**Primary succession** is the series of changes that occur in an area where no soil or organisms exist. Such an area might be a new island formed by the eruption of an undersea volcano or an area of rock uncovered by a melting sheet of ice.

Figure 19 shows the series of changes an area might undergo after a violent volcanic eruption. The first species to populate the area are called **pioneer species.** They are often carried to the area by wind or water. Typical pioneer species are mosses or lichens, which are fungi and algae growing in a symbiotic relationship. As pioneer species grow, they help break up the rocks. When the organisms die, they provide nutrients that enrich the thin layer of soil that is forming on the rocks.

Over time, plant seeds land in the new soil and begin to grow. The specific plants that grow depend on the climate of the area. For example, in a cool, northern area, early seedlings might include alder and cottonwood trees. Eventually, succession may lead to a community of organisms that does not change unless the ecosystem is disturbed. Reaching this mature community can take centuries.

**Reading Checkpoint** **What are some pioneer species?**



**1 Abandoned Field**
Grasses and wildflowers have taken over this abandoned field.

**2 Tree Growth Begins**
After a few years, pine seedlings and other plants replace some of the grasses and wildflowers.

FIGURE 20
**Secondary Succession**
Secondary succession occurs following a disturbance to an ecosystem, such as clearing a forest for farmland.

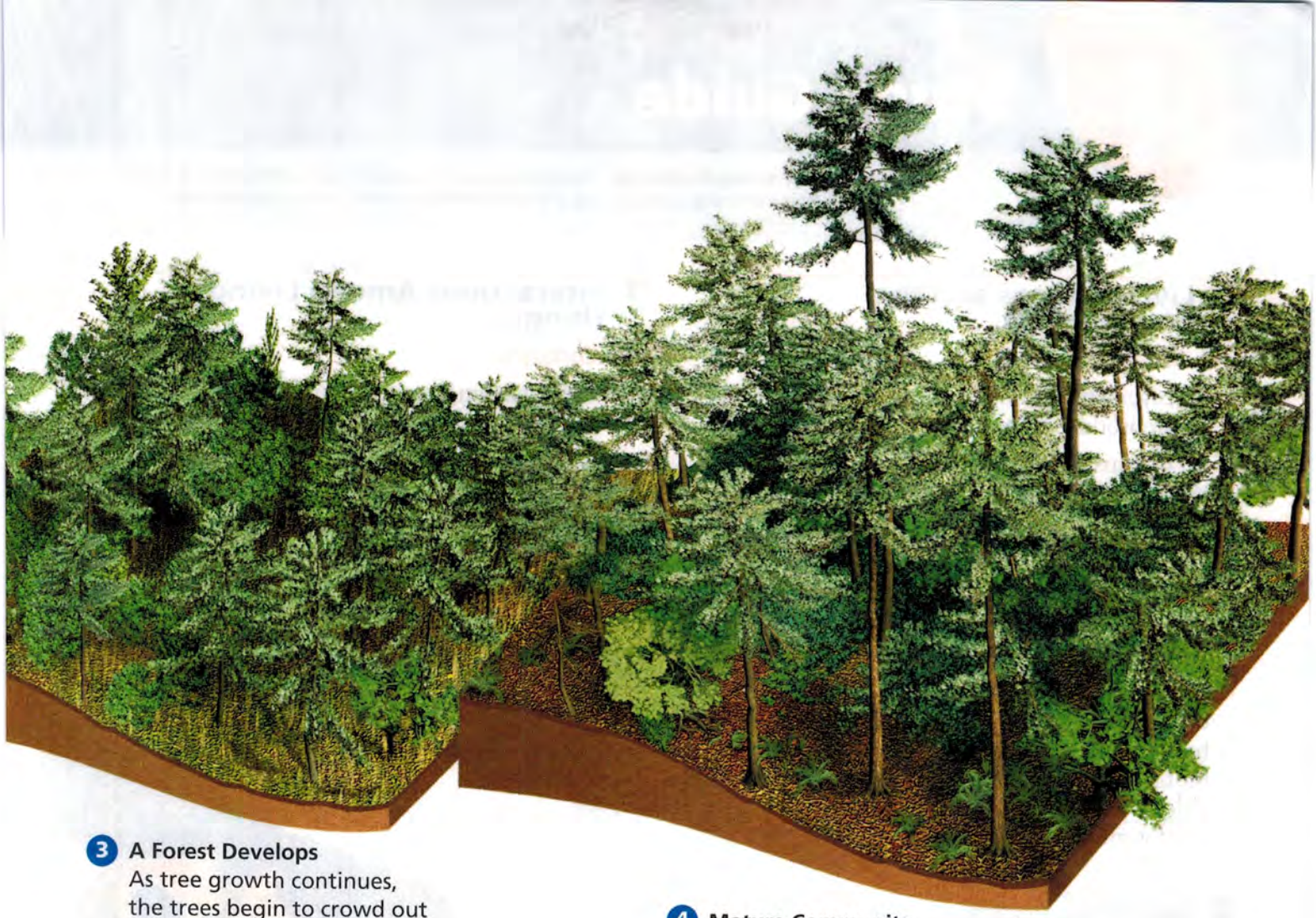
## Secondary Succession

The changes following the Yellowstone fire were an example of secondary succession. **Secondary succession** is the series of changes that occur in an area where the ecosystem has been disturbed, but where soil and organisms still exist. Natural disturbances that have this effect include fires, hurricanes, and tornadoes. Human activities, such as farming, logging, or mining, may also disturb an ecosystem. **Unlike primary succession, secondary succession occurs in a place where an ecosystem currently exists.**

Secondary succession usually occurs more rapidly than primary succession. Consider, for example, an abandoned field in the southeastern United States. You can follow the process of succession in such a field in Figure 20. After a century, a hardwood forest is developing. This forest community may remain for a long time.

Reading Checkpoint **What are two natural events that can disturb an ecosystem?**

Go Online NSTA SCILINKS™
**For:** Links on succession
**Visit:** www.SciLinks.org
**Web Code:** scn-0514



**3 A Forest Develops**
As tree growth continues, the trees begin to crowd out the grasses and wildflowers.

**4 Mature Community**
Eventually, a mixed forest of pine, oak, and hickory dominates the landscape.

## Section 4 Assessment

**Target Reading Skill** **Comparing and Contrasting** Use the information in your table to help you answer Question 1 below.

### Reviewing Key Concepts

1. a. **Defining** What is primary succession? What is secondary succession?
   b. **Comparing and Contrasting** How do primary succession and secondary succession differ?
   c. **Classifying** Grass poking through a crack in a sidewalk is an example of succession. Is it primary succession or secondary succession? Explain.

**Lab zone At-Home Activity**

**Community Changes** Interview a family member or neighbor who has lived in your neighborhood for a long time. Ask the person to describe how the neighborhood has changed over time. Have areas that were formerly grassy been paved or developed? Have any farms, parks, or lots returned to a wild state? Write a summary of your interview. Can you classify any of the changes as examples of succession?

# Chapter 21 Study Guide

**The BIG Idea** **Populations and Ecosystems** Ecosystems are composed of populations that interact with their nonliving surroundings and with the community of other organisms.

## 1 Living Things and the Environment

### Key Concepts

- An organism obtains what it needs to live, grow, and reproduce from its environment.
- An organism interacts with both the living and nonliving parts of its habitat.
- An organism belongs to a population that includes other members of its species. The population belongs to a community of different species. The community and abiotic factors together form an ecosystem.

### Key Terms

organism
habitat
biotic factor
abiotic factor
photosynthesis
species
population
community
ecosystem
ecology

## 2 Studying Populations

### Key Concepts

- Some methods of determining the size of a population are direct and indirect observations, sampling, and mark-and-recapture studies.
- Populations can change in size when members join or leave the population.
- Population density can be determined using the following equation:

$$\text{Population density} = \frac{\text{Number of individuals}}{\text{Unit area}}$$

- Some limiting factors for populations are food and water, space, and weather conditions.

### Key Terms

estimate
birth rate
death rate
immigration
emigration
population density
limiting factor
carrying capacity

## 3 Interactions Among Living Things

### Key Concepts

- Every organism has a variety of adaptations that are suited to its specific living conditions.
- Competition, predation, and symbiosis are interactions among organisms.
- The three types of symbiotic relationships are mutualism, commensalism, and parasitism.

### Key Terms

natural selection
adaptations
niche
competition
predation
predator
prey
symbiosis
mutualism
commensalism
parasitism
parasite
host

## 4 Changes in Communities

### Key Concept

- Unlike primary succession, secondary succession occurs in a place where an ecosystem currently exists.

### Key Terms

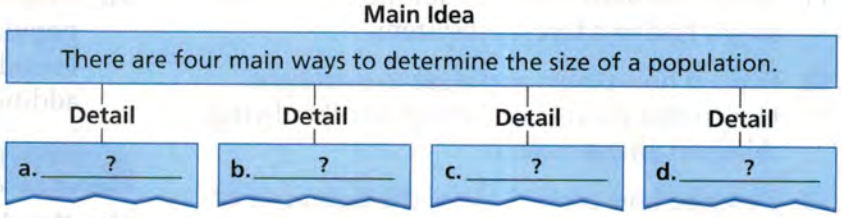
succession
primary succession
pioneer species
secondary succession

# Review and Assessment

Go Online
PHSchool.com
**For:** Self-Assessment
**Visit:** PHSchool.com
**Web Code:** cea-5010

## Organizing Information

**Identifying Main Ideas** Copy the graphic organizer about determining population size onto a separate sheet of paper. Then complete it and add a title. (For more on Identifying Main Ideas, see the Skills Handbook.)




## Reviewing Key Terms

**Choose the letter of the best answer.**

1. A prairie dog, a hawk, and a badger all are members of the same
   **a.** niche.
   **b.** community.
   **c.** species.
   **d.** population.
2. All of the following are examples of limiting factors for populations *except*
   **a.** space.
   **b.** food.
   **c.** time.
   **d.** weather.
3. In which type of interaction do both species benefit?
   **a.** predation
   **b.** mutualism
   **c.** commensalism
   **d.** parasitism
4. Which of these relationships is an example of parasitism?
   **a.** a bird building a nest on a tree branch
   **b.** a bat pollinating a saguaro cactus
   **c.** a flea living on a cat's blood
   **d.** ants protecting a tree that produces the ants' only food
5. The series of predictable changes that occur in a community over time is called
   **a.** natural selection.
   **b.** ecology.
   **c.** commensalism.
   **d.** succession.

**If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.**

6. Grass is an example of a biotic factor in a habitat.
7. Immigration is the number of individuals in a specific area.
8. An organism's specific role in its habitat is called its niche.
9. The struggle between organisms for limited resources is called mutualism.
10. A parasite lives on or inside its predator.

## Writing in Science

**Descriptive Paragraph** Use what you have learned about predators and prey to write about an interaction between two organisms. For each organism, describe at least one adaptation that helps it either catch prey or fend off predators.

Discovery CHANNEL SCHOOL

*Populations and Communities*
Video Preview
Video Field Trip
▶ Video Assessment

# Review and Assessment

## Checking Concepts

11. Name two biotic and two abiotic factors you might find in a forest ecosystem.
12. Explain how plants and algae use sunlight. How is this process important to other living things in an ecosystem?
13. Describe how ecologists use the technique of sampling to estimate population size.
14. Give an example showing how space can be a limiting factor for a population.
15. What are two adaptations that prey organisms have developed to protect themselves? Describe how each adaptation protects the organism.

## Thinking Critically

16. **Making Generalizations** Explain why ecologists usually study a specific population of organisms rather than the entire species.
17. **Problem Solving** In a summer job working for an ecologist, you have been assigned to estimate the population of grasshoppers in a field. Propose a method and explain how you would carry out your plan.
18. **Relating Cause and Effect** Competition for resources in an area is usually more intense within a single species than between two different species. Suggest an explanation for this observation. (*Hint:* Consider how niches help organisms avoid competition.)
19. **Classifying** Lichens and mosses have just begun to grow on the rocky area shown below. Which type of succession is occurring? Explain.

## Math Practice

20. **Inequalities** Review the two inequalities about population size. Then revise each inequality to include immigration and emigration in addition to birth rate and death rate.

## Applying Skills

**Use the data in the table below to answer Questions 21–24.**

*Ecologists monitoring a deer population collected data during a 30-year study.*

| Year | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Population (thousands) | 15 | 30 | 65 | 100 | 40 | 25 | 10 |

21. **Graphing** Make a line graph using the data in the table. Plot years on the horizontal axis and population on the vertical axis.
22. **Interpreting Data** In which year did the deer population reach its highest point? Its lowest point?
23. **Communicating** Write a few sentences describing how the deer population changed during the study.
24. **Developing Hypotheses** In Year 16 of the study, this region experienced a very severe winter. How might this have affected the deer population?

## Lab zone Chapter Project

**Performance Assessment** Review your report and graph to be sure that they clearly state your conclusion about the effects of crowding on plant growth. With your group, decide how you will present your results. Do a practice run-through to make sure all group members feel comfortable with their parts. After your presentation, list some improvements you could have made in your experimental plan.

# Standardized Test Prep

### Test-Taking Tip

**Interpreting Graphs**

When you are asked to interpret a line graph, look at the labels on the axes. The labels tell you what relationship is plotted—in other words, what variables are being compared. On the graph below, the axis labels show that the size of a prairie dog population is being compared over time.


***Sample Question***

Based on the graph, which of the following is true?

- **A** The prairie dog population was smaller in 1990 than in 1995.
- **B** The prairie dog population was greater in 1990 than in 1995.
- **C** The prairie dog population density was greater in 1990 than in 1985.
- **D** The prairie dog population density was smaller in 1990 than in 1985.

***Answer***

The correct answer is **A**. You can eliminate **C** and **D** because the axis labels refer to population size rather than population density. Of the remaining choices, **A** is the only one that is correct, because the line of the graph is lower in 1990 than in 1995.

**Choose the letter of the best answer.**

1. According to the graph above, in what year was the prairie dog population the largest?
   - **A** 1980
   - **B** 1990
   - **C** 1995
   - **D** 2000
2. In general, which of the following is a true statement about population size?
   - **F** If birth rate < death rate, population size increases.
   - **G** If death rate < birth rate, population size decreases.
   - **H** If birth rate > death rate, population size increases.
   - **J** If death rate > birth rate, population size increases.
3. A freshwater lake has a muddy bottom, which is home to different types of algae and other organisms. Many species of fish feed on the algae. Which of the following is an *abiotic* factor in this ecosystem?
   - **A** the temperature of the water
   - **B** the color of the algae
   - **C** the number of species of fish
   - **D** the amount of food available to the fish
4. Although three different bird species all live in the same trees in an area, competition between the birds rarely occurs. The most likely explanation for this lack of competition is that these birds
   - **F** occupy different niches.
   - **G** eat the same food.
   - **H** have a limited supply of food.
   - **J** live in the same part of the trees.
5. During primary succession, a typical pioneer species is
   - **A** grass.
   - **B** lichen.
   - **C** pine trees.
   - **D** soil.

## Constructed Response

6. Suppose that two species of squirrels living in the same habitat feed on the same type of nut. Describe two possible outcomes of competition between the two squirrel species.