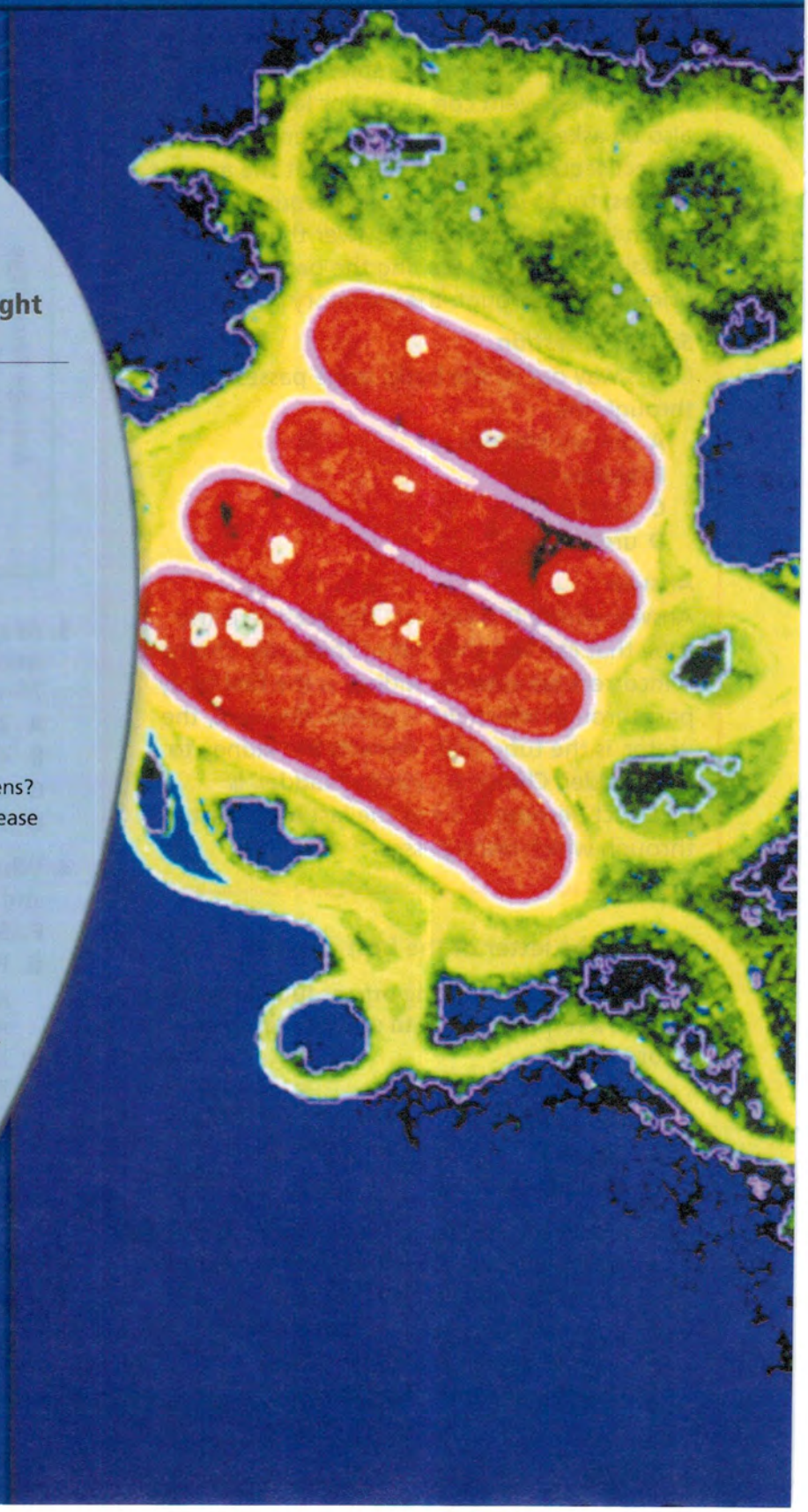
Chapter 18

Fighting Disease

The BIG Idea
Personal Health

How does the human body fight disease?

Chapter Preview



These rod-shaped bacteria *(Legionella)* cause Legionnaires' disease.

Discovery CHANNEL SCHOOL™

Fighting Disease

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™

Chapter Project

Stop the Invasion!

When you catch a cold, your body is under attack by cold viruses. Many other diseases are caused by viruses or bacteria that invade your body. In this project, you'll develop a series of informative news reports on how your body defends itself against such invasions.

Your Goal To create a series of imaginary news broadcasts from "battlefield sites" where the body is fighting an infectious disease

To complete this project successfully, you must

- choose a specific disease and represent the sequence of events that occurs when that disease strikes the body
- describe the stages of the disease as if they were battles between two armies
- present your story creatively in at least three reports, using newspaper, radio, or television news-reporting techniques

Plan It! With some classmates, list the techniques reporters use to make stories interesting or to explain complicated information. Also, recall the times you've had a cold, the flu, or another infectious disease. Write down how your body responded, how long you were sick, and any other useful information. Then select a specific disease to research.


Immune System Daily

Today's Edition

Inflammatory Response Destroys Pathogens

Section 1

Infectious Disease

Reading Preview

Key Concepts

- What is the relationship between pathogens and infectious disease?
- What kinds of pathogens cause infectious diseases in humans?
- What are four ways that pathogens can spread?

Key Terms

- pathogen
- infectious disease
- toxin

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 infectious diseases in a graphic organizer like the one below. As you read, continue to write in what you learn.

What You Know
1. Bacteria and viruses can cause disease. 2.

What You Learned
1. 2.

Lab zone Discover Activity

How Does a Disease Spread?

1. On a sheet of paper, write three headings: Round 1, Round 2, and Round 3.
2. Everyone in the class should shake hands with two people. Under Round 1, record the names of the people whose hand you shook.
3. Now shake hands with two different people. Record the name of each person whose hand you shook under Round 2.
4. Repeat Step 3. Under Round 3, record the names of the people whose hand you shook.

Think It Over

Calculating Suppose you had a disease that was spread by shaking hands. Everyone whose hand you shook has caught the disease and so has anyone who later shook hands with those people. Calculate how many people you "infected."

Before the twentieth century, surgery was a risky business. Even if people lived through an operation, they were not out of danger. After the operation, many patients' wounds became infected, and the patients often died. No one knew what caused these infections.

In the 1860s, a British surgeon named Joseph Lister hypothesized that microorganisms caused the infections. Before performing an operation, Lister washed his hands and surgical instruments with carbolic acid, a chemical that kills microorganisms. After the surgery, he covered the patient's wounds with bandages dipped in carbolic acid. Lister's results were dramatic. Before he used his new method, about 45 percent of his surgical patients died from infection. With Lister's new techniques, only 15 percent died.

Understanding Infectious Disease

Like the infections that Lister observed after surgery, many illnesses, such as ear infections and food poisoning, are caused by living things that are too small to see without a microscope. Organisms that cause disease are called **pathogens.**

Diseases that are caused by pathogens are called infectious diseases. An **infectious disease** is a disease that is caused by the presence of a living thing within the body. **When you have an infectious disease, pathogens have gotten inside your body and caused harm.** Pathogens make you sick by damaging individual cells, even though you may feel pain throughout your body. For example, when you have strep throat, pathogens have damaged cells in your throat.

Before Lister's time, people believed that things like evil spirits or swamp air led to sickness. Several scientists in the late 1800s contributed to the understanding of infectious diseases. In the 1860s, the French scientist Louis Pasteur showed that microorganisms cause certain kinds of diseases. Pasteur also showed that killing the microorganisms could prevent the spread of those diseases. In the 1870s and 1880s, the German physician Robert Koch demonstrated that each infectious disease is caused by a specific kind of pathogen. In other words, one kind of pathogen causes pneumonia, another kind causes chickenpox, and still another kind causes rabies.

Reading Checkpoint **What causes infectious disease?**

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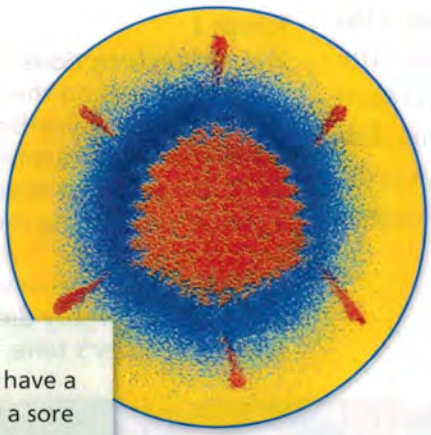
FIGURE 1
Preventing Infections
The illustration on the left shows how Lister used a carbolic steam sprayer to spread a mist of carbolic acid. The photo on the right shows a modern operating room.
Comparing and Contrasting
Identify some ways in which present-day surgery differs from surgery in Lister's time.

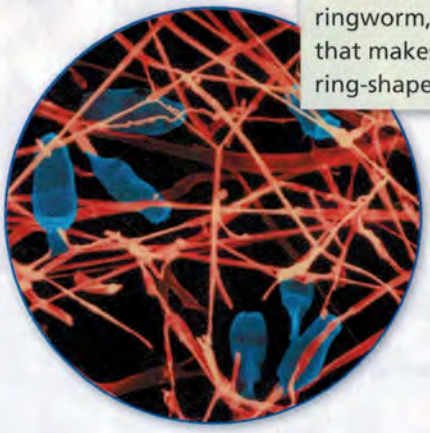
FIGURE 2
Pathogens
Most infectious diseases are caused by microscopic organisms.

Bacteria
This rod-shaped bacterium causes tetanus, a disease that harms the nervous system.



Viruses
When you have a cough and a sore throat, this round-shaped virus, called an adenovirus, may be to blame.

Fungi
This fungus causes ringworm, a disease that makes a round, ring-shaped skin rash.



Kinds of Pathogens

You share Earth with many kinds of organisms. Most of these organisms are harmless, but some can make you sick. Some diseases are caused by multicelled animals, such as worms. However, most pathogens can be seen only with a microscope. **The four major groups of human pathogens are bacteria, viruses, fungi, and protists.** Look at Figure 2 to see some examples of pathogens.

Bacteria Bacteria are one-celled microorganisms. They cause a wide variety of diseases, including ear infections, food poisoning, and strep throat.

Some bacterial pathogens damage body cells directly. Strep throat is caused by streptococcus bacteria that invade cells in your throat. Other bacterial pathogens damage cells indirectly by producing a poison, or **toxin.** For example, if the bacteria that cause tetanus get into a wound, they produce a toxin that damages the nervous system. Tetanus is also called lockjaw because the nerve damage can lock the jaw muscles.

Viruses Viruses are tiny particles, much smaller than bacteria. Viruses cannot reproduce unless they are inside living cells. The cells are damaged or destroyed in the process, releasing new viruses to infect other cells. Both colds and flu are caused by viruses that invade cells in the respiratory system. There are more than 200 kinds of cold viruses, each of which can give you a sore throat and runny nose.

Fungi Fungi, which include molds and yeasts, also cause some infectious diseases. Fungi grow best in warm, dark, and moist areas. Two examples of fungal diseases are athlete's foot and ringworm.

Protists Protists are also a cause of disease. Malaria, an infection of the blood that is common in tropical areas, is one disease caused by protists. Other diseases caused by protists are African sleeping sickness and amebic dysentery.

Reading Checkpoint **What is required in order for viruses to reproduce?**

How Pathogens Are Spread

Like all living things, pathogens need food and a place to live and reproduce. Unfortunately, your body may be the right place to meet a pathogen's needs. You can become infected by a pathogen in several ways. **Pathogens can spread through contact with either an infected person; soil, food, or water; a contaminated object; or an infected animal.**

Infected People Pathogens often pass from one person to another through direct physical contact, such as kissing and shaking hands. For example, if you kiss someone who has an open cold sore, cold-sore viruses may get into your body.

Diseases are also spread through indirect contact with an infected person. For example, when a person with a cold or the flu sneezes, pathogens shoot into the air. Other people may catch a cold or the flu if they inhale these pathogens.

Soil, Food, and Water Some pathogens occur naturally in the environment. The bacteria that cause botulism, a severe form of food poisoning, live in soil. Botulism bacteria can produce toxins in foods that have been improperly canned.

Some pathogens can contaminate food and water. If people then eat the food or drink the water, they may become sick. Some pathogens that cause severe diarrhea are spread through contaminated food and water. Cholera and dysentery are two deadly diseases that spread through food or water.

Lab zone Skills Activity

Posing Questions

In 1854, cholera spread throughout London, England. Dr. John Snow analyzed where most of the cholera victims lived, as well as the locations of the water pumps in the area.

1. The map in Figure 3 shows Dr. Snow's findings. Dr. Snow hypothesized that the disease was spread by water that came from one of the pumps. Which pump was probably the source of the contaminated water?
2. Suppose that Dr. Snow just learned that two additional people had died of cholera. What questions would Dr. Snow most likely ask about the additional cholera cases?

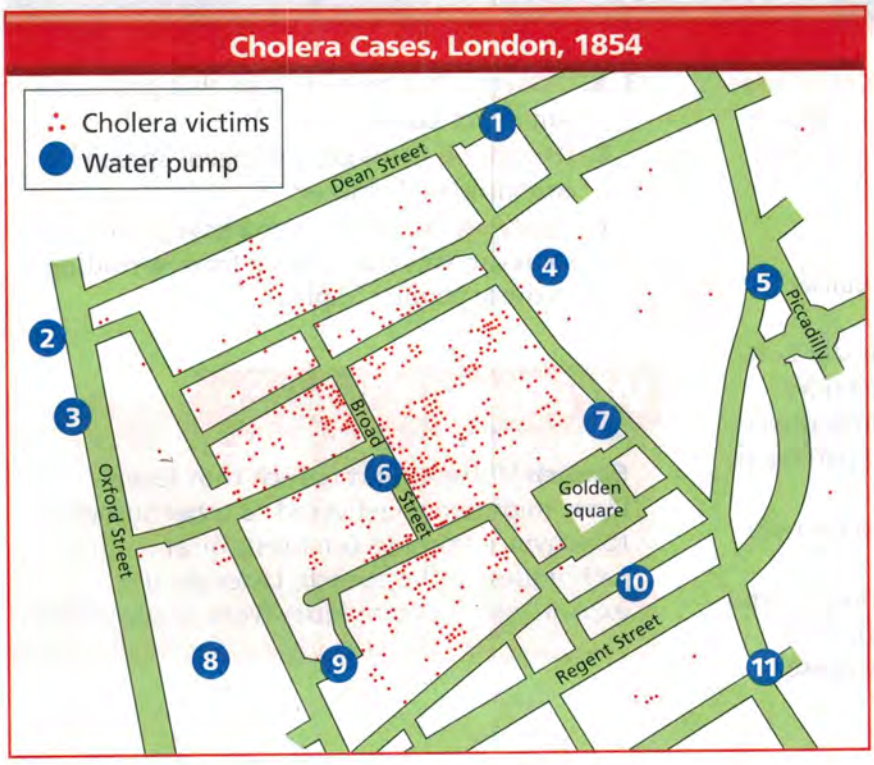


FIGURE 3
Cholera is a deadly disease caused by cholera bacteria. The map shows the location of cholera cases in the 1854 epidemic in London, England.
Inferring *How are cholera bacteria spread?*

FIGURE 4
Deer Ticks and Lyme Disease
The tiny deer tick may carry the bacteria that cause Lyme disease, a serious condition that can damage the joints.
Problem Solving *How might people reduce their risk of catching Lyme disease?*

Contaminated Objects Some pathogens can survive for a time outside a person's body. People can come into contact with pathogens by using objects, such as towels or silverware, that have been handled by an infected person. Colds and flu can be spread in this way. Tetanus bacteria can enter the body if a person steps on a contaminated object.

Infected Animals If an animal that is infected with certain pathogens bites a person, it can pass the pathogens to the person. People can get rabies, a serious disease that affects the nervous system, from the bite of an infected animal, such as a dog or a raccoon. Lyme disease and Rocky Mountain spotted fever are both spread by tick bites. For example, if a deer tick that is carrying Lyme disease bacteria bites a person, the person may get Lyme disease. The protist that causes malaria is transferred by the bites of mosquitoes that live in tropical regions.

Reading Checkpoint **Name a disease that can be spread by an animal bite.**

Section 1 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 is a pathogen?
   b. **Explaining** How do pathogens cause infectious disease?
   c. **Relating Cause and Effect** How did Pasteur and Koch contribute to the understanding of the causes of infectious disease?
2. a. **Identifying** Name four kinds of pathogens that cause disease in humans.
   b. **Explaining** In what two ways do bacteria cause disease?
   c. **Comparing and Contrasting** Compare and contrast bacteria and viruses—both in terms of their size and how they cause disease.
3. a. **Listing** What are four ways that pathogens can infect humans?
   b. **Describing** How are pathogens spread by contaminated objects?
   c. **Applying Concepts** If you have a cold, what steps can you take to keep from spreading it to other people? Explain.

Writing in Science

Speech Write a short speech that Joseph Lister might have delivered to other surgeons to convince them to use his surgical techniques. In the speech, Lister should explain why his techniques were so successful.

Section 2

The Body's Defenses

Reading Preview

Key Concepts

- How does the body's first line of defense guard against pathogens?
- What happens during the inflammatory response?
- How does the immune system respond to pathogens?
- How does HIV affect the immune system and how does it spread?

Key Terms

- inflammatory response
- phagocyte • immune response
- lymphocyte • T cell
- antigen • B cell • antibody
- AIDS • HIV

Target Reading Skill

Building Vocabulary After you read this section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

Which Pieces Fit Together?

1. Your teacher will give you a piece of paper with one jagged edge.
2. One student in the class has a piece of paper with a jagged edge that matches yours, like two pieces of a jigsaw puzzle. Find the student whose paper matches yours and fit the two edges together.

Think It Over

Inferring Imagine that one piece of paper in each matching pair is a pathogen. The other is a cell in your body that defends your body against the invading pathogen. How many kinds of invaders can each defender cell recognize?

Your eyes are glued to the video screen. Enemy troops have gotten through an opening in the wall. Your soldiers have held back most of the invaders. However, some enemy soldiers are breaking through the defense lines. You need your backup defenders. They can zap invaders with their more powerful weapons. If your soldiers can fight off the enemy until the backup team arrives, you can save your fortress.

Video games create fantasy wars, but in your body, real battles happen all the time. In your body, the "enemies" are invading pathogens. You are hardly ever aware of these battles. The body's disease-fighting system is so effective that most people get sick only occasionally. By eliminating pathogens that can harm your cells, your body maintains homeostasis.

The fight is on. ▶

Barriers That Keep Pathogens Out

Your body has three lines of defense against pathogens. The first line consists of barriers that keep most pathogens from getting into the body. You do not wear a sign that says "Pathogens Keep Out," but that doesn't matter. **In the first line of defense, the surfaces of the skin, breathing passages, mouth, and stomach function as barriers to pathogens. These barriers trap and kill most pathogens with which you come into contact.**

Skin When pathogens land on the skin, they are exposed to destructive chemicals in oil and sweat. Even if these chemicals don't kill them, the pathogens may fall off with dead skin cells. If the pathogens manage to stay on the skin, they must get through the tightly packed dead cells that form a barrier on top of living skin cells. Most pathogens get through the skin only when it is cut. Scabs form over cuts so rapidly that the period in which pathogens can enter the body in this way is very short.

Breathing Passages Pathogens can also enter the body when you inhale. The nose, pharynx, trachea, and bronchi, however, contain mucus and cilia. Together, the mucus and cilia trap and remove most of the pathogens that enter the respiratory system. In addition, irritation by pathogens may make you sneeze or cough. Both actions force the pathogens out of your body.

Mouth and Stomach Some pathogens are found in foods, even if the foods are handled safely. The saliva in your mouth contains destructive chemicals, and your stomach produces acid. Most pathogens that you swallow are destroyed by saliva or stomach acid.

Reading Checkpoint **How do your breathing passages help keep pathogens out of your body?**

FIGURE 5
Barriers to Pathogens
The surfaces of your skin and breathing passages are the first line of defense for keeping pathogens out of your body.
Relating Cause and Effect *How can washing your hands help prevent infection?*

FIGURE 6
Phagocytes Destroy Pathogens
Caught! A phagocyte (shown in red) is a white blood cell that engulfs and destroys bacteria (shown in green). As phagocytes do their job, the body shows visible signs of inflammation, which include redness and swelling.

The Inflammatory Response

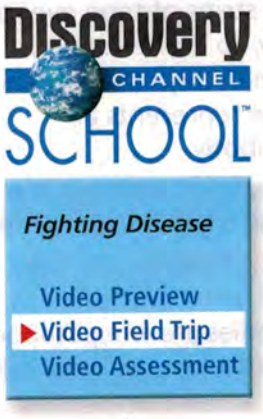
In spite of barriers, pathogens sometimes get into your body and begin to damage cells. When body cells are damaged, they release chemicals that trigger the **inflammatory response,** which is the body's second line of defense. **In the inflammatory response, fluid and white blood cells leak from blood vessels into nearby tissues. The white blood cells then fight the pathogens.** Because the inflammatory response is the same regardless of the pathogen, it is called the body's general defense.

White Blood Cells All white blood cells are disease fighters. However, there are different types of white blood cells, each with its own particular function. The type involved in the inflammatory response are the phagocytes. A **phagocyte** (FAG uh syt) is a white blood cell that engulfs pathogens and destroys them by breaking them down.

Inflammation During the inflammatory response, blood vessels widen in the area affected by the pathogens. This enlargement increases blood flow to the area. As a result, more disease-fighting white blood cells are delivered to the area. The enlarged blood vessels, and the fluid that leaks out of them, make the affected area red and swollen. If you touch the swollen area, it will feel slightly warmer than normal.

Fever In some cases, chemicals produced during the inflammatory response cause a fever. Although fever makes you feel bad, it actually helps your body fight the infection. Some pathogens do not grow and reproduce well at higher temperatures.

Reading Checkpoint **What role do white blood cells play in the inflammatory response?**



The Immune System

If a pathogen infection is severe enough to cause a fever, it triggers the body's third line of defense—the **immune response.** The immune response is controlled by the immune system, the body's disease-fighting system. **The cells of the immune system can distinguish between different kinds of pathogens. The immune system cells react to each kind of pathogen with a defense targeted specifically at that pathogen.**

The white blood cells that distinguish between different kinds of pathogens are called **lymphocytes** (LIM fuh syts). There are two major kinds of lymphocytes—T lymphocytes and B lymphocytes, which are also called T cells and B cells. In Figure 7, you can see how T cells and B cells work together to destroy flu viruses.

T Cells A major function of **T cells** is to identify pathogens and distinguish one kind of pathogen from another. You have tens of millions of T cells circulating in your blood. Each kind of T cell recognizes a different kind of pathogen. What T cells actually recognize are marker molecules, called antigens, found on each pathogen. **Antigens** are molecules that the immune system recognizes either as part of your body or as coming from outside your body.

You can think of antigens as something like the uniforms that athletes wear. When you watch a track meet, you can look at the runners' uniforms to tell which school each runner comes from. Like athletes from different schools, each different pathogen has its own kind of antigen. Antigens differ from one another because each kind of antigen has a different chemical structure. T cells distinguish one chemical structure from another.

B Cells The lymphocytes called **B cells** produce proteins that help destroy pathogens. These proteins are called **antibodies.** Each kind of B cell produces only one kind of antibody, and each kind of antibody has a different structure. Antigen and antibody molecules fit together like pieces of a puzzle. An antigen on a flu virus will only bind to one kind of antibody—the antibody that acts against that flu virus.

When antibodies bind to the antigens on a pathogen, they mark the pathogen for destruction. Some antibodies make pathogens clump together. Others keep pathogens from attaching to the body cells that they might damage. Still other antibodies make it easier for phagocytes to destroy the pathogens.

Reading Checkpoint **What is the function of an antibody?**

Lab zone **Try This Activity**

Stuck Together

In this activity, you will model one way in which an antibody prevents a pathogen from infecting a body cell.

1. Use a large ball to represent a body cell, and a smaller ball to represent a pathogen.
2. Press a lump of modeling clay onto the small ball. Then use the clay to stick the two balls together. This model shows how a pathogen attaches itself to a body cell.
3. Pull the two balls apart, keeping the clay on the small ball (the pathogen).
4. Put strips of tape over the clay, so that the clay is completely covered. The tape represents an antibody.
5. Now try to reattach the small ball to the larger one.

Making Models Use the model to explain how antibodies prevent pathogens from attaching to body cells.

FIGURE 7

The Immune Response

The immune system includes T cells and B cells. The cells of the immune system work together to combat an infection, such as one caused by flu viruses.

Interpreting Diagrams *What happens after a T cell recognizes an invading virus?*

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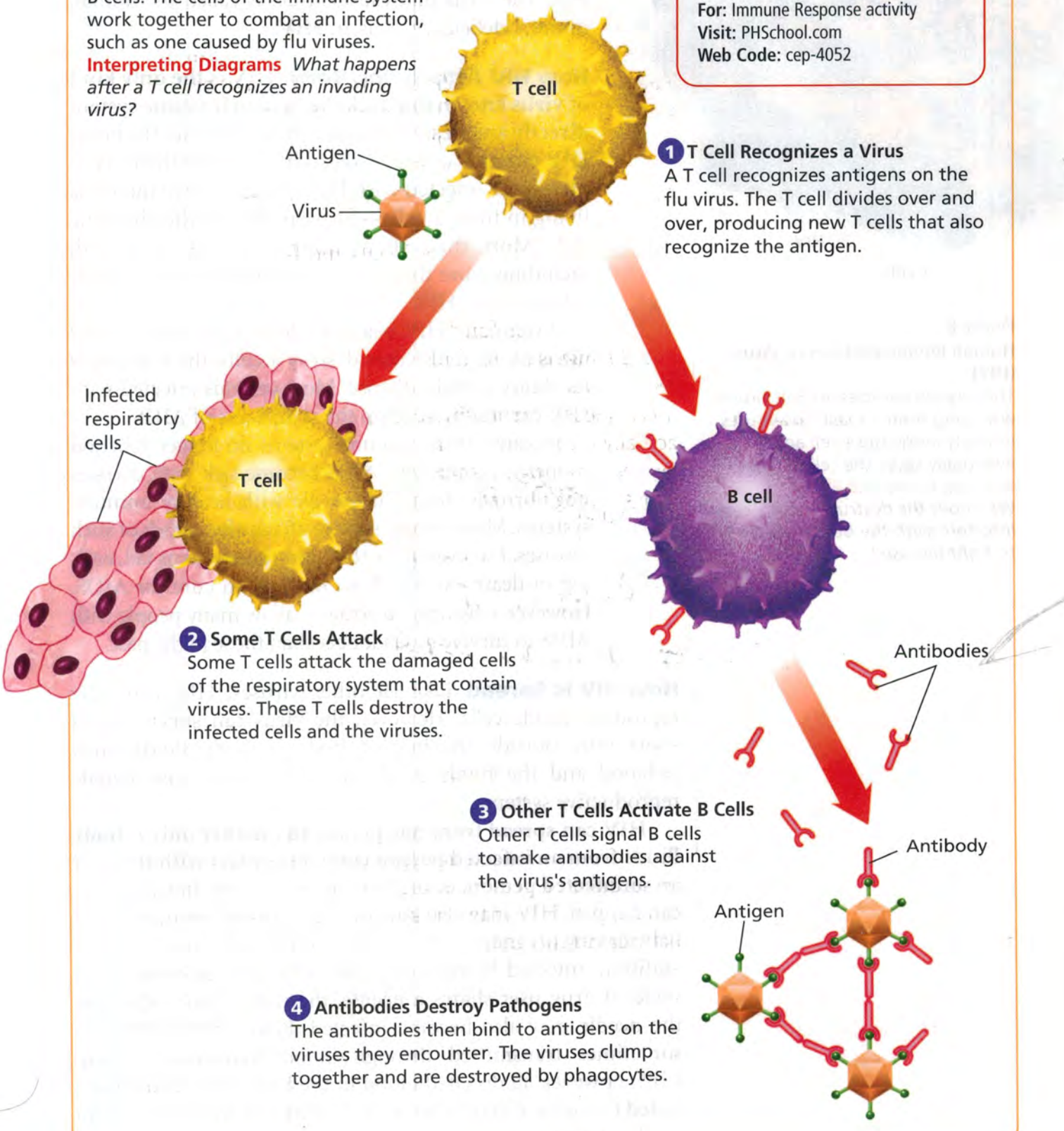


1 T Cell Recognizes a Virus
A T cell recognizes antigens on the flu virus. The T cell divides over and over, producing new T cells that also recognize the antigen.

2 Some T Cells Attack
Some T cells attack the damaged cells of the respiratory system that contain viruses. These T cells destroy the infected cells and the viruses.

3 Other T Cells Activate B Cells
Other T cells signal B cells to make antibodies against the virus's antigens.

4 Antibodies Destroy Pathogens
The antibodies then bind to antigens on the viruses they encounter. The viruses clump together and are destroyed by phagocytes.

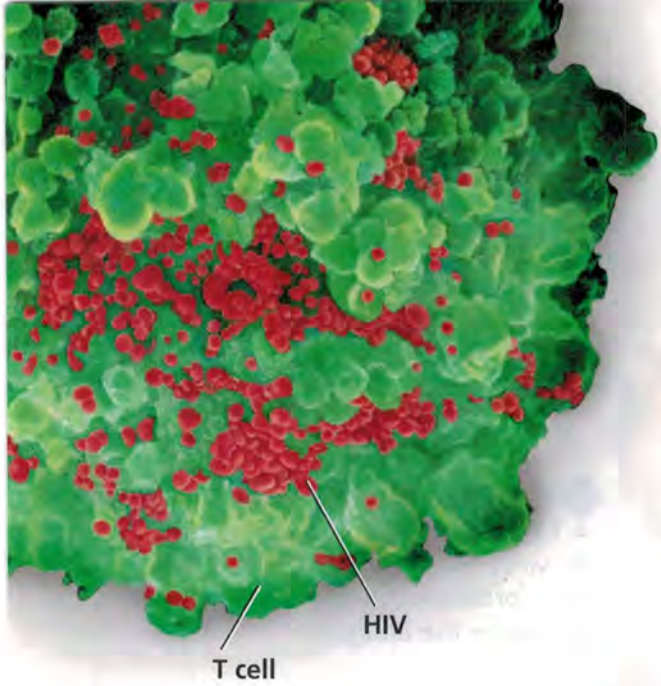


FIGURE 8
Human Immunodeficiency Virus (HIV)
The tiny red particles are HIV viruses emerging from a T cell. The viruses multiply inside the T cell and eventually cause the cell to die.
Relating Cause and Effect
Why does the destruction of T cells interfere with the body's ability to fight disease?

AIDS

Acquired immunodeficiency syndrome, or **AIDS,** is a disease caused by a virus that attacks the immune system. The virus that causes AIDS is called the human immunodeficiency virus, or **HIV.**

How HIV Affects the Body **HIV is the only kind of virus known to attack the human immune system directly and destroy T cells.** Once it invades the body, HIV enters T cells and reproduces inside them. People can be infected with HIV—that is, have the virus living in their T cells—for years before they become sick. More than 40 million people in the world, including more than 3 million children under 15, are infected with HIV.

Eventually, HIV begins to destroy the T cells it has infected. As the viruses destroy T cells, the body loses its ability to fight disease. Most persons infected with HIV eventually develop the symptoms of AIDS.

Because their immune systems no longer function properly, people with AIDS become sick with diseases not normally found in people with healthy immune systems. Many people survive attack after attack of such diseases. But eventually their immune systems fail, ending in death. At this time, there is no cure for AIDS. However, new drug treatments allow many people with AIDS to survive much longer than those in the past.

How HIV Is Spread Like all other viruses, HIV can only reproduce inside cells. However, the virus can survive for a short time outside the human body in body fluids, such as blood and the fluids produced by the male and female reproductive systems.

HIV can spread from one person to another only if body fluids from an infected person come in contact with those of an uninfected person. Sexual contact is one way in which this can happen. HIV may also pass from an infected woman to her baby during pregnancy or childbirth or through breast milk. In addition, infected blood can spread HIV. For example, if an infected drug user shares a needle, the next person who uses the needle may also become infected. Before 1985, HIV was sometimes transmitted through blood transfusions. Since 1985, however, all donated blood in the United States has been tested for signs of HIV. If blood is identified as infected, it is not used in transfusions.

FIGURE 9
How HIV Is Not Spread
You cannot get HIV, the virus that causes AIDS, by hugging someone infected with the virus.

How HIV Is Not Spread It is important to know the many ways in which HIV is *not* spread. HIV does not live on skin, so you cannot be infected by hugging or shaking hands with an infected person. You can't get infected by using a toilet seat after it has been used by someone with HIV. HIV is also not spread when you bump into someone while playing sports.

Reading Checkpoint **What disease is caused by HIV?**

Section 2 Assessment

Target Reading Skill **Building Vocabulary** Use your definitions to help you answer the questions below.

Reviewing Key Concepts

1. a. **Listing** Name four barriers that prevent pathogens from getting into the body.
   b. **Explaining** Briefly describe how each barrier prevents infections.
   c. **Predicting** What could happen if you got a cut that did not heal?
2. a. **Reviewing** What triggers the inflammatory response?
   b. **Describing** How does the inflammatory response defend against invading pathogens?
   c. **Relating Cause and Effect** Why is the presence of large numbers of white blood cells in a wound a sign of infection?
3. a. **Identifying** Identify the cells that are part of the immune system.
   b. **Sequencing** Outline the steps involved in the immune response.
4. a. **Reviewing** Where in the body does HIV reproduce?
   b. **Summarizing** What are three ways that HIV can be passed from one person to another?

Writing in Science

Explanation An antigen and antibody can be compared to a lock and key. Write a paragraph in which you explain how the lock-and-key model is a good way to describe the relationship between an antigen and antibody.

Lab zone Skills Lab

The Skin as a Barrier

Problem

How does the skin act as a barrier to pathogens?

Skills Focus

observing, making models, controlling variables

Materials

- 4 sealable plastic bags
- 4 fresh apples
- rotting apple
- cotton swabs
- marking pen
- paper towels
- toothpick
- rubbing alcohol

Procedure

1. Read over the entire procedure to see how you will treat each of four fresh apples. Write a prediction in your notebook about the change(s) you expect to see in each apple. Then, copy the data table into your notebook.
2. Label four plastic bags *1*, *2*, *3*, and *4*.
3. Wash your hands with soap and water. Then, gently wash four fresh apples with water and dry them carefully with paper towels. Place one apple into plastic bag 1, and seal the bag.
4. Insert a toothpick tip into a rotting apple and withdraw it. Lightly draw the tip of the toothpick down the side of the second apple without breaking the skin. Repeat these actions three more times, touching the toothpick to different parts of the apple without breaking the skin. Insert the apple into plastic bag 2, and seal the bag.
5. Insert the toothpick tip into the rotting apple and withdraw it. Use the tip to make a long, thin scratch down the side of the third apple. Be sure to pierce the apple's skin. Repeat these actions three more times, making additional scratches on different parts of the apple. Insert the apple into plastic bag 3, and seal the bag.
6. Repeat Step 5 with the fourth apple. However, before you place the apple into the bag, dip a cotton swab in rubbing alcohol, and swab the scratches. Then, place the apple into plastic bag 4, and seal the bag. **CAUTION:** *Alcohol and its vapors are flammable. Work where there are no sparks, exposed flames, or other heat sources.*

Data Table

Date	Apple 1 (no contact with decay)	Apple 2 (contact with decay, unbroken skin)	Apple 3 (contact with decay, scratched, untreated)	Apple 4 (contact with decay, scratched, treated with alcohol)

7. Store the four bags in a warm, dark place. Wash your hands thoroughly with soap and water.
8. Every day for one week, remove the apples from their storage place and observe them without opening the bags. Record your observations, and return the bags to their storage location. At the end of the activity, dispose of the unopened bags as directed by your teacher.

Analyze and Conclude

1. **Observing** How did the appearance of the four apples compare?
2. **Inferring** Explain the differences you observed in Question 1.
3. **Making Models** In this experiment, what condition in the human body is each of the four fresh apples supposed to model?
4. **Controlling Variables** What is the purpose of Apple 1 in this experiment? Explain.
5. **Making Models** What is the role of the rotting apple in this experiment?
6. **Communicating** Write a paragraph in which you explain how this investigation shows why routine cuts and scrapes should be cleaned and bandaged.

Design an Experiment

Using apples as you did in this activity, design an experiment to model how washing hands can prevent the spread of disease. *Obtain your teacher's permission before carrying out your investigation.*

Preventing Infectious Disease

Reading Preview

Key Concepts

- How does the body acquire active immunity?
- How does passive immunity occur?

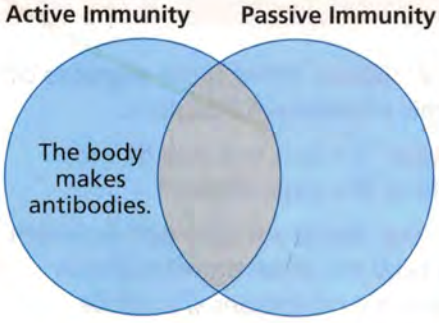
Key Terms

- immunity
- active immunity
- vaccination
- vaccine
- antibiotic
- passive immunity

Target Reading Skill

Comparing and Contrasting

As you read, compare and contrast active immunity and passive immunity in a Venn diagram like the one below. Write the similarities in the space where the circles overlap and the differences on the left and right sides.



Lab zone Discover Activity

What Substances Can Kill Pathogens?

1. Your teacher will give you a variety of products, such as disinfectant cleansers and mouthwashes, that claim to kill pathogens. Read the labels to learn the pathogens that each product is supposed to destroy.
2. Also note the ingredients in each product that act against pathogens. These are labeled "active ingredients."

Think It Over

Designing Experiments How could you determine which of two different cleansers is more effective at killing bacteria? Design an experiment to find out. Do not perform the experiment without obtaining your teacher's approval.

Ask an adult if he or she remembers having the chickenpox. Chances are, the response will be, "Wow, did I itch!" But someone who has had chickenpox can be pretty sure of never getting that disease again. As people recover from some diseases, they develop immunity to the diseases. **Immunity** is the body's ability to destroy pathogens before they can cause disease. There are two basic types of immunity—active and passive.

Active Immunity

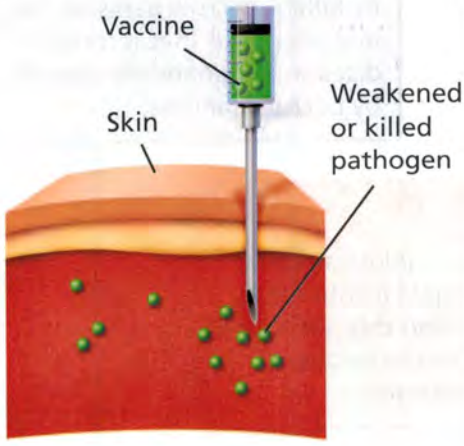
Someone who has been sick with chickenpox was invaded by chickenpox viruses. The immune system responded to the virus antigens by producing antibodies. The next time chickenpox viruses invade the body, a healthy immune system will produce antibodies so quickly that the person will not become sick with chickenpox. This reaction is called **active immunity** because the body has produced the antibodies that fight the disease pathogens. **A person acquires active immunity when their own immune system produces antibodies in response to the presence of a pathogen.** Active immunity can result from either getting the disease or being vaccinated.

The Immune Response When someone gets a disease such as chickenpox, active immunity is produced by the immune system as part of the immune response. Remember that during the immune response, T cells and B cells help destroy the pathogens. After the person recovers, some T cells and B cells keep the "memory" of the pathogen's antigen. If that kind of pathogen enters the body again, these memory cells recognize the antigen. The memory cells start the immune response so quickly that the person usually does not get sick. Active immunity often lasts for many years, and sometimes it lasts for life.

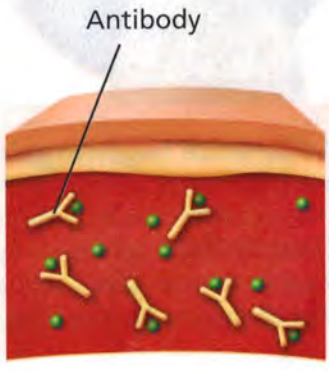
Vaccination A second way to gain active immunity is by being vaccinated. **Vaccination** (vac suh NAY shun), or immunization, is the process by which harmless antigens are deliberately introduced into a person's body to produce active immunity. Vaccinations are given by injection, by mouth, or through a nasal spray. Vaccinations can prevent polio, chickenpox, and other diseases.

The substance that is used in a vaccination is called a vaccine. A **vaccine** (vak SEEN) usually consists of pathogens that have been weakened or killed but can still trigger the immune system to go into action. The T cells and B cells still recognize and respond to the antigens of the weakened or dead pathogen. When you receive a vaccination with weakened pathogens, you usually do not get sick. However, your immune system responds by producing memory cells and active immunity to the disease.

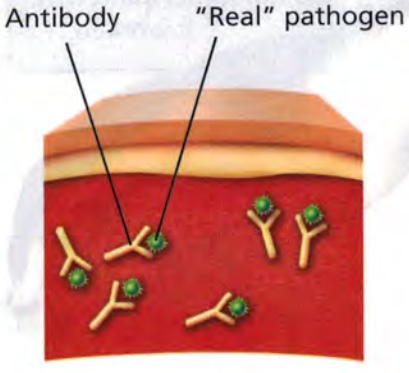
FIGURE 10
Vaccination
Follow the steps below to see how vaccinations work. **Classifying** *Why do vaccinations produce active immunity?*



1 A person receives an injection with weakened or killed pathogens.



2 The immune system produces antibodies against the disease. It also produces memory cells.



3 If the "real" pathogen invades later, memory cells help to produce antibodies that disable the pathogen.

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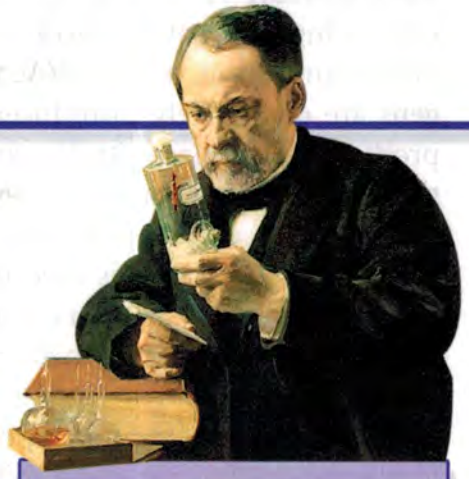
When You Do Get Sick You develop immunity to certain diseases either because you have had the diseases or because you have been vaccinated against them. However, no one is immune to all diseases.

Unfortunately, you probably will become sick from time to time. Sometimes, when you become sick, medications can help you get better. If you have a disease that is caused by bacteria, you may be given an antibiotic. An **antibiotic** (an tih by AHT ik) is a chemical that kills bacteria or slows their growth without harming body cells. Unfortunately, there are no medications that are effective against viral illnesses, including the common cold. The best way to deal with most viral diseases is to get plenty of rest.

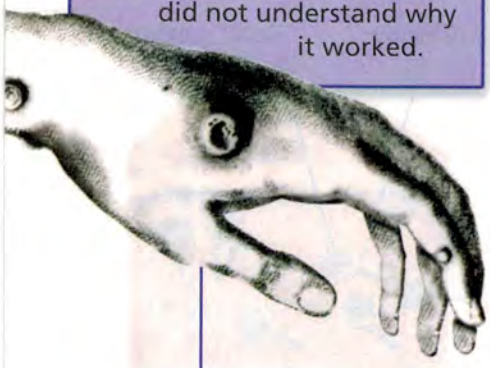
Science and History

Fighting Infectious Disease

From ancient times, people have practiced methods for preventing disease and caring for sick people. About 200 years ago, people began to learn much more about the causes of infectious diseases and how to protect against them.



1796 Edward Jenner
Edward Jenner, a country doctor in England, successfully vaccinated a child against smallpox, a deadly viral disease. Jenner used material from the sore of a person with cowpox, a mild but similar disorder. Although Jenner's procedure was successful, he did not understand why it worked.



1868 Louis Pasteur
In France, Louis Pasteur showed that microorganisms were the cause of disease in silkworms. Pasteur reasoned that he could control the spread of disease by killing microorganisms. He also proposed that infectious disease in humans are caused by microorganisms.

1854 Florence Nightingale
As an English nurse caring for British soldiers during the Crimean War, Florence Nightingale insisted that army hospitals be kept clean. By doing this, she saved many soldiers' lives. She is considered to be the founder of the modern nursing profession.

1800 1840 1880

Although some medicines don't kill pathogens, they may help you feel more comfortable while you get better. Many of these are over-the-counter medications—drugs that can be purchased without a doctor's prescription. Such medications may reduce fever, clear your nose so you can breathe more easily, or stop a cough. Be sure you understand and follow the instructions for all types of medications.

While you recover, be sure to get plenty of rest. Drink plenty of fluids. Unless your stomach is upset, try to eat well-balanced meals. And if you don't start to feel better in a short time, you should see a doctor.

Reading Checkpoint **What is an antibiotic?**

Writing in Science

Research and Write Learn more about the work of one of these scientists. Then, imagine that a new hospital is going to be dedicated to that person and that you have been chosen to deliver the dedication speech. Write a speech that praises the person's contributions to fighting disease.

1928 Alexander Fleming

In Britain, Alexander Fleming observed that bacteria growing on laboratory plates were killed when various kinds of fungi grew on the same plate. He discovered that one fungus produced a substance that killed bacteria—penicillin.

1952 Jonas Salk

In 1952, there were more than 57,000 cases of polio, making it one of the most dreaded diseases known at the time. That same year, Jonas Salk, a professor at a medical university in the United States, showed that people injected with killed polio viruses did not get the disease, but produced antibodies against it.

1985 Mathilde Krim

Mathilde Krim, an American biomedical researcher, founded The American Foundation for AIDS Research, or AmFAR. Krim recognized that AIDS was a serious threat to public health and has dedicated her life to supporting AIDS research.

1920 1960 2000

FIGURE 11
Passive Immunity
This baby has acquired passive immunity from her mother.
Relating Cause and Effect *How do babies acquire passive immunity?*

Passive Immunity

Some diseases, such as rabies, are so uncommon that people rarely receive vaccinations against them. However, if a person is bitten by an animal that might have rabies, the person is usually given injections that contain antibodies to the rabies antigen. The protection that the person acquires this way is an example of passive immunity. **Passive immunity** results when antibodies are given to a person—the person's immune system does not make them. **A person acquires passive immunity when the antibodies that fight the pathogen come from a source other than the person's body.** Unlike active immunity, which is long-lasting, passive immunity usually lasts no more than a few months.

A baby acquires passive immunity to some diseases before birth. This immunity results from antibodies that are passed from the mother's blood into the baby's blood during pregnancy. After birth, these antibodies protect the baby for a few months. By then, the baby's own immune system has begun to function fairly efficiently.

Reading Checkpoint **What is one disease for which you can acquire passive immunity?**

Section 3 Assessment

Target Reading Skill **Comparing and Contrasting**
Use the information in your Venn diagram about active immunity and passive immunity to help you answer the questions below.

Reviewing Key Concepts

1. a. **Defining** What is active immunity?
   b. **Explaining** What are two ways in which active immunity can be acquired?
   c. **Applying Concepts** After receiving certain vaccinations, some children may develop mild symptoms of the disease. Explain why.
2. a. **Reviewing** What is passive immunity?
   b. **Describing** How is passive immunity acquired?
   c. **Inferring** Why does passive immunity usually not last for very long?

Lab zone At-Home Activity

Vaccination History With a family member, make a list of all the vaccinations you have received. For each, note when you received the vaccination. Then, with your family member, learn about one of the diseases against which you were vaccinated. What kind of pathogen causes the disease? What are the symptoms of the disease? Is the disease still common in the United States?

Section 4

Noninfectious Disease

Reading Preview

Key Concepts

- What causes allergies?
- How does diabetes affect the body?
- What are the effects of cancer on the body?

Key Terms

- noninfectious disease
- allergy • allergen
- histamine • asthma • insulin
- diabetes • tumor • carcinogen

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, answer your questions.

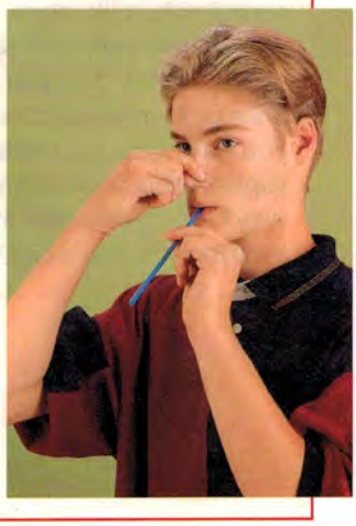
Noninfectious Disease

Question	Answer
What is an allergy?	An allergy is a disorder in which . . .

Lab zone Discover Activity

What Happens When Airflow Is Restricted?

1. Asthma is a disorder in which breathing passages become narrower than normal. This activity will help you understand how this condition affects breathing. **CAUTION:** *Do not perform this activity if you have a medical condition that affects your breathing.* Begin by breathing normally, first through your nose and then through your mouth. Observe how deeply you breathe.
2. Put one end of a drinking straw in your mouth. Then, gently pinch your nostrils shut so that you cannot breathe through your nose.
3. With your nostrils pinched closed, breathe by inhaling air through the straw. Continue breathing this way for thirty seconds.



Think It Over

Observing Compare your normal breathing pattern to that when breathing through the straw. Which way were you able to take deeper breaths? Did you ever feel short of breath?

Americans are living longer today than ever before. A person who was born in 2000 can expect to live about 77 years. In contrast, a person born in 1950 could expect to live only about 68 years, and a person born in 1900 only about 50 years.

Progress against infectious disease is one reason why life spans have increased. However, as infectious diseases have become less common, noninfectious diseases have grown more common. **Noninfectious diseases** are diseases that are not caused by pathogens in the body. Unlike infectious diseases, noninfectious diseases cannot be transmitted from person to person. One noninfectious disease, cardiovascular disease, is the leading cause of death in the United States. Allergies, diabetes, and cancer are other noninfectious diseases.

◀ People live longer today than ever before.

Lab zone Skills Activity

Drawing Conclusions

Two weeks ago, after you ate strawberry shortcake with whipped cream, you broke out in an itchy rash. The ingredients in the dessert were strawberries, sugar, flour, butter, eggs, vanilla, baking powder, salt, and cream. Last night, you ate a strawberry tart with whipped cream and again broke out in a rash. The ingredients were strawberries, sugar, cornstarch, milk, eggs, flour, shortening, salt, and vanilla.

You think that you may be allergic to strawberries. Do you have enough evidence to support this conclusion? If so, why? If not, what additional evidence do you need?

Allergies

Spring has arrived. Flowers are in bloom, and the songs of birds fill the air. Unfortunately, for some people, sneezing is another sound that fills the air. People who sneeze and cough in the spring may not have colds. Instead, they may be suffering from allergies to plant pollen. An **allergy** is a disorder in which the immune system is overly sensitive to a foreign substance—something not normally found in the body. **An allergy develops in response to various foreign substances that set off a series of reactions in the body.**

Allergens Any substance that causes an allergy is called an **allergen**. In addition to different kinds of pollen, allergens include dust, molds, some foods, and even some medicines. If you are lucky, you have no allergies at all. However, the bodies of many people react to one or more allergens.

Allergens may get into your body when you inhale them, eat them in food, or touch them with your skin. When lymphocytes encounter an allergen, they produce antibodies to that allergen. These antibodies, unlike the ones made during the immune response, signal cells in the body to release a substance called histamine. **Histamine** (HIS tuh meen) is a chemical that is responsible for the symptoms of an allergy, such as sneezing and watery eyes. Drugs that interfere with the action of histamine, called antihistamines, may lessen this reaction. However, if you have an allergy, the best strategy is to try to avoid the substance to which you are allergic.

FIGURE 12
Allergens
Some people have allergic reactions to plant pollen, dust mites, or cats.

◀ Pollen

Dust Mite ▲

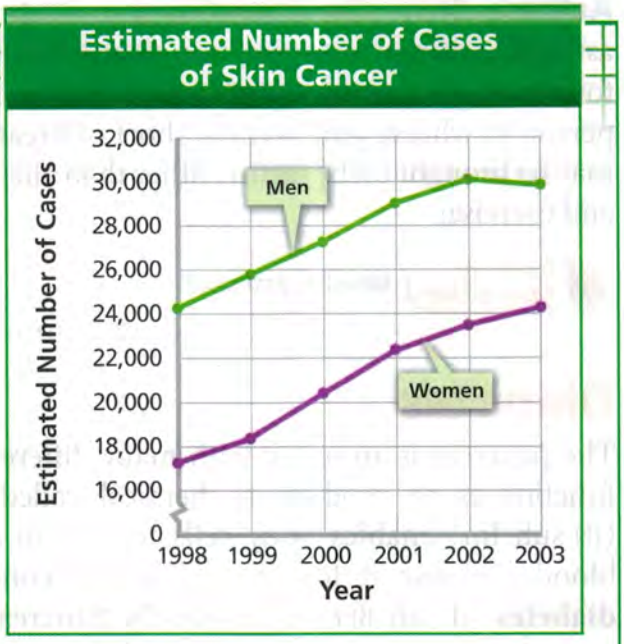
◀ Cat

Math Analyzing Data

Skin Cancer

The graph shows the frequency of skin cancer in the United States from 1998 to 2003.

1. **Reading Graphs** What variable is being plotted on the *y*-axis?
2. **Interpreting Data** How many cases of skin cancer were estimated for women in 1998? In 2003?
3. **Calculating** Using the data from Question 2, calculate the increase in the number of skin cancer cases among women.
4. **Calculating** How did the number of cases differ for men and women in 1999?
5. **Predicting** Will the number of skin cancers change in the next five years? Explain.



Cancer

Under normal conditions, the body produces new cells at about the same rate that other cells die. In a condition known as cancer, however, the situation is quite different. **Cancer is a disease in which cells multiply uncontrollably, over and over, destroying healthy tissue in the process.**

How Cancer Develops As cells divide over and over, they often form abnormal tissue masses called **tumors**. Not all tumors are cancerous. Cancerous tumors invade and destroy the healthy tissue around them. Cancer cells can break away from a tumor and invade blood or lymph vessels. The blood or lymph carries the cancer cells to other parts of the body, where they may begin to divide and form new tumors. Unless stopped by treatment, cancer progresses through the body.

Causes of Cancer Different factors may work together in causing cells to become cancerous. One such factor is the characteristics that people inherit from their parents. Because of their inherited characteristics, some people are more likely than others to develop certain kinds of cancer. For example, if you are female, and your mother or grandmother has breast cancer, you have an increased chance of developing breast cancer.

Some substances or factors in the environment, called **carcinogens** (kahr SIN uh junz), can cause cancer. The tar in cigarette smoke is an example of a carcinogen. Ultraviolet light, which is part of sunlight, can also be a carcinogen.

Asthma Some allergic reactions can create a condition called asthma. **Asthma** (AZ muh) is a disorder in which the respiratory passages narrow significantly. This narrowing causes the person to wheeze and become short of breath. Asthma attacks may be brought on by factors other than allergies, such as stress and exercise.

Reading Checkpoint **What is asthma?**

Diabetes

The pancreas is an organ with many different functions. One function is to produce a chemical called insulin. **Insulin** (IN suh lin) enables body cells to take in glucose from the blood and use it for energy. In the condition known as **diabetes** (dy uh BEE tis), either the pancreas fails to produce enough insulin or the body's cells fail to properly use insulin. **As a result, a person with diabetes has high levels of glucose in the blood and may even excrete glucose in the urine. The person's body cells, however, do not have enough glucose.**

Effects of Diabetes If untreated, people with diabetes may lose weight, feel weak, and be hungry all the time. These symptoms occur because body cells are unable to take in the glucose they need. In addition, diabetics may urinate frequently and feel thirsty as the kidneys work to eliminate the excess glucose from the body. The long-term effects of diabetes are serious and can include blindness, kidney failure, and heart disease.

Forms of Diabetes There are two main forms of diabetes. Type I diabetes usually begins in childhood or early adulthood. In Type I diabetes, the pancreas produces little or no insulin. People with this condition must get insulin injections.

Type II diabetes usually develops during adulthood. In this condition, either the pancreas does not make enough insulin, or body cells do not respond normally to insulin. People with Type II diabetes may be able to control their symptoms through proper diet, weight control, and exercise.

Reading Checkpoint **What are two symptoms of diabetes?**

FIGURE 13
Glucose Testing
Many people with diabetes must test their blood frequently to determine the level of glucose in their blood.
Relating Cause and Effect *What accounts for the high level of glucose in the blood of diabetics?*

Cancer Treatment Surgery, drugs, and radiation are all used to treat cancer. If cancer is detected before it has spread, doctors may remove the cancerous tumors through surgery. After surgery, radiation or drugs may be used to make sure all the cancer cells have been killed.

Radiation treatment uses high-energy waves to kill cancer cells. When these rays are aimed at tumors, the intense energy damages and kills cancer cells more than it damages normal cells. Drug therapy is the use of chemicals to destroy cancer cells. Many of these chemicals, however, destroy some normal cells as well.

Cancer Prevention As with other diseases, the best way to fight cancer is to prevent it. People can reduce their risk of cancer by avoiding carcinogens, such as those found in tobacco. Even chewing tobacco and snuff contain carcinogens, which can cause mouth cancers. A low-fat diet that includes plenty of fruits and vegetables can help prevent cancers of the digestive system.

People can also increase their chance of surviving cancer by having regular medical checkups. The earlier cancer is detected, the more likely it can be treated successfully.

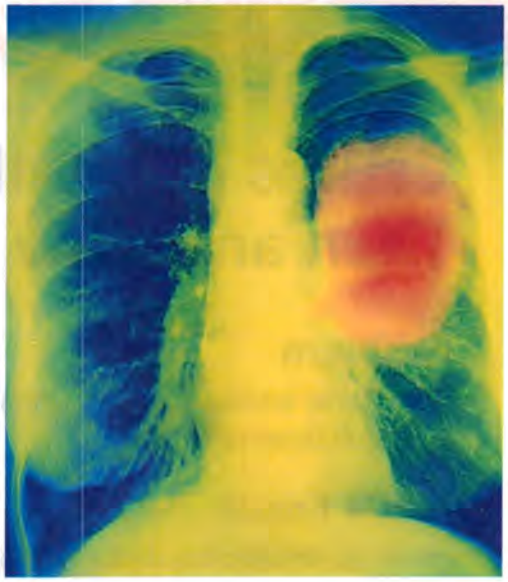


FIGURE 14
Lung Tumor
The large orange mass in the X-ray is a cancerous tumor in the lung.

Reading Checkpoint What is a carcinogen?

Section 4 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. **Defining** What is an allergy?
   b. **Describing** Describe how the body reacts to the presence of an allergen.
   c. **Inferring** You and your friends go to a movie. When you enter the theater, you start to sneeze and your throat feels scratchy. Explain what you think is happening.
2. a. **Identifying** What is the function of insulin in the body?
   b. **Explaining** How does diabetes affect the level of glucose in the blood and in body cells?
3. a. **Reviewing** What is a cancerous tumor?
   b. **Relating Cause and Effect** Describe how cancerous tumors harm the body.
   c. **Applying Concepts** Why do doctors look for cancerous tumors in the lymphatic system when someone is diagnosed with cancer?

Lab zone At-Home Activity

Family History of Allergies Explain to your family what allergies are and how allergens affect the body. Make a list of any substances to which your family members are allergic. Use this list to determine whether certain allergies occur frequently in your family.

Lab zone Skills Lab

Causes of Death, Then and Now

Problem

How do the leading causes of death today compare with those in 1900?

Skills Focus

graphing, interpreting data, drawing conclusions

Materials

- colored pencils
- ruler
- calculator (optional)
- protractor
- compass

Procedure

1. The data table on the next page shows the leading causes of death in the United States in 1900 and today. Examine the data and note that one cause of death—accidents—is not a disease. The other causes are labeled either "I," indicating an infectious disease, or "NI," indicating a noninfectious disease.

PART 1 Comparing Specific Causes of Death

2. Look at the following causes of death in the data table: (a) pneumonia and influenza, (b) heart disease, (c) accidents, and (d) cancer. Construct a bar graph that compares the numbers of deaths from each of those causes in 1900 and today. Label the horizontal axis *"Causes of Death."* Label the vertical axis *"Deaths per 100,000 People."* Draw two bars side by side for each cause of death. Use a key to show which bars refer to 1900 and which refer to today.

PART 2 Comparing Infectious and Noninfectious Causes of Death

3. In this part of the lab, you will make two circle graphs showing three categories: infectious diseases, noninfectious diseases, and "other." You may want to review the information on creating circle graphs on page 262 of the Skills Handbook.

Ten Leading Causes of Death in the United States, 1900 and Today			
1900		Today	
Cause of Death	Deaths Per 100,000	Cause of Death	Deaths Per 100,000
Pneumonia, influenza (I)*	215	Heart disease (NI)	246
Tuberculosis (I)	185	Cancer (NI)	194
Diarrhea (I)	140	Stroke (NI)	57
Heart disease (NI)	130	Lung disease (NI)	43
Stroke (NI)	110	Accidents	34
Kidney disease (NI)	85	Diabetes (NI)	25
Accidents	75	Pneumonia, influenza (I)	22
Cancer (NI)	65	Alzheimer's disease (NI)	19
Senility (NI)	55	Kidney disease (NI)	14
Diphtheria (I)	40	Septicemia (I)	11
Total	**1,100**	**Total**	**665**

* (I) indicates an infectious disease. (NI) indicates a noninfectious disease.

4. Start by grouping the data from 1900 into the three categories—infectious diseases, noninfectious diseases, and other causes. Calculate the total number of deaths for each category. Then find the size of the "pie slice" (the number of degrees) for each category, and construct your circle graph. To find the size of the infectious disease slice for 1900, for example, use the following formula:

$$\frac{\text{Number of deaths from infectious diseases}}{\text{1,100 deaths total}} = \frac{x}{360^\circ}$$

5. Calculate the percentage represented by each category using this formula:

$$\frac{\text{Numbers of degrees in a slice}}{360^\circ} \times 100 = \blacksquare\%$$

6. Repeat Steps 4 and 5 using the data from today to make the second circle graph. What part of the formula in Step 4 do you need to change?

Analyze and Conclude

1. **Observing** What information did you learn from examining the data table in Step 1?
2. **Graphing** According to your bar graph, which cause of death showed the greatest increase between 1900 and today? The greatest decrease?
3. **Interpreting Data** In your circle graphs, which category decreased the most from 1900 to today? Which increased the most?
4. **Drawing Conclusions** Suggest an explanation for the change in the number of deaths due to infectious diseases from 1900 to today.
5. **Communicating** In a paragraph, explain how graphs help you identify patterns and other information in data that you might otherwise overlook.

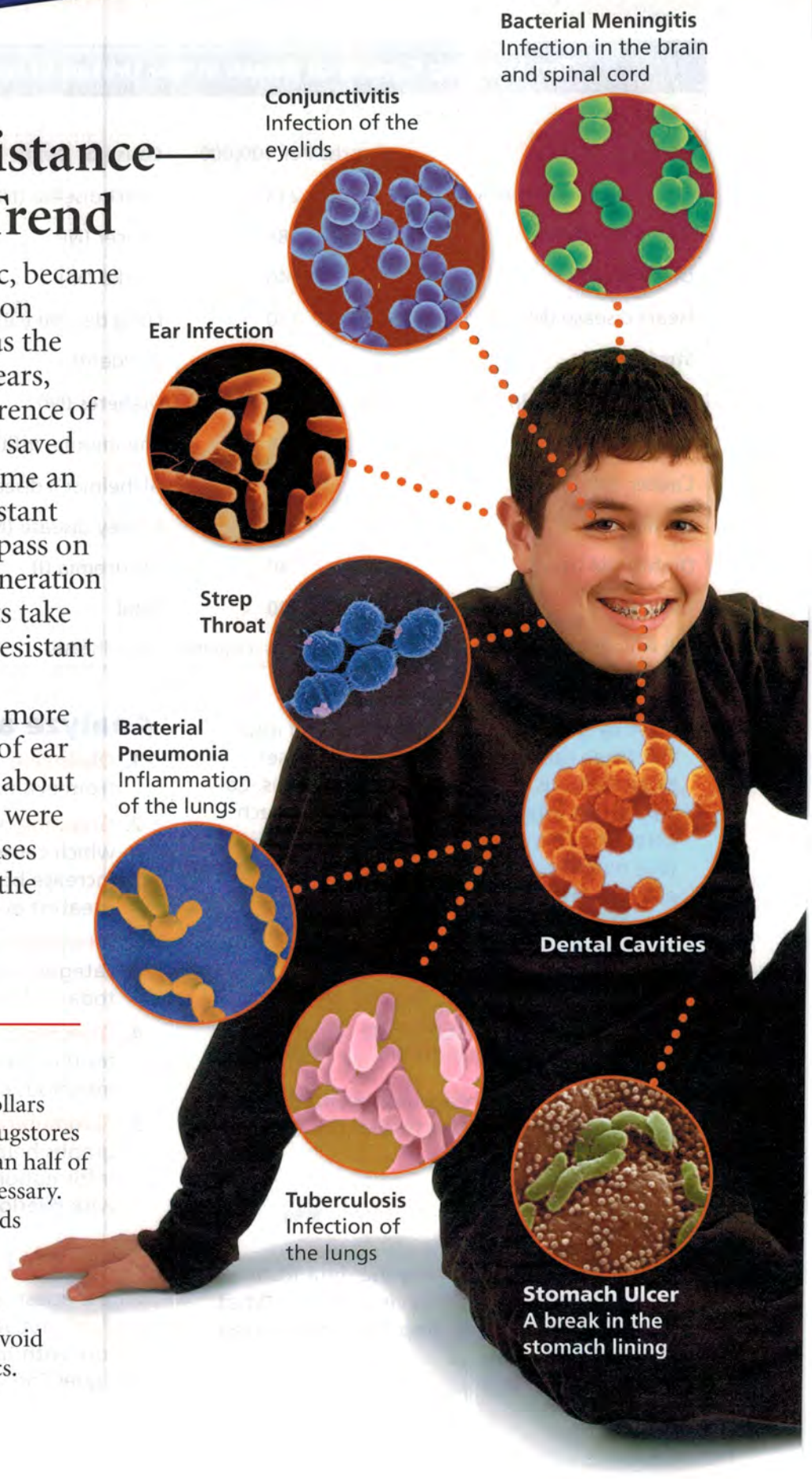
More to Explore

Write a question related to the data table that you have not yet answered. Then create a graph or work with the data in other ways to answer your question.

Antibiotic Resistance—An Alarming Trend

Penicillin, the first antibiotic, became available for use in 1943. Soon antibiotics became known as the "wonder drugs." Over the years, they have reduced the occurrence of many bacterial diseases and saved millions of lives. But each time an antibiotic is used, a few resistant bacteria may survive. They pass on their resistance to the next generation of bacteria. As more patients take antibiotics, the number of resistant bacteria increases.

In 1987, penicillin killed more than 99.9 percent of a type of ear infection bacteria. By 2000, about 30 percent of these bacteria were resistant to penicillin. Diseases such as tuberculosis are on the rise due in part to growing antibiotic resistance.



The Issues

What Can Doctors Do?

Each year, more than 20 billion dollars worth of antibiotics are sold to drugstores and hospitals worldwide. More than half of antibiotic prescriptions are unnecessary. They include those written for colds and other viral illnesses, which antibiotics are ineffective against. If doctors could better identify the cause of an infection, they could avoid prescribing unnecessary antibiotics.

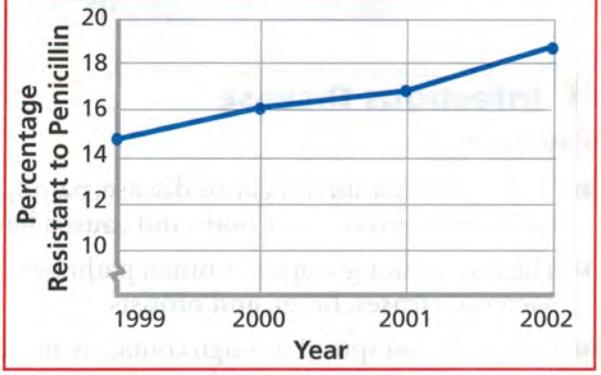
What Can Patients Do?

If a doctor prescribes a ten-day course of antibiotics, the patient should take all of the prescription to make sure that all the bacteria have been killed. If a patient stops taking the antibiotic, resistant bacteria will survive and reproduce. Then, a second or third antibiotic may be necessary. Patients also need to learn that some illnesses are best treated with rest and not with antibiotics.

Limiting Nonmedical Uses of Antibiotics

About half of the antibiotics used each year are not given to people. Instead, the drugs are fed to food animals, such as cattle and poultry, to prevent illness and increase growth. Reducing this type of use would limit the amount of the drugs in food animals and in the people who eat them. But these actions might increase the risk of disease in animals and lead to higher meat prices.

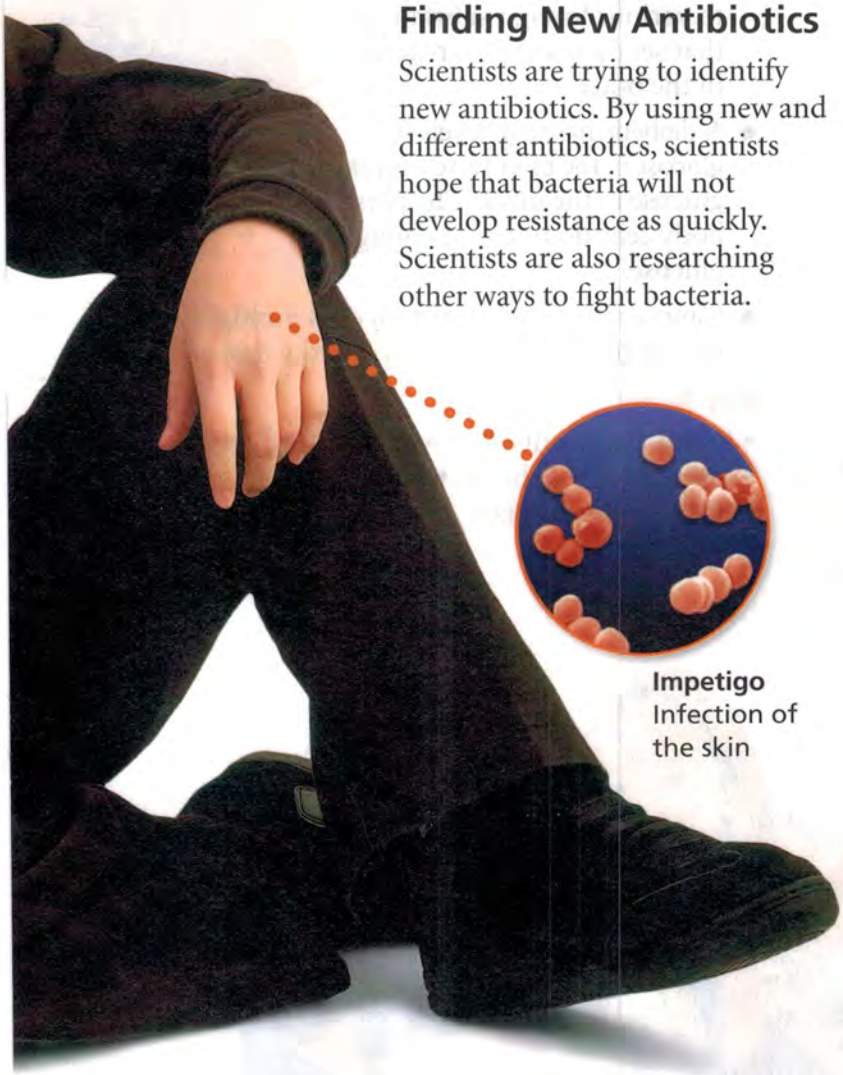
Antibiotic Resistance in Pneumonia Bacteria



The percentage of resistant bacteria has increased steadily over the years.

Finding New Antibiotics

Scientists are trying to identify new antibiotics. By using new and different antibiotics, scientists hope that bacteria will not develop resistance as quickly. Scientists are also researching other ways to fight bacteria.



Impetigo
Infection of the skin

You Decide

1. Identify the Problem
How can the use of antibiotics make these medicines less effective?

2. Analyze the Options
List all the ways to fight the development of antibiotic resistance in bacteria. Mention any costs or drawbacks.

3. Find a Solution
Make a persuasive poster about one way to deal with antibiotic resistance. Support your viewpoint with sound reasons.

Go Online
PHSchool.com

For: More on bacterial resistance
Visit: PHSchool.com
Web Code: ceh-1020

Chapter 18 Study Guide

The BIG Idea **Personal Health** The human body has three lines of defense against fighting disease—barriers, the inflammatory response, and the immune response.

1 Infectious Disease

Key Concepts

- When you have an infectious disease, pathogens have gotten inside your body and caused harm.
- The four major groups of human pathogens are bacteria, viruses, fungi, and protists.
- Pathogens can spread through contact with either an infected person; soil, food, or water; a contaminated object; or an infected animal.

Key Terms

pathogen
infectious disease
toxin

2 The Body's Defenses

Key Concepts

- The surfaces of the skin, breathing passages, mouth, and stomach function as barriers to pathogens. These barriers trap and kill most pathogens with which you come into contact.
- In the inflammatory response, fluid and white blood cells leak from blood vessels into nearby tissues. The white blood cells then fight the pathogens.
- The cells of the immune system can distinguish between different kinds of pathogens. The immune system cells react to each kind of pathogen with a defense targeted specifically at that pathogen.
- HIV is the only kind of virus known to attack the human immune system directly and destroy T cells. HIV can spread from one person to another only if body fluids from an infected person come in contact with those of an uninfected person.

Key Terms

• inflammatory response • phagocyte
• immune response • lymphocyte
• T cell • antigen • B cell • antibody
• AIDS • HIV

3 Preventing Infectious Disease

Key Concepts

- A person acquires active immunity when their own immune system produces antibodies in response to the presence of a pathogen.
- A person acquires passive immunity when the antibodies that fight the pathogen come from a source other than the person's body.

Key Terms

• immunity • active immunity • vaccination
• vaccine • antibiotic • passive immunity

4 Noninfectious Disease

Key Concepts

- An allergy develops in response to various foreign substances that set off a series of reactions in the body.
- A diabetic has high levels of glucose in the blood and excretes glucose in the urine. The person's body cells do not have enough glucose.
- Cancer is a disease in which cells multiply uncontrollably and destroy healthy tissue.

Key Terms

• noninfectious disease • allergy • allergen
• histamine • asthma • insulin • diabetes
• tumor • carcinogen

Review and Assessment

Go Online
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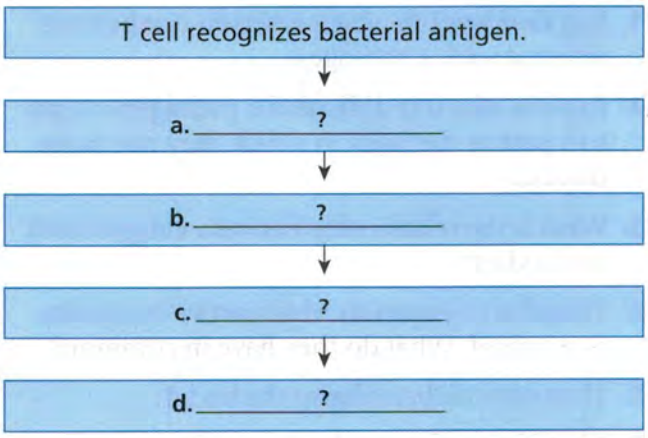
Organizing Information

Sequencing Copy the flowchart showing what happens after strep bacteria begin to multiply in the throat. 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. Some bacteria produce poisons called
   a. histamines. **b.** toxins.
   c. phagocytes. **d.** pathogens.

2. Antibodies are produced by
   a. phagocytes. **b.** B cells.
   c. T cells. **d.** pathogens.

3. A chemical that kills bacteria or slows their growth without harming body cells is called a(n)
   a. pathogen.
   b. antibiotic.
   c. allergen.
   d. histamine.

4. High levels of glucose in the blood may be a sign of
   a. an allergy.
   b. AIDS.
   c. cancer.
   d. diabetes.

5. A carcinogen causes
   a. cancer.
   b. AIDS.
   c. an infectious disease.
   d. an allergy.

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

6. Bacteria, viruses, fungi, and protists are the major human <u>phagocytes</u>.
7. A <u>T cell</u> engulfs pathogens and destroys them.
8. Vaccination produces <u>active immunity</u>.
9. During an allergic reaction, cells in the body release the chemical <u>insulin</u>.
10. A <u>tumor</u> is a mass of abnormal tissue.

Writing in Science

Newspaper Article Suppose you are a reporter who is able to travel inside the human body and document how the body fights a virus. Write an article on the battle between the virus and the human immune system, describing the different ways the body fights pathogens.

Discovery CHANNEL SCHOOL

Fighting Disease
Video Preview
Video Field Trip
▶ Video Assessment

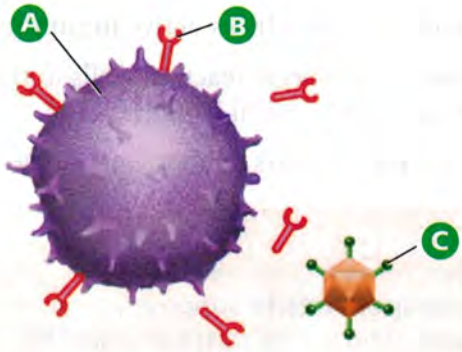
Review and Assessment

Checking Concepts

11. List four ways in which a person can become infected with a pathogen.
12. Explain why it is difficult for pathogens to get to a part of the body in which they can cause disease.
13. What is the relationship between antigens and antibodies?
14. Describe two ways in which active immunity is acquired. What do they have in common?
15. How does diabetes harm the body?
16. Identify two factors that can make a person likely to develop cancer.

Thinking Critically

17. **Applying Concepts** Can you catch a cold by sitting in a chilly draft? Explain.
18. **Interpreting Diagrams** Identify each structure labeled below and its role in the immune response.



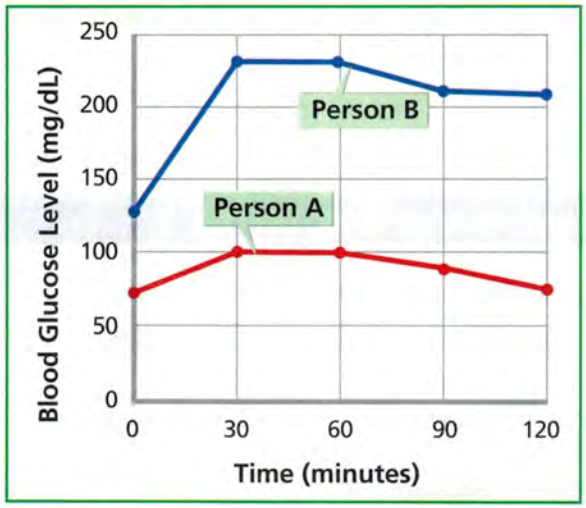
19. **Relating Cause and Effect** Why is the immune system successful in fighting most pathogens but is unsucessful in fighting HIV?
20. **Comparing and Contrasting** Compare and contrast active immunity and passive immunity. Then, describe one way in which a person can acquire each type of immunity.
21. **Making Judgments** What precautions can people take to decrease their risk of cancer?

Applying Skills

Use the graph to answer Questions 22–25.

A glucose tolerance test can check for diabetes. A doctor gives a patient a sugar drink and measures the blood glucose level over a 2 hour period. The graph below shows the results of this test for two people.

Blood Glucose Levels



22. **Reading Graphs** What was each person's glucose level at the start of the test?
23. **Interpreting Data** Which person's blood glucose level rose more quickly during the first 30 minutes?
24. **Interpreting Data** Which person's blood glucose level returned to near the starting level after 2 hours? Which person's blood glucose level remained elevated after 2 hours?
25. **Drawing Conclusions** Which person may have diabetes? Explain your answer.

Lab zone Chapter Project

Performance Assessment Before you present your news broadcasts, make sure any sound effects and props support the story. Do your broadcasts help people better understand how the body fights disease?

Chapter

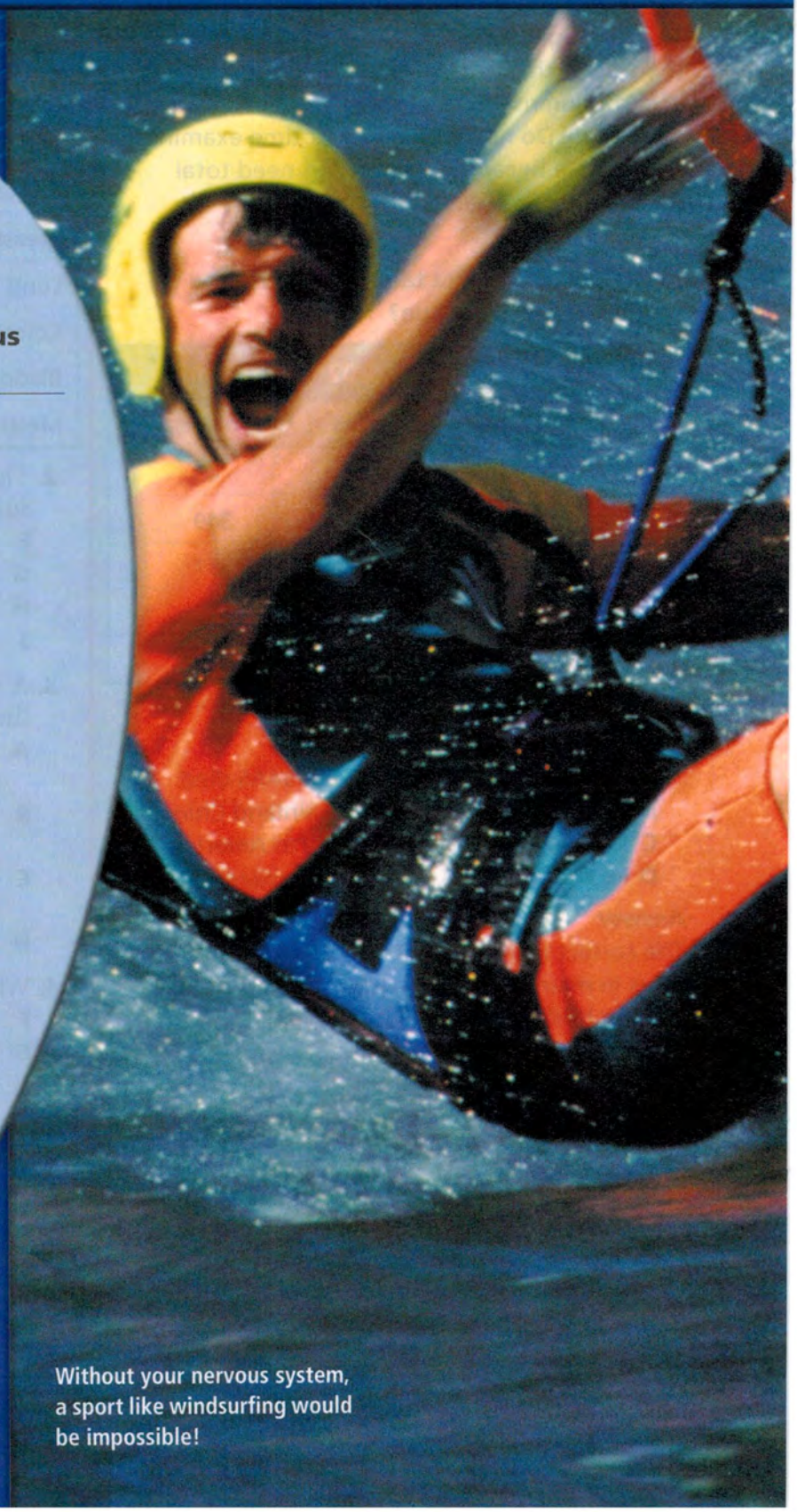
19 The Nervous System

The BIG Idea

Structure and Function

Which organs and other structures enable the nervous system to function?

Chapter Preview



Without your nervous system, a sport like windsurfing would be impossible!

Discovery CHANNEL SCHOOL

The Nervous System

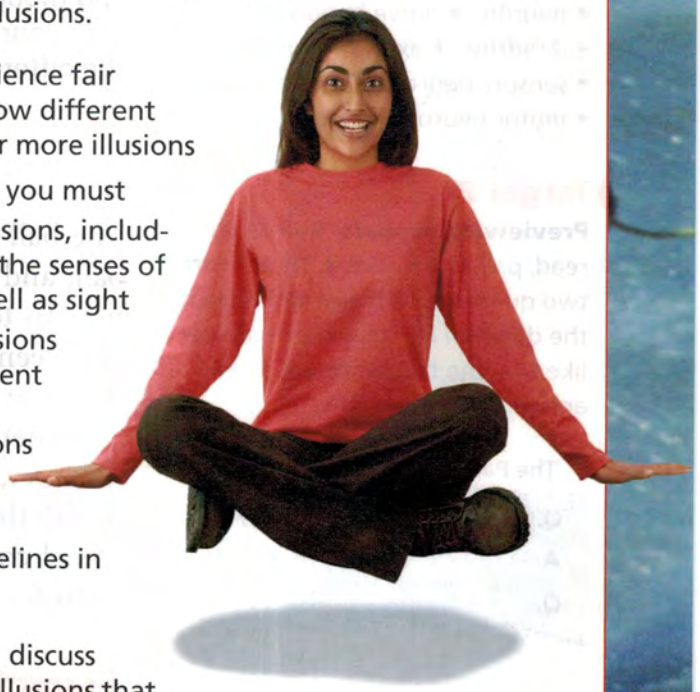
- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™

Chapter Project

Tricks and Illusions

Things aren't always what they seem. For example, an optical illusion is a picture or other visual effect that tricks you into seeing something incorrectly. In this project, you'll investigate how your senses sometimes can be fooled by illusions.



Your Goal To set up a science fair booth to demonstrate how different people respond to one or more illusions

To complete this project, you must

- try out a variety of illusions, including some that involve the senses of hearing or touch as well as sight
- select one or more illusions and set up an experiment to monitor people's responses to the illusions
- learn why the illusions fool the senses
- follow the safety guidelines in Appendix A

Plan It! In a small group, discuss optical illusions or other illusions that you know about. Look in books to learn about others. Try them out. Which illusions would make an interesting experiment? How could you set up such an experiment at a science fair?

Section 1

How the Nervous System Works

Reading Preview

Key Concepts

- What are the functions of the nervous system?
- What is the structure of a neuron and what kinds of neurons are found in the body?
- How do nerve impulses travel from one neuron to another?

Key Terms

- stimulus • response
- neuron • nerve impulse
- dendrite • axon • nerve
- sensory neuron • interneuron
- motor neuron • synapse

Target Reading Skill

Previewing Visuals Before you read, preview Figure 3. Then, write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

The Path of a Nerve Impulse

Q. What is a sensory neuron?
A.
Q.

Lab zone Discover Activity

How Simple Is a Simple Task?

1. Trace the outline of a penny in twelve different places on a piece of paper.
2. Number the circles 1 through 12. Write the numbers randomly, in no particular order.
3. Now, pick up the penny again. Put it in each circle, one after another, in numerical order, beginning with 1 and ending with 12.

Think It Over

Inferring Make a list of all the sense organs, muscle movements, and thought processes used in this activity. Compare your list with your classmates' lists. What organ system coordinated all the different processes involved in this task?

The ball whizzes toward the soccer goalie. She lunges for the ball, and in one swift movement blocks it from entering the net. To tend goal, soccer players need excellent coordination and keen vision. In addition, they must remember what they have learned from years of practice.

Whether or not you play soccer, you too need coordination, memory, and the ability to learn. Your nervous system carries out all these functions. The nervous system includes the brain, spinal cord, and nerves that run throughout the body. It also includes sense organs, such as the eyes and ears.

Functions of the Nervous System

The Internet lets people gather information from anywhere in the world with the click of a button. Like the Internet, your nervous system is a communications network. But it is much more efficient than the Internet.

The nervous system receives information about what is happening both inside and outside your body. It also directs the way in which your body responds to this information. In addition, your nervous system helps maintain homeostasis. Without your nervous system, you could not move, think, feel pain, or taste a spicy taco.

Receiving Information Because of your nervous system, you are aware of what is happening in the environment around you. For example, you know that a fly is buzzing around your head, that the wind is blowing, or that a friend is telling a funny joke. Your nervous system also checks conditions inside your body, such as the level of glucose in your blood.

Responding to Information Any change or signal in the environment that can make an organism react is called a **stimulus** (STIM yoo lus) (plural: *stimuli*). A buzzing fly is a stimulus. After your nervous system analyzes the stimulus, it causes a response. A **response** is what your body does in reaction to a stimulus—you swat at the fly.

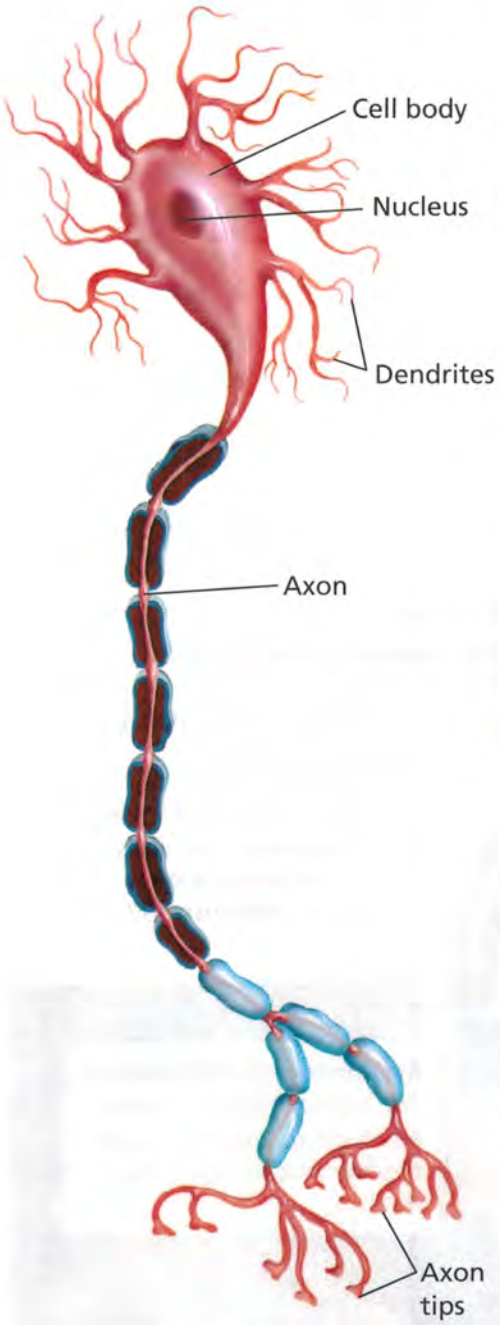
Some nervous system responses, such as swatting a fly, are voluntary, or under your control. However, many processes necessary for life, such as heart rate, are controlled by involuntary actions of the nervous system.

Maintaining Homeostasis The nervous system helps maintain homeostasis by directing the body to respond appropriately to the information it receives. For example, when you are hungry, your nervous system prompts you to eat. This action maintains homeostasis by supplying your body with the nutrients and energy it needs.

Reading Checkpoint **What is a stimulus?**

FIGURE 1
The Nervous System at Work
The zooming soccer ball is a stimulus. The goalie responds by lunging toward the ball and blocking the shot.
Interpreting Diagrams *How does the goalie's nervous system help her body maintain homeostasis?*

FIGURE 2
Structure of a Neuron
A neuron has one axon and many dendrites that extend from the cell body.



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The Neuron

Your nervous system includes various organs, tissues, and cells. For example, your brain is an organ, and the nerves running throughout your body are tissues. The cells that carry information through your nervous system are called **neurons** (NOO rahnz), or nerve cells. The message that a neuron carries is called a **nerve impulse.**

The Structure of a Neuron The structure of a neuron enables it to carry nerve impulses. **A neuron has a large cell body that contains the nucleus, threadlike extensions called dendrites, and an axon.** The **dendrites** carry impulses toward the neuron's cell body. The **axon** carries impulses away from the cell body. Nerve impulses begin in a dendrite, move toward the cell body, and then move down the axon. A neuron can have many dendrites, but it has only one axon. An axon, however, can have more than one tip, so the impulse can go to more than one other cell.

Axons and dendrites are sometimes called nerve fibers. Nerve fibers are often arranged in parallel bundles covered with connective tissue, something like a package of uncooked spaghetti wrapped in cellophane. A bundle of nerve fibers is called a **nerve.**

Kinds of Neurons **Three kinds of neurons are found in the body—sensory neurons, interneurons, and motor neurons.** Figure 3 shows how these three kinds of neurons work together.

A **sensory neuron** picks up stimuli from the internal or external environment and converts each stimulus into a nerve impulse. The impulse travels along the sensory neuron until it reaches an interneuron, usually in the brain or spinal cord. An **interneuron** is a neuron that carries nerve impulses from one neuron to another. Some interneurons pass impulses from sensory neurons to motor neurons. A **motor neuron** sends an impulse to a muscle or gland, and the muscle or gland reacts in response.

Reading Checkpoint **What is the function of an axon?**

How a Nerve Impulse Travels

Every day of your life, billions of nerve impulses travel through your nervous system. Each of those nerve impulses begins in the dendrites of a neuron. The impulse moves rapidly toward the neuron's cell body and then down the axon until it reaches the axon tip. A nerve impulse travels along the neuron in the form of electrical and chemical signals. Nerve impulses can travel as fast as 120 meters per second!

FIGURE 3

The Path of a Nerve Impulse

When you hear your phone ring, you pick it up to answer it. Many sensory neurons, interneurons, and motor neurons are involved in this action.

Interpreting Diagrams *To where does the impulse pass from the sensory neurons?*

1 Sensory Neuron
Nerve impulses begin when receptors pick up stimuli from the environment. Receptors in the ear pick up the sound of the phone ringing. The receptors trigger nerve impulses in sensory neurons.

2 Interneuron
From the sensory neurons, the nerve impulse passes to interneurons in the brain. Your brain interprets the impulses from many interneurons and makes you realize that the phone is ringing. Your brain also decides that you should answer the phone.

3 Motor Neuron
Impulses then travel along thousands of motor neurons. The motor neurons send the impulses to muscles. The muscles carry out the response, and you reach for the phone.

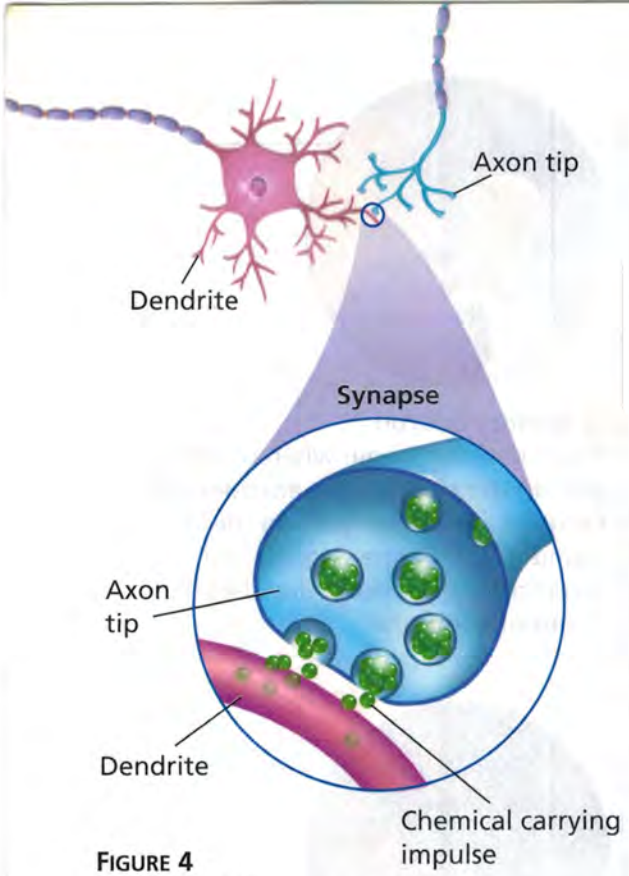


FIGURE 4
The Synapse
When a nerve impulse reaches the tip of an axon, chemicals are released into the gap at the synapse. The chemicals carry the nerve impulse across the gap.

The Synapse What happens when a nerve impulse reaches the axon tip at the end of a neuron? At that point, the impulse can pass to the next structure. Sometimes the structure is the dendrite of another neuron. Other times, the structure is a muscle or a cell in another organ, such as a sweat gland. The junction where one neuron can transfer an impulse to another structure is called a **synapse** (SIN aps).

How an Impulse is Transferred Figure 4 shows a synapse between the axon tip of one neuron and the dendrite of another neuron. Notice that a small gap separates these two structures. **For a nerve impulse to be carried along at a synapse, it must cross the gap between the axon and the next structure. The axon tips release chemicals that carry the impulse across the gap.**

You can think of the gap at a synapse as a river, and an axon as a road that leads up to the riverbank. The nerve impulse is like a car traveling on the road. To get to the other side, the car has to cross the river. The car gets on a ferry boat, which carries it across the river. The chemicals that the axon tips release are like the ferry, carrying the nerve impulse across the gap.

Section 1 Assessment

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 3 to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Listing** What are three functions of the nervous system?
   b. **Describing** Give an example of a stimulus and describe how the nervous system produces a response.
   c. **Predicting** Your heart rate is controlled by involuntary actions of the nervous system. What would life be like if your heartbeat were under voluntary control?
2. a. **Identifying** Identify the three kinds of neurons that are found in the nervous system.
   b. **Explaining** How do the three kinds of neurons interact to carry nerve impulses?
   c. **Comparing and Contrasting** How do sensory neurons and motor neurons differ?
3. a. **Reviewing** What is a synapse?
   b. **Sequencing** Outline the steps by which a nerve impulse reaches and then crosses the gap at a synapse.

Lab zone At-Home Activity

Pass the Salt, Please During dinner, ask a family member to pass the salt and pepper to you. Observe what your family member then does. Explain that the words you spoke were a stimulus and that the family member's reaction was a response. Discuss other examples of stimuli and responses with your family.

Section 2

Divisions of the Nervous System

Reading Preview

Key Concepts

- What are the structures and functions of the central nervous system?
- What are the structures and functions of the peripheral nervous system?
- What is a reflex?
- What are two ways in which the nervous system can be injured?

Key Terms

- central nervous system
- peripheral nervous system
- brain • spinal cord
- cerebrum • cerebellum
- brain stem
- somatic nervous system
- autonomic nervous system
- reflex • concussion

Target Reading Skill

Building Vocabulary After you read this section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

How Does Your Knee React?

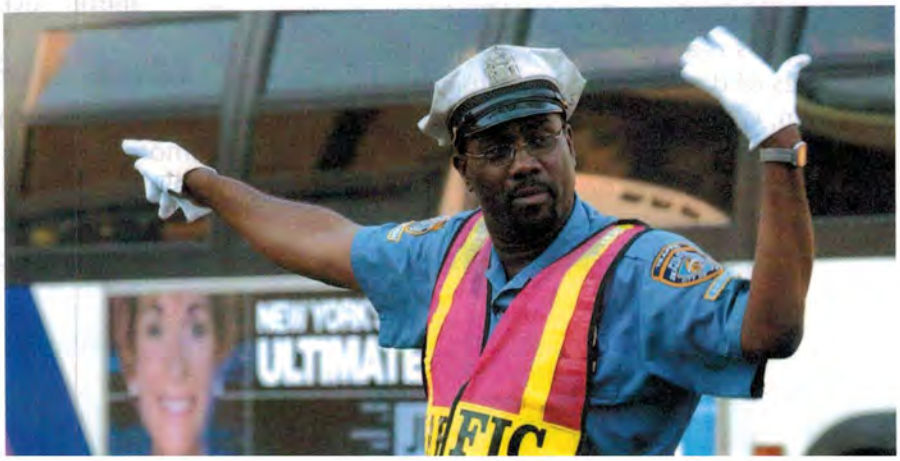
1. Sit on a table or counter so that your legs dangle freely. Make sure that your partner is not directly in front of your legs.
2. Have your partner use the side of his or her hand to tap one of your knees gently just below the kneecap. Observe what happens to your leg. Note whether you have any control over your reaction.
3. Change places with your partner. Repeat Steps 1 and 2.

Think It Over

Inferring When might it be an advantage for your body to react very quickly and without your conscious control?

You are standing at a busy street corner, waiting to cross the street. A traffic cop blows his whistle and waves his arms energetically. For the heavy traffic to move smoothly, there needs to be a traffic cop and responsive drivers. The traffic cop coordinates the movements of the drivers, and they maneuver the cars safely through the intersection.

Similarly, your nervous system has two divisions that work together. The **central nervous system** consists of the brain and spinal cord. The **peripheral nervous system** (puh RIF uh rul) includes all the nerves located outside of the central nervous system. The central nervous system is like a traffic cop. The peripheral nervous system is like the drivers and pedestrians.



The traffic cop keeps everybody moving.

Lab zone

Design Your Own Lab

Ready or Not!

Problem

Do people's reaction times vary at different times of the day?

Skills Focus

developing hypotheses, controlling variables, drawing conclusions

Material

- meter stick

Procedure

PART 1 **Observing a Response to a Stimulus**

1. Have your partner hold a meter stick with the zero end about 50 cm above a table.
2. Get ready to catch the meter stick by positioning the top of your thumb and forefinger just at the zero position, as shown in the photograph.
3. Your partner should drop the meter stick without any warning. Using your thumb and forefinger only (no other part of your hand), catch the meter stick as soon as you can. Record the distance in centimeters that the meter stick fell. This distance is a measure of your reaction time.

PART 2 **Designing Your Experiment**

4. With your partner, discuss how you can use the activity from Part 1 to find out whether people's reaction times vary at different times of day. Consider the questions below. Then, write up your experimental plan.
   - What hypothesis will you test?
   - What variables do you need to control?
   - How many people will you test? How many times will you test each person?
5. Submit your plan for your teacher's review. Make any changes your teacher recommends. Create a data table to record your results. Then, perform your experiment.

Analyze and Conclude

1. **Inferring** In this lab, what is the stimulus? What is the response? Is the response voluntary or involuntary? Explain.
2. **Developing Hypotheses** What hypothesis did you test in Part 2?
3. **Controlling Variables** In Part 2, why was it important to control all variables except the time of day?
4. **Drawing Conclusions** Based on your results in Part 2, do people's reaction times vary at different times of the day? Explain.
5. **Communicating** Write a paragraph to explain why you can use the distance on the meter stick as a measure of reaction time.

More to Explore

Do you think people can do arithmetic problems more quickly and accurately at certain times of the day? Design an experiment to investigate this question. *Obtain your teacher's permission before carrying out your investigation.*

Central Nervous System

You can see the central and peripheral nervous systems in Figure 5. **The central nervous system is the control center of the body. It includes the brain and spinal cord.** All information about what is happening in the world inside or outside your body is brought to the central nervous system. The **brain,** located in the skull, is the part of the central nervous system that controls most functions in the body. The **spinal cord** is the thick column of nervous tissue that links the brain to most of the nerves in the peripheral nervous system.

Most impulses from the peripheral nervous system travel through the spinal cord to get to the brain. Your brain then directs a response. The response usually travels from the brain, through the spinal cord, and then to the peripheral nervous system.

For example, here is what happens when you reach under the sofa to find a lost quarter. Your fingers move over the floor, searching for the quarter. When your fingers finally touch the quarter, the stimulus of the touch triggers nerve impulses in sensory neurons in your fingers. These impulses travel through nerves of the peripheral nervous system to your spinal cord. Then the impulses race up to your brain. Your brain interprets the impulses, telling you that you've found the quarter. Your brain starts nerve impulses that move down the spinal cord. From the spinal cord, the impulses travel through motor neurons in your arm and hand. The impulses in the motor neurons cause your fingers to grasp the quarter.

Reading Checkpoint **What are the parts of the central nervous system?**

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active art

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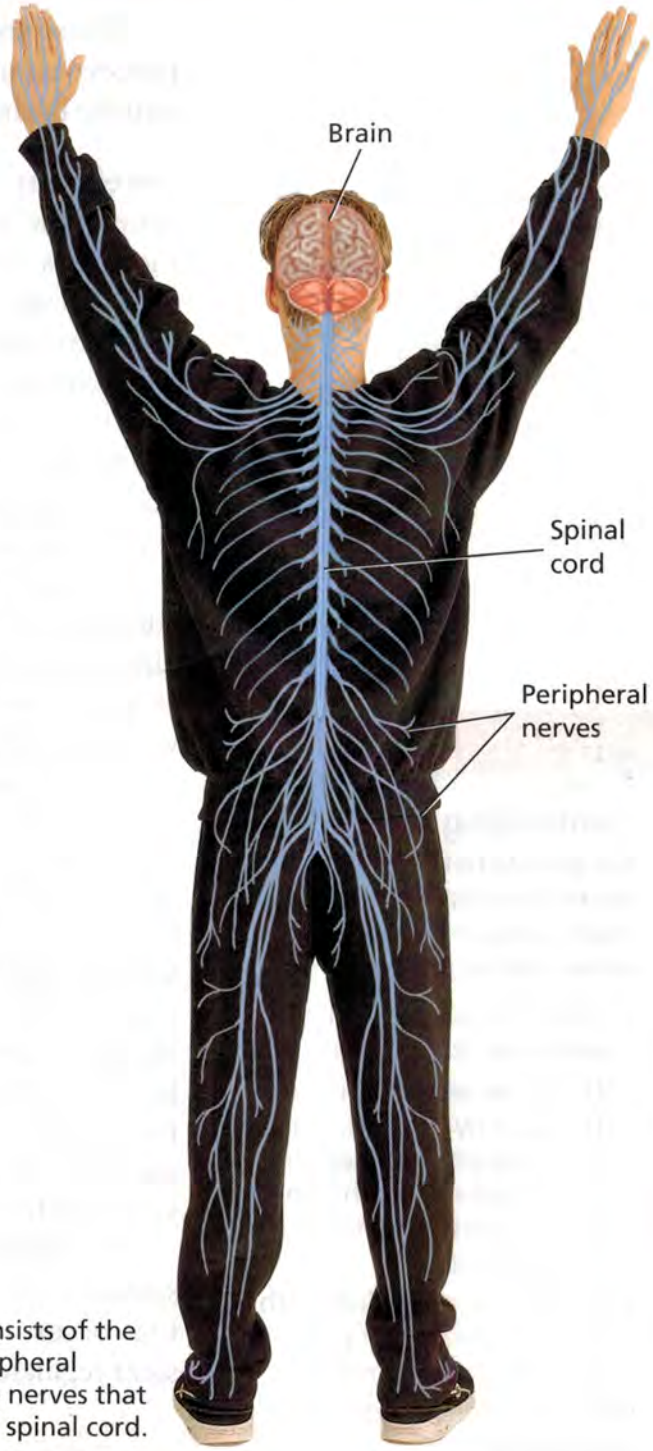


FIGURE 5
The Nervous System
The central nervous system consists of the brain and spinal cord. The peripheral nervous system includes all the nerves that branch out from the brain and spinal cord.

The Brain and Spinal Cord

Your brain contains about 100 billion neurons, all of which are interneurons. Each of those neurons may receive messages from up to 10,000 other neurons and may send messages to about 1,000 more! Three layers of connective tissue cover the brain. The space between the middle layer and innermost layer is filled with a watery fluid. The skull, the layers of connective tissue, and the fluid all help protect the brain from injury.

There are three main regions of the brain that receive and process information. These are the cerebrum, the cerebellum, and the brain stem. Find each in Figure 6.

Cerebrum The largest part of the brain is called the cerebrum. The **cerebrum** (suh REE brum) interprets input from the senses, controls movement, and carries out complex mental processes such as learning and remembering. Because of your cerebrum, you can locate your favorite comic strip in the newspaper, read it, and laugh at its funny characters.

The cerebrum is divided into a right and a left half. The right half sends impulses to skeletal muscles on the left side of the body. In contrast, the left half controls the right side of the body. When you reach with your right hand for a pencil, the messages that tell you to do so come from the left half of the cerebrum. In addition, each half of the cerebrum controls slightly different kinds of mental activity. The right half is usually associated with creativity and artistic ability. The left half is usually associated with mathematical skills and logical thinking.

As you can see in Figure 6, certain areas of the cerebrum are associated with smell, touch, taste, hearing, and vision. Other areas control movement, speech, written language, and abstract thought.

Cerebellum and Brain Stem The second largest part of your brain is called the cerebellum. The **cerebellum** (sehr uh BEL um) coordinates the actions of your muscles and helps you keep your balance. When you walk, the impulses that tell your feet to move start in your cerebrum. However, your cerebellum gives you the muscular coordination and sense of balance that keep you from falling down.

The **brain stem,** which lies between the cerebellum and spinal cord, controls your body's involuntary actions—those that occur automatically. For example, neurons in the brain stem regulate your breathing and help control your heartbeat.

Reading Checkpoint **What actions does the brain stem control?**

Lab zone Skills Activity

Controlling Variables

Are people better able to memorize a list of words in a quiet room or in a room where soft music is playing?

1. Write a hypothesis that addresses this question.
2. Design an experiment to test your hypothesis. Make sure that all variables are controlled except the one you are testing—music versus quiet.
3. Check your procedure with your teacher. Then perform your experiment.

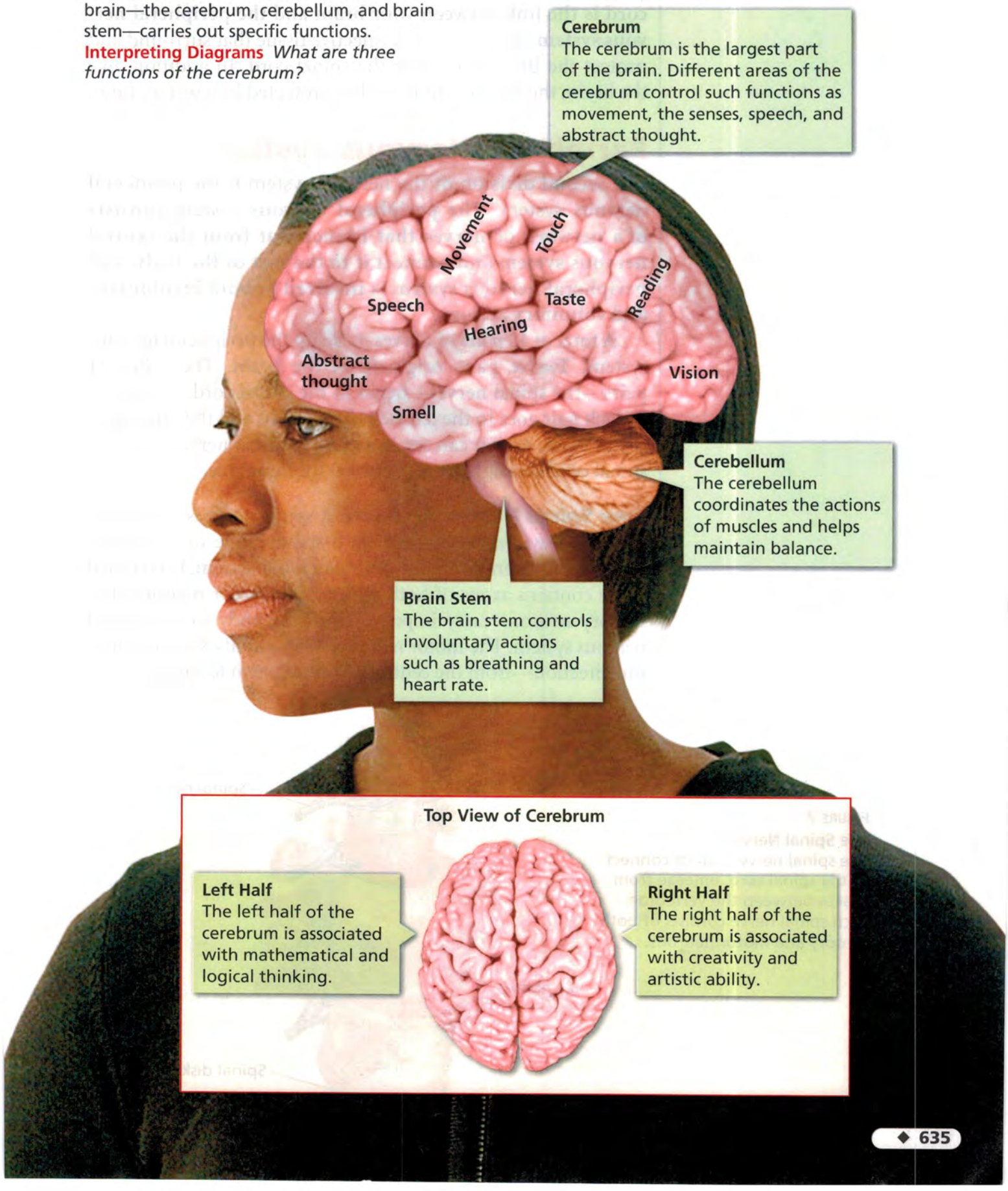
Did your results support your hypothesis?

FIGURE 6

The Brain

Each of the three main parts of the human brain—the cerebrum, cerebellum, and brain stem—carries out specific functions.

Interpreting Diagrams *What are three functions of the cerebrum?*



The Spinal Cord Run your fingers down the center of your back to feel the bones of the vertebral column. The vertebral column surrounds and protects the spinal cord. **The spinal cord is the link between your brain and the peripheral nervous system.** The layers of connective tissue that surround and protect the brain also cover the spinal cord. In addition, like the brain, the spinal cord is further protected by a watery fluid.

Peripheral Nervous System

The second division of the nervous system is the peripheral nervous system. **The peripheral nervous system consists of a network of nerves that branch out from the central nervous system and connect it to the rest of the body. The peripheral nervous system is involved in both involuntary and voluntary actions.**

A total of 43 pairs of nerves make up the peripheral nervous system. Twelve pairs originate in the brain. The other 31 pairs—the spinal nerves—begin in the spinal cord. One nerve in each pair goes to the left side of the body, and the other goes to the right. As you can see in Figure 7, spinal nerves leave the spinal cord through spaces between the vertebrae.

How Spinal Nerves Function A spinal nerve is like a two-lane highway. Impulses travel on a spinal nerve in two directions—both to and from the central nervous system. Each spinal nerve contains axons of both sensory and motor neurons. The sensory neurons carry impulses from the body to the central nervous system. The motor neurons carry impulses in the opposite direction—from the central nervous system to the body.

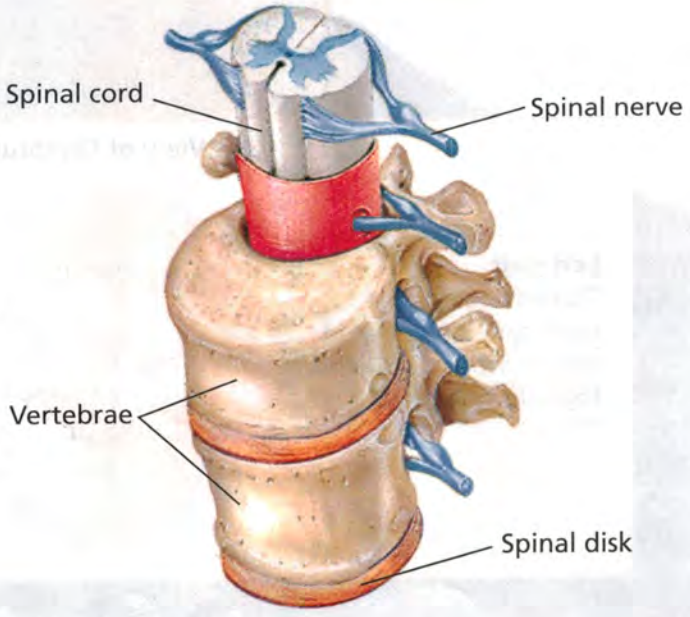


FIGURE 7
The Spinal Nerves
The spinal nerves, which connect to the spinal cord, emerge from spaces between the vertebrae. Each spinal nerve consists of both sensory and motor neurons.

Actions Controlled by the Somatic Nervous System

- Hands shape the clay.
- Foot turns the wheel.
- Mouth smiles.

Actions Controlled by the Autonomic Nervous System

- Heartbeat is regulated.
- Breathing rate is kept steady.
- Body temperature remains constant.

FIGURE 8
Somatic and Autonomic Nervous Systems
The somatic nervous system controls voluntary actions. The autonomic nervous system controls involuntary actions. **Classifying** *Which system helps regulate the artist's heartbeat?*

Somatic and Autonomic Systems The nerves of the peripheral nervous system can be divided into two groups, the somatic (soh MAT ik) and autonomic (awt uh NAHM ik) nervous systems. The nerves of the **somatic nervous system** control voluntary actions such as using a fork or tying your shoes. In contrast, nerves of the **autonomic nervous system** control involuntary actions. For example, the autonomic nervous system regulates the contractions of the smooth muscles that adjust the diameter of blood vessels.

Reading Checkpoint **What kinds of actions are controlled by the autonomic nervous system?**

Reflexes

Imagine that you are watching an adventure movie. The movie is so thrilling that you don't notice a fly circling above your head. When the fly zooms right in front of your eyes, however, your eyelids immediately blink shut. You didn't decide to close your eyes. The blink, which is a **reflex,** is a response that happened automatically. **A reflex is an automatic response that occurs very rapidly and without conscious control. Reflexes help to protect the body.** If you did the Discover activity for this section, you observed another reflex.

Lab zone Try This Activity

You Blinked!

Can you make yourself *not* blink? To answer this question, try the following activity.

1. Put on safety goggles.
2. Have your partner stand across from you and gently toss ten cotton balls toward your goggles. Your partner should not give you any warning before tossing the cotton balls.
3. Count the number of times you blink and the number of times you are able to keep from blinking.

Interpreting Data Compare the two numbers. Why is blinking considered a reflex?

A Reflex Pathway As you have learned, the contraction of skeletal muscles is usually controlled by the brain. However, in some reflex actions, skeletal muscles contract with the involvement of the spinal cord only—not the brain.

Figure 9 shows the reflex action that occurs when you touch a sharp object. When your finger touches the object, sensory neurons send impulses to the spinal cord. The impulses may then pass to interneurons in the spinal cord. From there the impulses pass directly to motor neurons in your arm and hand. The muscles then contract, and your hand jerks up and away from the sharp object. By removing your hand quickly, this reflex protects you from getting badly cut.

Signaling the Brain At the same time that some nerve impulses make your arm muscles contract, other nerve impulses travel up your spinal cord to your brain. When these impulses reach your brain, your brain interprets them. You then feel a sharp pain in your finger.

It takes longer for the pain impulses to get to the brain and be interpreted than it does for the reflex action to occur. By the time you feel the pain, you have already moved your hand away.

Reading Checkpoint **What is an example of a reflex?**

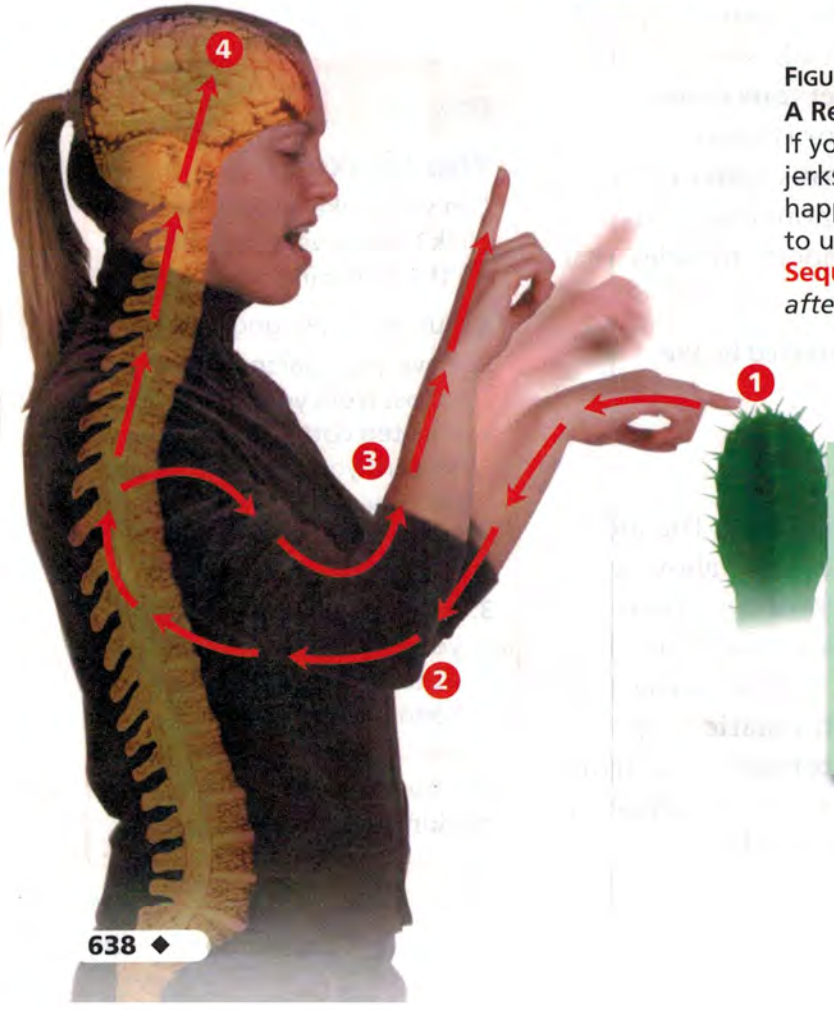


FIGURE 9
A Reflex Action
If you touch a sharp object, your hand immediately jerks away. This action, which is known as a reflex, happens automatically. Follow the numbered steps to understand how a reflex happens.
Sequencing *Do you pull your hand away before or after you feel the pain? Explain.*

1. Sensory neurons in your fingertip detect a pain stimulus.
2. Nerve impulses travel to your spinal cord.
3. Nerve impulses return to motor neurons in your hand, and you pull your hand away.
4. As you pull your hand away, nerve impulses travel to your brain. You feel the pain.

Nervous System Injuries

The nervous system can suffer injuries that interfere with its functioning. **Concussions and spinal cord injuries are two ways in which the central nervous system can be damaged.**

Concussions A **concussion** is a bruiselike injury of the brain. A concussion occurs when the soft tissue of the brain collides against the skull. Concussions can happen when you bump your head in a hard fall, an automobile accident, or a contact sport such as football.

With most concussions, you may have a headache for a short time, but the injured tissue heals by itself. However, with more serious concussions, you may lose consciousness, experience confusion, or feel drowsy after the injury. To decrease your chances of getting a brain injury, wear a helmet during activities in which you risk bumping your head.

Spinal Cord Injuries Spinal cord injuries occur when the spinal cord is cut or crushed. As a result, axons in the injured region are damaged, so impulses cannot pass through them. This type of injury usually results in paralysis, which is the loss of movement in some part of the body. Car crashes are the most common cause of spinal cord injuries.

Reading Checkpoint What is paralysis?

FIGURE 10
Protecting the Nervous System
You can help protect yourself from a spinal cord injury by wearing a seatbelt when you travel in a car.

Section 2 Assessment

Target Reading Skill **Building Vocabulary**
Use your definitions to help you answer the questions below.

Reviewing Key Concepts

1. a. **Listing** What two structures are part of the central nervous system?
   b. **Describing** Describe the functions of the three main regions of the brain.
   c. **Relating Cause and Effect** What symptoms might indicate that a person's cerebellum has been injured?
2. a. **Identifying** What are the two groups of nerves into which the peripheral nervous system is divided?
   b. **Comparing and Contrasting** How do the functions of the two groups of peripheral nerves differ?
3. a. **Defining** What is a reflex?
   b. **Sequencing** Trace the pathway of a reflex in the nervous system.
   c. **Inferring** How do reflexes help protect the body from injury?
4. a. **Reviewing** What is a concussion?
   b. **Applying Concepts** How can you reduce your risk of concussion?

Writing in Science

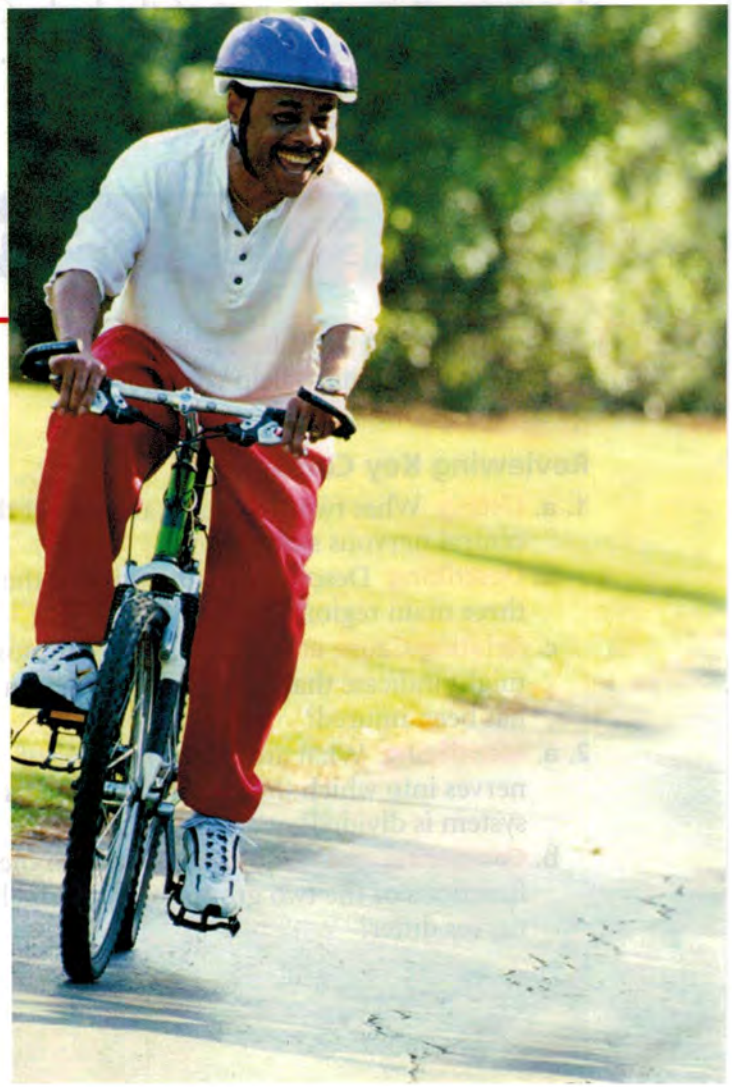
Comparison Paragraph Write a paragraph in which you compare the functions of the left and right halves of the cerebrum. Discuss what kinds of mental activities each half controls as well as which side of the body it controls.

Science and Society

Should People Be Required to Wear Bicycle Helmets?

Bicycling is an enjoyable activity. Unfortunately, many bicyclists are injured while riding. Each year, more than 500,000 people in the United States are treated in hospitals for bicycling injuries. Many of those people suffer head injuries. Head injuries can affect everything your brain does—thinking, remembering, seeing, and being able to move.

Depending on the age group and geographic location, helmet use ranges from less than 10 percent to about 80 percent of bicyclists. What is the best way to get bicyclists to protect themselves from head injury?



The Issues

Should Laws Require the Use of Bicycle Helmets?

Experts estimate that bicycle helmets could reduce the risk of bicycle-related head injuries by as much as 85 percent. Today, about 19 states have passed laws requiring bicycle riders to wear helmets. Most of these statewide laws, however, apply only to children.

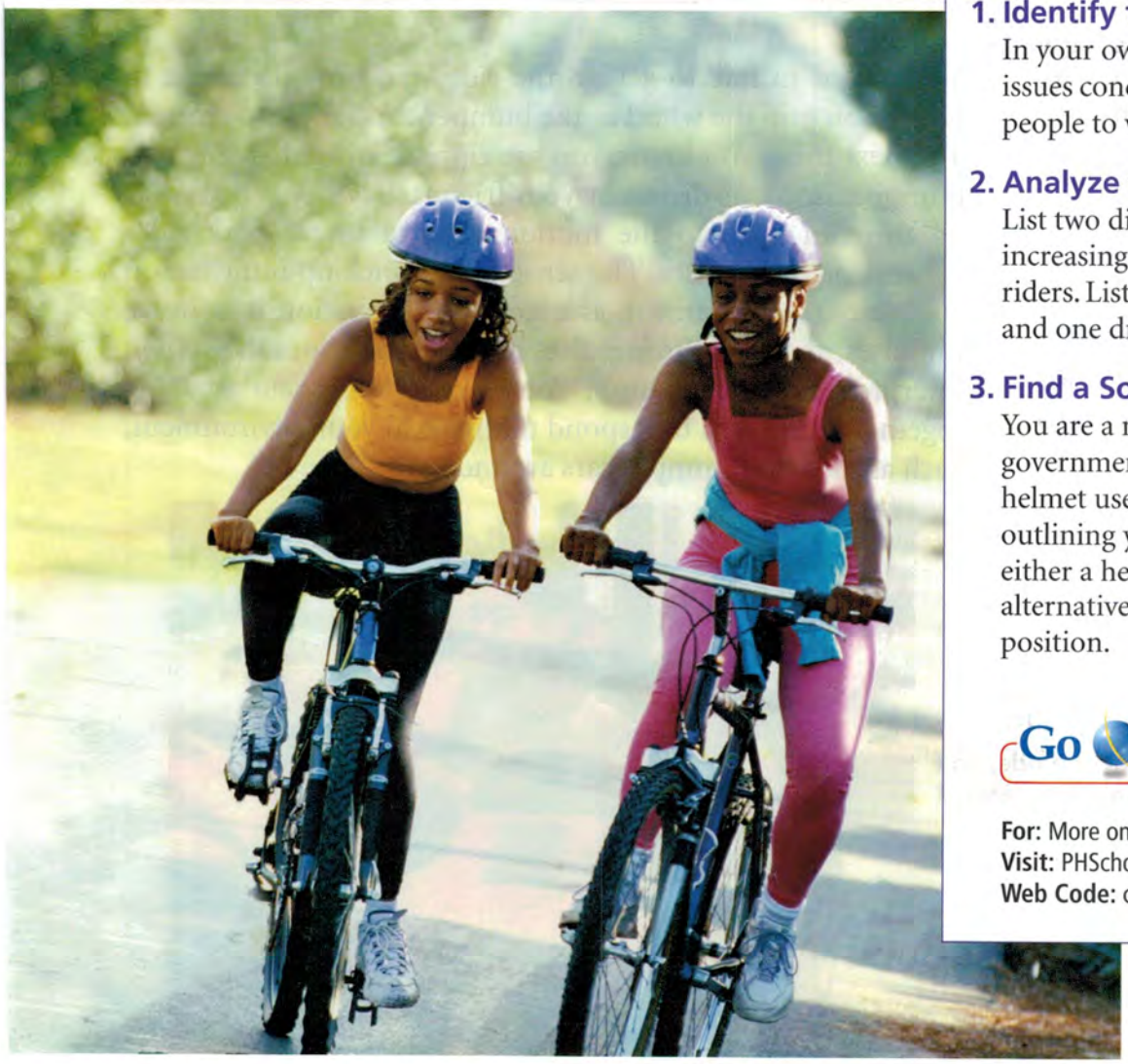
Some supporters of helmet laws want to see the laws extended to all riders. They claim that laws are the most effective way to increase helmet use.

What Are the Drawbacks of Helmet Laws?

Opponents of helmet laws believe it is up to the individual to decide whether or not to wear a helmet. They say it is not the role of government to stop people from taking risks. They argue that, rather than making people pay fines if they don't wear bicycle helmets, governments should educate people about the benefits of helmets. Car drivers should also be educated about safe driving procedures near bicycles.

Are There Alternatives to Helmet Laws?

Instead of laws requiring people to wear helmets, some communities and organizations have set up educational programs that teach about the advantages of helmets. Effective programs teach about the dangers of head injuries and the protection that helmets provide. Effective education programs, though, can be expensive. They also need to reach a wide audience, including children, teens, and adults.



You Decide

1. Identify the Problem
In your own words, explain the issues concerning laws requiring people to wear bicycle helmets.

2. Analyze the Options
List two different plans for increasing helmet use by bicycle riders. List at least one advantage and one drawback of each plan.

3. Find a Solution
You are a member of the city government hoping to increase helmet use. Write a speech outlining your position for either a helmet law or an alternative plan. Support your position.

Go Online
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Section 3

The Senses

Reading Preview

Key Concepts

- How do your eyes enable you to see?
- How do you hear and maintain your sense of balance?
- How do your senses of smell and taste work together?
- How is your skin related to your sense of touch?

Key Terms

- cornea • pupil • iris • lens
- retina • nearsightedness
- farsightedness • eardrum
- cochlea • semicircular canal

Target Reading Skill

Outlining As you read, make an outline about the senses. Use the red headings for the main ideas and the blue headings for the supporting ideas.

The Senses
I. Vision
A. How light enters your eye
B.
C.

Lab zone

Discover Activity

What's in the Bag?

1. Your teacher will give you a paper bag that contains several objects. Your challenge is to use only your sense of touch to identify each object. You will not look inside the bag.
2. Put your hand in the bag and carefully touch each object. Observe the shape of each object. Note whether its surface is rough or smooth. Also note other characteristics, such as its size, what it seems to be made of, and whether it can be bent.
3. After you have finished touching each object, write your observations on a sheet of paper. Then, write your inference about what each object is.

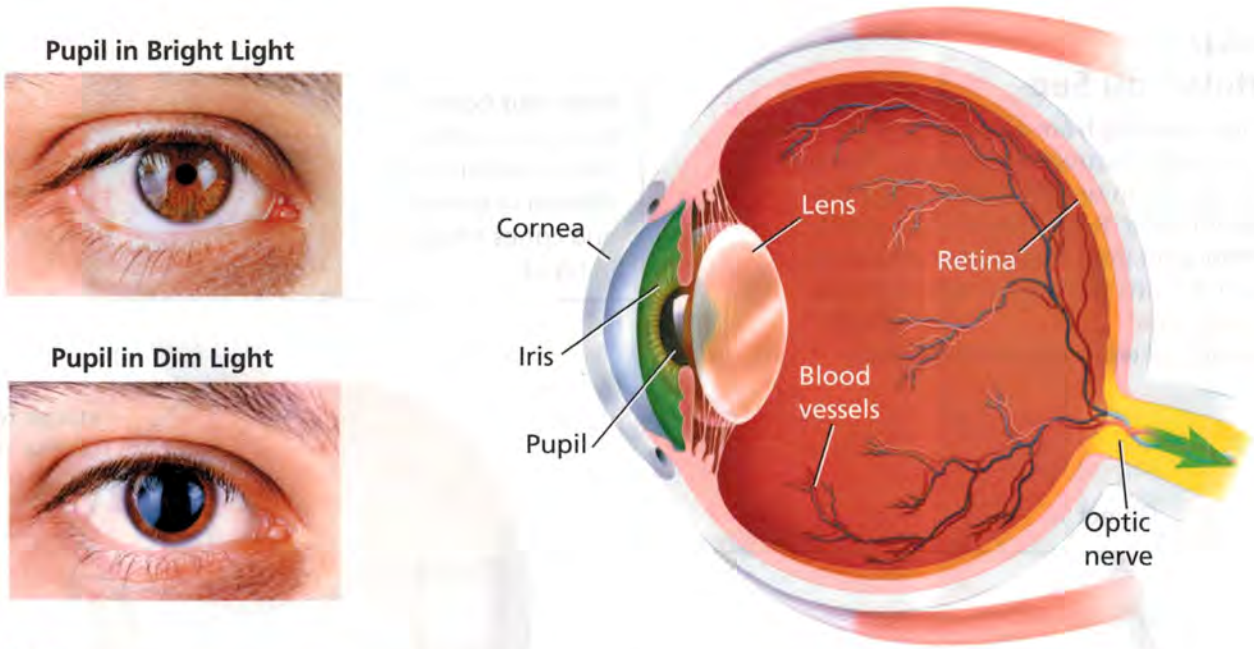
Think It Over

Observing What could you determine about each object without looking at it? What could you not determine?

You waited in line to get on the ride, and now it's about to begin. You grip the wheel as the bumper cars jerk into motion. The next thing you know, you are zipping around crazily and bumping into cars driven by your friends.

You can thrill to the motion of amusement park rides because of your senses. The sense organs pick up information about your environment, change the information into nerve impulses, and send the impulses to your brain. Your brain then interprets the information. Your senses and brain working together enable you to respond to things in your environment, such as the other bumper cars around you.

Enjoy the ride, and thank your senses!



Vision

Your eyes are the sense organs that enable you to see the objects in your environment. They let you see this textbook in front of you, the window across the room, and the world outside the window. **Your eyes respond to the stimulus of light. They convert that stimulus into impulses that your brain interprets, enabling you to see.**

How Light Enters Your Eye When rays of light strike the eye, they pass through the structures shown in Figure 11. First, the light strikes the **cornea** (KAWR nee uh), the clear tissue that covers the front of the eye. The light then passes through a fluid-filled chamber behind the cornea and reaches the pupil. The **pupil** is the opening through which light enters the eye.

You may have noticed that people's pupils change size when they go from a dark room into bright sunshine. In bright light, the pupil becomes smaller. In dim light, the pupil becomes larger. The size of the pupil is adjusted by muscles in the iris. The **iris** is a circular structure that surrounds the pupil and regulates the amount of light entering the eye. The iris also gives the eye its color. If you have brown eyes, it is actually your irises that are brown.

How Light Is Focused Light that passes through the pupil strikes the lens. The **lens** is a flexible structure that focuses light. The lens of your eye functions something like the lens of a camera, which focuses light on photographic film. Because of the way in which the lens of the eye bends the light rays, the image it produces is upside down and reversed. Muscles that attach to the lens adjust its shape, producing an image that is in focus.

FIGURE 11

The Eye

The eye is a complex organ that allows you to sense light. The pupil is the opening through which light enters the eye. In bright light, the pupil becomes smaller. In dim light, the pupil enlarges and allows more light to enter the eye.

Interpreting Diagrams *What structure adjusts the size of the pupil?*

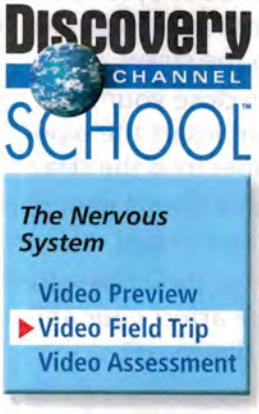
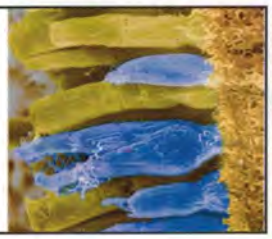


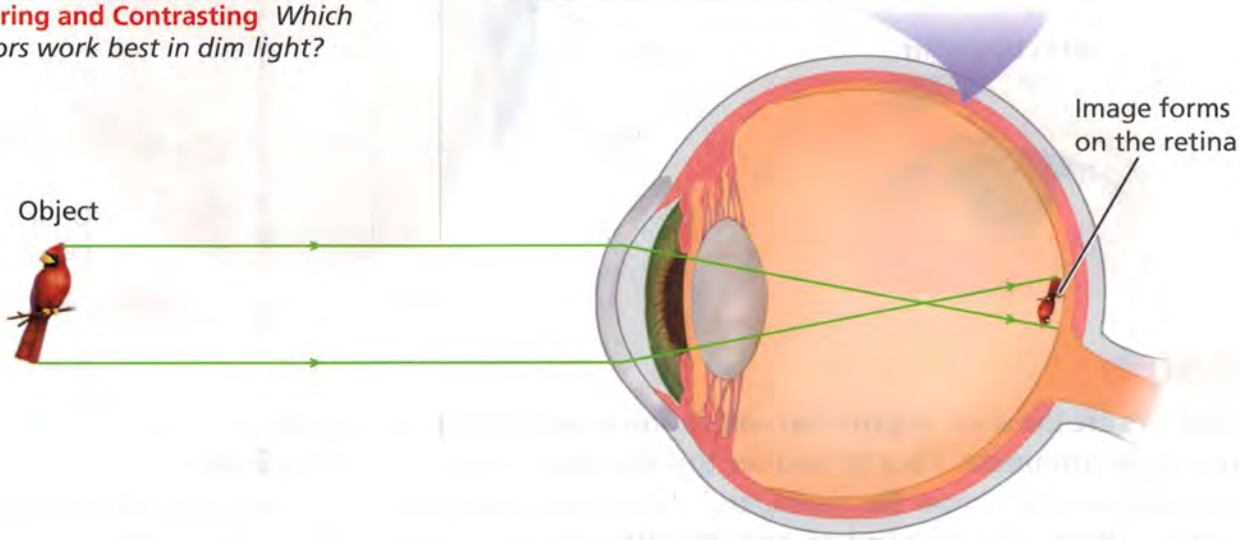
FIGURE 12

How You See

Light coming from an object enters your eye and is focused by the lens. The light produces an upside-down image on your retina. Receptors in your retina then send impulses to your cerebrum, which turns the image right-side up.
Comparing and Contrasting *Which receptors work best in dim light?*

Rods and Cones Receptors in the retina include rods (shown in green) and cones (shown in blue).





How You See an Image After passing through the lens, the focused light rays pass through a transparent, jellylike fluid. Then the light rays strike the **retina** (RET 'n uh), the layer of receptor cells that lines the back of the eye. The retina contains about 130 million receptor cells that respond to light. There are two types of receptors: rods and cones. Rod cells work best in dim light and enable you to see black, white, and shades of gray. In contrast, cone cells work best in bright light and enable you to see colors. This difference between rods and cones explains why you see colors best in bright light, but you see only shadowy gray images in dim light.

When light strikes the rods and cones, nerve impulses travel to the cerebrum through the optic nerves. One optic nerve comes from the left eye and the other one comes from the right eye. In the cerebrum, two things happen. The brain turns the reversed image right-side up, and it also combines the images from each eye to produce a single image.

Correcting Nearsightedness A lens—whether it is in your eye or in eyeglasses—is a curved, transparent object that bends light rays as they pass through it. If the lens of the eye does not focus light properly on the retina, vision problems result. The lenses in eyeglasses can help correct vision problems.

Lab zone **Try This Activity**

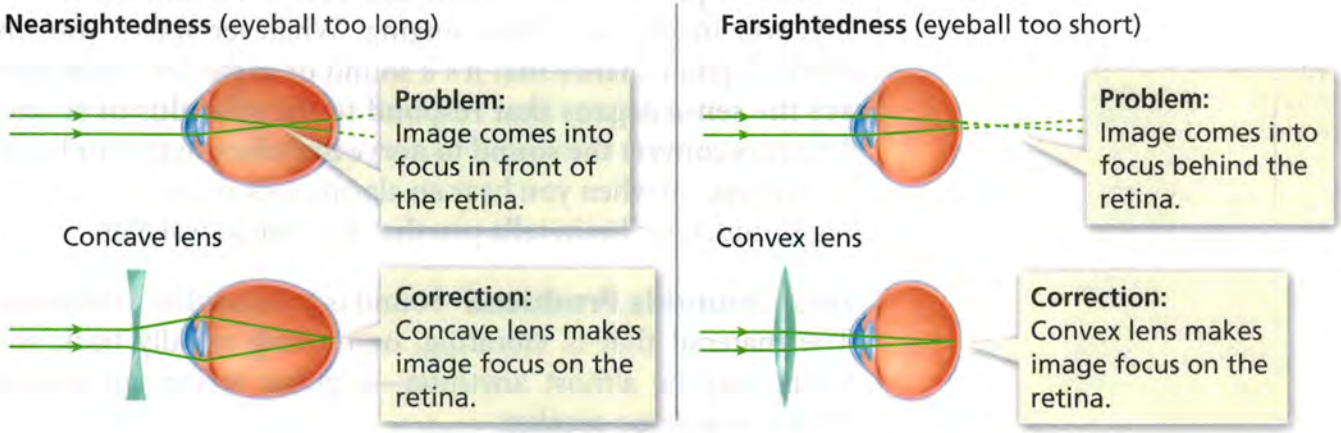
Working Together

Discover how your two eyes work together.

1. With your arms fully extended, hold a drinking straw in one hand and a pipe cleaner in the other.
2. With both eyes open, try to insert the pipe cleaner into the straw.
3. Now close your right eye. Try to insert the pipe cleaner into the straw.
4. Repeat Step 3 with your left eye closed.

Inferring How does closing one eye affect your ability to judge distances?

FIGURE 13
Correcting Vision Problems



People with **nearsightedness** can see nearby objects clearly. However, they have trouble seeing objects far away. Nearsightedness results when the eyeball is too long. Because of the extra length that light must travel to reach the retina, distant objects do not focus sharply on the retina. Instead, the lens of the eye makes the image come into focus at a point in front of the retina, as shown in Figure 13.

To correct nearsightedness, eyeglasses with concave lenses are worn. A concave lens is thicker at the edges than it is in the center. When light rays pass through a concave lens, they are bent away from the center of the lens. The concave lenses in glasses make light rays spread out before they reach the lens of the eye. After the rays pass through the lens of the eye, they focus on the retina rather than in front of it.

Correcting Farsightedness People with **farsightedness** can see distant objects clearly. Nearby objects, however, look blurry. The eyeballs of people with farsightedness are too short. Because of this, the lens of the eye bends light from nearby objects so that the image does not focus properly on the retina. If light could pass through the retina, the image would come into sharp focus at a point behind the retina, as shown in Figure 13.

Convex lenses are used to help correct farsightedness. A convex lens is thicker in the middle than at the edges. The convex lens makes the light rays bend toward each other before they reach the eye. Then the lens of the eye bends the rays even more. This bending makes the image focus exactly on the retina.

Reading Checkpoint What type of lens corrects nearsightedness?

Hearing and Balance

What wakes you up in the morning? Maybe an alarm clock buzzes, or perhaps your parent calls you. On a summer morning, you might hear birds singing. Whatever wakes you up, there's a good chance that it's a sound of some sort. **Your ears are the sense organs that respond to the stimulus of sound. The ears convert the sound to nerve impulses that your brain interprets.** So when you hear an alarm clock or another morning sound, your brain tells you that it's time to wake up.

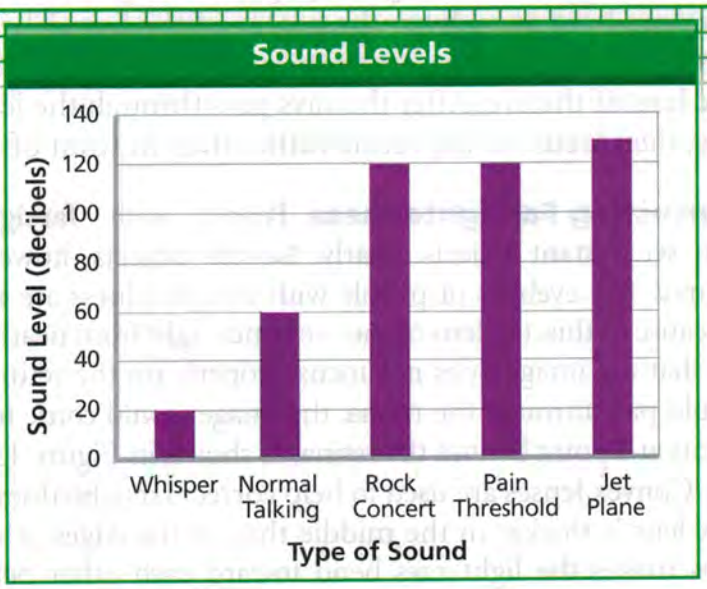
How Sound Is Produced Sound is produced by vibrations. The material that is vibrating, or moving rapidly back and forth, may be almost anything—a guitar string, an insect's wings, or a stereo speaker.

The vibrations move outward from the source of the sound, something like ripples moving out from a stone dropped in water. The vibrations cause particles, such as the gas molecules that make up air, to vibrate. In this way, sound is carried. When you hear a friend's voice, for example, sound has traveled from your friend's larynx to your ears. In addition to being able to travel through gases such as those in air, sound waves can also travel through liquids, such as water, and solids, such as wood.

Math Analyzing Data

Sound Intensity

Sound intensity, or loudness, is measured in units called decibels. The threshold of hearing for the human ear is 0 decibels. For every 10-decibel increase, the sound intensity increases ten times. Thus, a 20-decibel sound is ten times more intense than a 10-decibel sound, not twice as intense. A 30-decibel sound is 100 times more intense than a 10-decibel sound. Sound levels for several sound sources are shown in the bar graph.



1. **Reading Graphs** What unit of measure is represented on the *y*-axis? What is represented on the *x*-axis?
2. **Interpreting Data** What is the sound intensity in decibels of a whisper? Normal talking? A rock concert?
3. **Calculating** How much more intense is normal talking than a whisper? Explain.
4. **Predicting** Based on the graph, what types of sound could be painful if you were exposed to them?

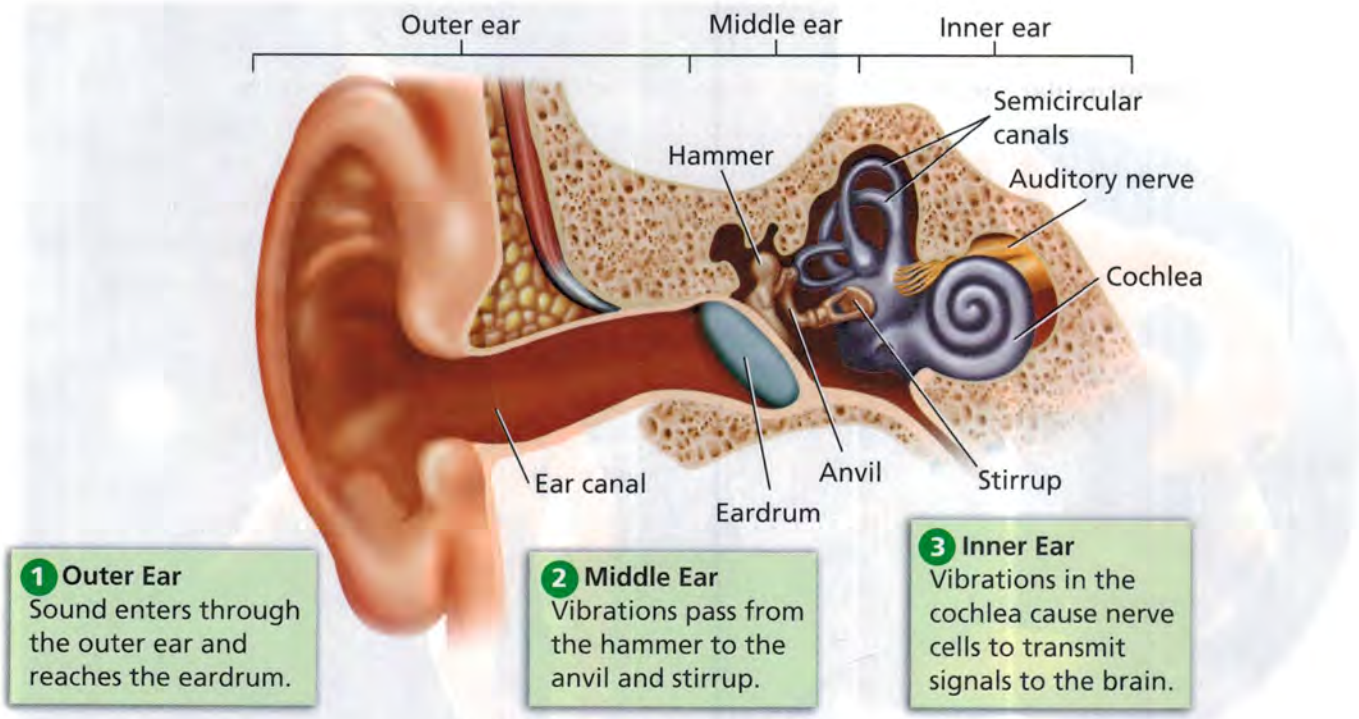


FIGURE 14
The Ear
Sound waves enter the outer ear and make structures in the middle ear vibrate. When the vibrations reach the inner ear, nerve impulses travel to the cerebrum through the auditory nerve. **Predicting** *What would happen if the bones of the middle ear were stuck together and could not move?*

The Outer Ear The ear is structured to receive sound vibrations. The three regions of the ear—the outer ear, middle ear, and inner ear—are shown in Figure 14. The visible part of the outer ear is shaped like a funnel. This funnel-like shape enables the outer ear to gather sound waves. The sound vibrations then travel down the ear canal, which is also part of the outer ear.

The Middle Ear At the end of the ear canal, sound vibrations reach the eardrum. The **eardrum,** which separates the outer ear from the middle ear, is a membrane that vibrates when sound strikes it. Your eardrum vibrates in much the same way that a drum vibrates when it is struck. Vibrations from the eardrum pass to the middle ear, which contains the three smallest bones in the body—the hammer, anvil, and stirrup. These bones are named for their shapes. The vibrating eardrum makes the hammer vibrate. The hammer passes the vibrations to the anvil, and the anvil passes them to the stirrup.

The Inner Ear The stirrup vibrates against a thin membrane that covers the opening of the inner ear. The membrane channels the vibrations into the fluid in the cochlea. The **cochlea** (KAHK le uh) is a snail-shaped tube that is lined with receptor cells that respond to sound. When the fluid in the cochlea vibrates, it stimulates these receptors. Sensory neurons then send nerve impulses to the cerebrum through the auditory nerve. These impulses are interpreted as sounds that you hear.

FIGURE 15
Balancing Act
This tightrope walker is able to keep his balance due to the functioning of his semicircular canals.
Relating Cause and Effect *How do the semicircular canals help you to maintain balance?*

The Inner Ear and Balance **Structures in your inner ear control your sense of balance.** Above the cochlea in your inner ear are the **semicircular canals,** which are the structures in the ear that are responsible for your sense of balance. You can see how these structures got their name if you look at Figure 15. These canals, as well as the two tiny sacs located behind them, are full of fluid. The canals and sacs are also lined with tiny cells that have hairlike extensions.

When your head moves, the fluid in the semicircular canals is set in motion. The moving fluid makes the cells' hairlike extensions bend. This bending produces nerve impulses in sensory neurons. The impulses travel to the cerebellum. The cerebellum then analyzes the impulses to determine the way your head is moving and the position of your body. If the cerebellum senses that you are losing your balance, it sends impulses to muscles that help you restore your balance.

Reading Checkpoint **Where in the ear are the semicircular canals located?**

Smell and Taste

You walk into the house and smell the aroma of freshly baked cookies. You bite into one and taste its rich chocolate flavor. When you smelled the cookies, receptors in your nose reacted to chemicals carried by the air from the cookies to your nose. When you took a bite of a cookie, taste buds on your tongue responded to chemicals in the food. These food chemicals were dissolved in saliva, which came in contact with your taste buds.

The senses of smell and taste work closely together. Both depend on chemicals in food or in the air. The chemicals trigger responses in receptors in the nose and mouth. Nerve impulses then travel to the brain, where they are interpreted as smells or tastes.

The nose can distinguish at least 50 basic odors. In contrast, there are only five main taste sensations—sweet, sour, salty, bitter, and a meatlike taste called *umami*. When you eat, however, you experience a much wider variety of tastes. The flavor of food is influenced by both smell and taste. When you have a cold, foods may not taste as good as they usually do. That is because a stuffy nose decreases your ability to smell food.

Lab zone Skills Activity

Designing Experiments

Can people tell one food from another if they can taste the foods but not smell them? Design an experiment to find out. Use these foods: a peeled pear, a peeled apple, and a peeled raw potato. Be sure to control all variables except the one you are testing. Write your hypothesis and a description of your procedure. Obtain your teacher's approval before carrying out your experiment.

Reading Checkpoint **What basic tastes can the tongue detect?**

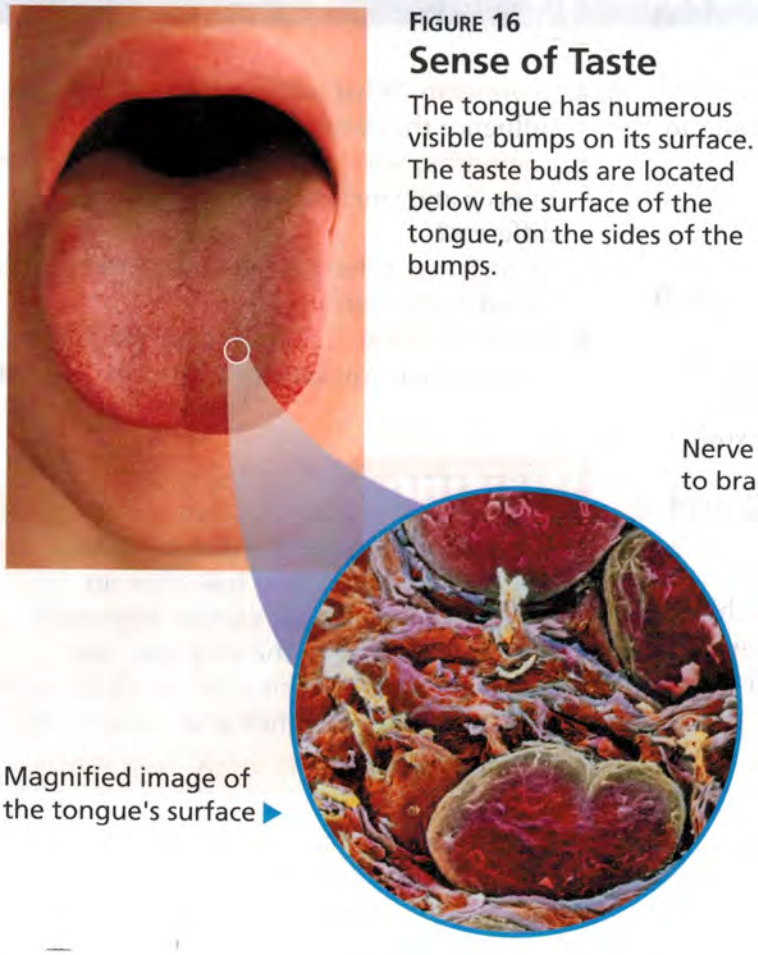


FIGURE 16
Sense of Taste
The tongue has numerous visible bumps on its surface. The taste buds are located below the surface of the tongue, on the sides of the bumps.

FIGURE 17
Reading by Touch
People who are blind use their sense of touch to read. To do this, they run their fingers over words written in Braille. Braille uses raised dots to represent letters and numbers. Here, a teacher shows a blind child how to read Braille.

Touch

Unlike vision, hearing, balance, smell, and taste, the sense of touch is not found in one specific place. Instead, the sense of touch is found in all areas of your skin. Your skin is your largest sense organ! **Your skin contains different kinds of touch receptors that respond to a number of stimuli.** Some of these receptors respond to light touch and others to heavy pressure. Still other receptors pick up sensations of pain and temperature change.

The receptors that respond to light touch are in the upper part of the dermis. They tell you when something brushes against your skin. These receptors also let you feel the textures of objects, such as smooth glass and rough sandpaper. Receptors deeper in the dermis pick up the feeling of pressure. Press down hard on the top of your desk, for example, and you will feel pressure in your fingertips.

The dermis also contains receptors that respond to temperature and pain. Pain is unpleasant, but it can be one of the body's most important feelings because it alerts the body to possible danger. Have you ever stepped into a bathtub of very hot water and then immediately pulled your foot out? If so, you can appreciate how pain can trigger an important response in your body.

Section 3 Assessment

Target Reading Skill **Outlining** Use the information in your outline about the senses to help you answer the questions below.

Reviewing Key Concepts

1. a. **Listing** What are the parts of the eye?
   b. **Sequencing** Describe the process by which the eye produces an image. Begin at the point at which light is focused by the lens.
   c. **Inferring** If nearby objects seem blurry, what type of vision problem might you have? How can it be corrected?
2. a. **Identifying** What are the three regions of the ear?
   b. **Describing** Describe the location and function of the eardrum and the cochlea.
   c. **Relating Cause and Effect** Why may an infection of the inner ear cause you to lose your balance?
3. a. **Reviewing** What two senses work together to influence the flavor of food?
   b. **Comparing and Contrasting** How are the senses of taste and smell similar? How are they different?
4. a. **Identifying** What kinds of touch receptors are found in the skin?
   b. **Applying Concepts** What happens in the dermis when you accidentally touch a hot stove?

Writing in Science

Cause-and-Effect Paragraph Write a description of how you feel after an amusement park ride. Explain how your feeling is related to the structure and function of the semicircular canals. Be sure to include a topic sentence and three to four supporting points.

Section 4

Integrating Health

Alcohol and Other Drugs

Reading Preview

Key Concepts

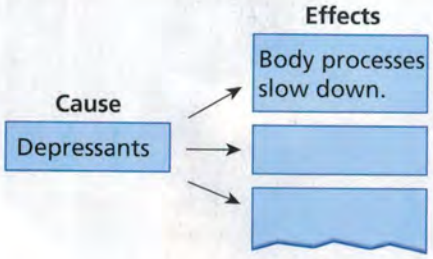
- What are the immediate and long-term effects of drug abuse?
- What are some commonly abused drugs and how does each affect the body?
- How does alcohol abuse harm the body?

Key Terms

- drug • drug abuse
- tolerance • addiction
- withdrawal • depressant
- stimulant • anabolic steroid
- alcoholism

Target Reading Skill

Relating Cause and Effect As you read, identify commonly abused drugs and how they affect the body. Write the information in a graphic organizer like the one below.



Lab zone **Discover Activity**

How Can You Best Say No?

1. In this activity, you will use marbles to represent drugs. Your teacher will divide the class into groups of three students. In each group, your teacher will appoint two students to try to convince the other person to take the "drugs."
2. Depending on your role, you should think of arguments to get the person to accept the marbles or arguments against accepting them. After everyone has had a chance to think of arguments, begin the discussion.
3. After a while, students in each group should exchange roles.

Think It Over

Inferring What role does peer pressure play in whether or not a person decides to abuse drugs?

Drugs! You probably hear and see that word in a lot of places. Drugstores sell drugs to relieve headaches, soothe upset stomachs, and stop coughs. Radio and television programs and magazine articles explore drug-related problems. Your school probably has a program to educate students about drugs. When people talk about drugs, what do they mean? To a scientist, a **drug** is any chemical taken into the body that causes changes in a person's body or behavior. Many drugs affect the functioning of the central nervous system.

Drug Abuse

The deliberate misuse of drugs for purposes other than medical ones is called **drug abuse.** Even medicines can be abused drugs if they are used in a way for which they were not intended. Many abused drugs, however, such as cocaine and heroin, are illegal under any circumstances. The use of these drugs is against the law because their effects on the body are almost always dangerous.

Go Online
SCILINKS NSTA
For: Links on drug addiction
Visit: www.SciLinks.org
Web Code: scn-0464

Effects of Abused Drugs Abused drugs start to affect the body shortly after they are taken. **Most commonly abused drugs, such as marijuana, alcohol, and cocaine, are especially dangerous because of their immediate effects on the brain and other parts of the nervous system. In addition, long-term drug abuse can lead to addiction and other health and social problems.**

Different drugs have different effects. Some drugs cause nausea and a fast, irregular heartbeat. Others can cause sleepiness. Drug abusers may also experience headaches, dizziness, and trembling. Alcohol can cause confusion, poor muscle coordination, and blurred vision. These effects are especially dangerous in situations in which an alert mind is essential, such as driving a car.

Most abused drugs can alter, or change, a person's mood and feelings. Because of this effect, these drugs are often called mood-altering drugs. For example, the mood of a person under the influence of marijuana may change from calm to anxious. Alcohol can sometimes make a person angry and even violent. Mood-altering drugs also affect patterns of thinking and the way in which the brain interprets information from the senses.

Tolerance If a person takes a drug regularly, the body may develop a tolerance to the drug. **Tolerance** is a state in which a drug user needs larger and larger amounts of the drug to produce the same effect on the body. Tolerance can cause people to take a very large amount of a drug, or an overdose. People who take an overdose may become unconscious or even die.

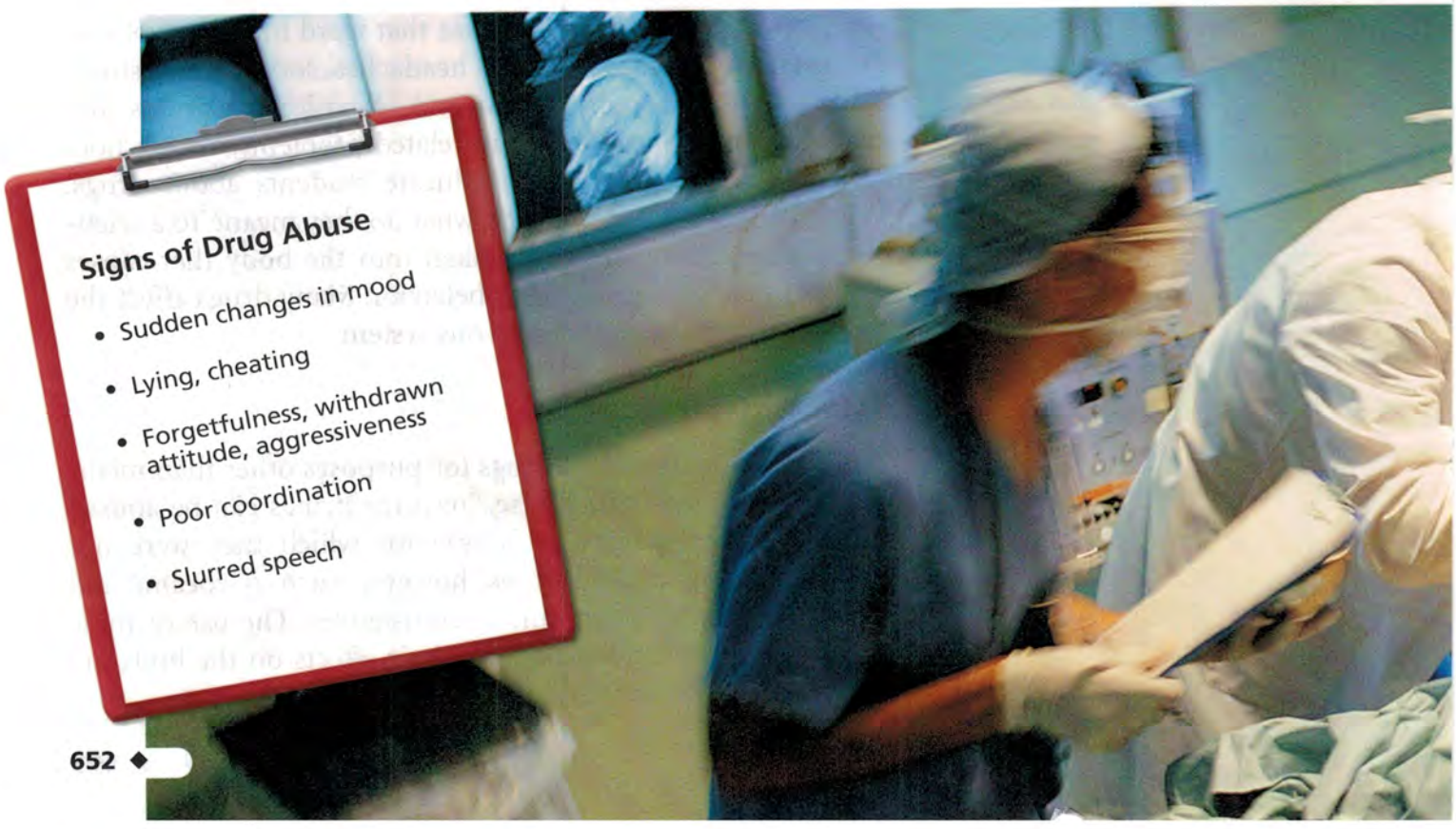


FIGURE 18
Drug Abuse
Drug abuse can have serious consequences. However, there are ways to tell if someone is abusing drugs and ways to help that person. **Interpreting Diagrams** *What are two ways you can help if someone you know is abusing drugs?*

Addiction For many commonly abused drugs, repeated use can result in addiction. In **addiction,** the body becomes physically dependent on the drug. If a drug addict misses a few doses of the drug, the body reacts to the lack of the drug. The person may experience headaches, dizziness, fever, vomiting, body aches, and muscle cramps. The person is experiencing **withdrawal,** a period of adjustment that occurs when a person stops taking a drug on which the body is dependent.

Some drugs may also cause a person to become emotionally dependent on them. The person becomes accustomed to the feelings and moods produced by the drug. Therefore, the person has a strong desire to continue using the drug.

Other Effects of Drug Abuse Drugs can also affect a person's health indirectly. Some drug users sometimes share needles. When a person uses a needle to inject a drug, some of the person's blood remains in the needle after it is withdrawn. If the person has HIV or another pathogen in the blood, the next person to use the needle may become infected with the pathogen.

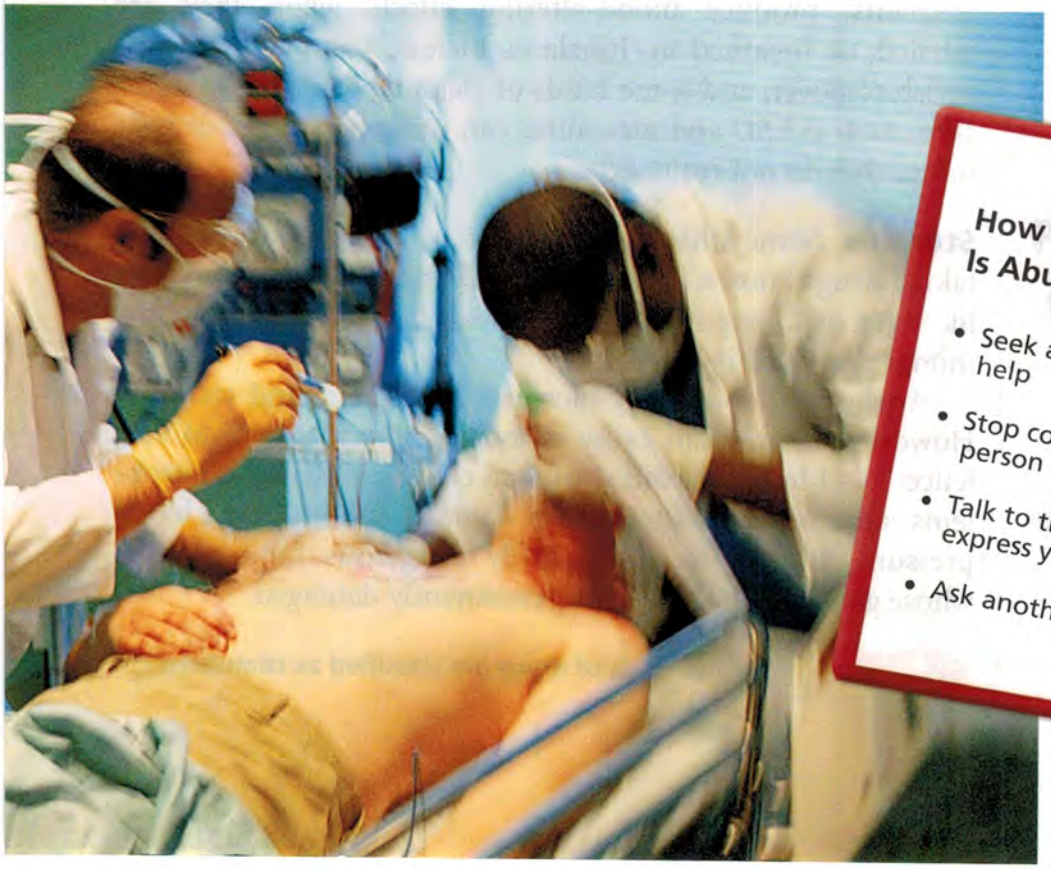
The abuse of drugs also has serious legal and social effects. A person who is caught using or selling an illegal drug may have to pay a fine or go to jail. Drug abuse can also make a person unable to get along with others. Drug abusers often have a hard time doing well in school or holding a job.

Reading Checkpoint **What is withdrawal?**

Lab zone **Skills Activity**

Communicating

Plan a 30-second television commercial aimed at teenagers to help them avoid the pressure to try drugs. Your commercial should reveal some harmful effects of drugs and give strategies for avoiding drugs. Create several storyboards to show what the commercial will look like. Then, write a script for your commercial.



How to Help If Someone Is Abusing Drugs

- Seek adult or professional help
- Stop covering up for the person and making excuses
- Talk to the person and express your concern
- Ask another friend to help

Kinds of Abused Drugs

There are many kinds of drugs, with a wide range of effects on the body. Some are legitimate medicines that a doctor prescribes to help the body fight disease and injury. However, many kinds of drugs are frequently abused. **Commonly abused drugs include depressants, stimulants, inhalants, hallucinogens, anabolic steroids, and alcohol. Many drugs affect the central nervous system, while others affect the overall chemical balance in the body.** Figure 20 lists and describes the characteristics of some commonly abused drugs.

Depressants Notice in Figure 20 that some drugs are classified as depressants. **Depressants** are drugs that slow down the activity of the central nervous system. When people take depressants, their muscles relax and they may become sleepy. They may take longer than normal to respond to stimuli. For example, depressants may prevent people from reacting quickly to the danger of a car rushing toward them. Alcohol and narcotics, such as heroin, are depressants.

Stimulants In contrast to depressants, **stimulants** speed up body processes. They make the heart beat faster and make the breathing rate increase. Cocaine and nicotine are stimulants, as are amphetamines (am FET uh meenz). Amphetamines are prescription drugs that are sometimes sold illegally.

Inhalants and Hallucinogens Some substances, called inhalants, produce mood-altering effects when they are inhaled, or breathed in. Inhalants include paint thinner, nail polish remover, and some kinds of cleaning fluids. Hallucinogens, such as LSD and mescaline, can make people see or hear things that do not really exist.

Steroids Some athletes try to improve their performance by taking drugs known as steroids. **Anabolic steroids** (an uh BAH lik STEER oydz) are synthetic chemicals that are similar to hormones produced in the body.

Anabolic steroids may increase muscle size and strength. However, steroids can cause mood changes that lead to violence. In addition, steroid abuse can cause serious health problems, such as heart damage, liver damage, and increased blood pressure. Steroid use is especially dangerous for teenagers, whose growing bodies can be permanently damaged.

Reading Checkpoint **What kinds of drugs are classified as stimulants?**

FIGURE 19
Making a Statement About Drug Abuse
Many teens are becoming active in antidrug campaigns.

FIGURE 20
Abused drugs can have many serious effects on the body. **Interpreting Tables** *What are the long-term effects of using inhalants?*

Some Effects of Commonly Abused Drugs				
Drug Type	**Short-Term Effects**	**Long-Term Effects**	**Addiction?**	**Emotional Dependence?**
Marijuana (including hashish)	Unclear thinking, loss of coordination, increased heart rate	Difficulty with concentration and memory; respiratory disease and lung cancer	Probably not	Yes
Nicotine (in cigarettes, cigars, chewing tobacco)	Stimulant; nausea, loss of appetite, headache	Heart and lung disease, difficulty breathing, heavy coughing	Yes, strongly so	Yes
Alcohol	Depressant; decreased alertness, poor reflexes, nausea, emotional depression	Liver and brain damage, inadequate nutrition	Yes	Yes
Inhalants (glue, nail polish remover, paint thinner)	Sleepiness, nausea, headaches, emotional depression	Damage to liver, kidneys, and brain; hallucinations	No	Yes
Cocaine (including crack)	Stimulant; nervousness, disturbed sleep, loss of appetite	Mental illness, damage to lining of nose, irregular heartbeat, heart or breathing failure, liver damage	Yes	Yes, strongly so
Amphetamines	Stimulant; restlessness, rapid speech, dizziness	Restlessness, irritability, irregular heartbeat, liver damage	Possible	Yes
Hallucinogens (LSD, mescaline, PCP)	Hallucinations, anxiety, panic; thoughts and actions not connected to reality	Mental illness; fearfulness; behavioral changes, including violence	No	Yes
Barbiturates (Phenobarbital, Nembutal, Seconal)	Depressant; decreased alertness, slowed thought processes, poor muscle coordination	Sleepiness, irritability, confusion	Yes	Yes
Tranquilizers (Valium, Xanax)	Depressant; blurred vision, sleepiness, unclear speech, headache, skin rash	Blood and liver disease	Yes	Yes
Narcotics (opium, codeine, morphine, heroin)	Depressant; sleepiness, nausea, hallucinations	Convulsion, coma, death	Yes, very rapid development	Yes, strongly so
Anabolic steroids	Mood swings	Heart, liver, and kidney damage; hypertension; overgrowth of skull and facial bones	No	Yes

Alcohol

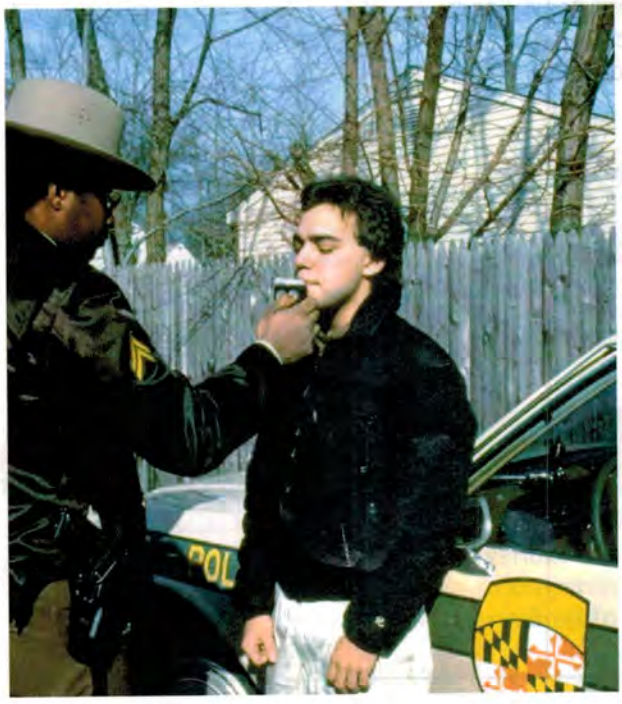
Alcohol is a drug found in many beverages, including beer, wine, cocktails, and hard liquor. Alcohol is a powerful depressant. In all states, it is illegal for people under the age of 21 to buy or possess alcohol. In spite of this fact, alcohol is the most commonly abused legal drug in people aged 12 to 17.

How Alcohol Affects the Body Alcohol is absorbed by the digestive system quickly. If a person drinks alcohol on an empty stomach, the alcohol enters the blood and gets to the brain and other organs almost immediately. If alcohol is drunk with a meal, it takes longer to get into the blood.

The chart in Figure 21 describes what alcohol does to the body. The more alcohol in the blood, the more serious the effects. The amount of alcohol in the blood is usually expressed as blood alcohol concentration, or BAC. A BAC value of 0.1 percent means that one tenth of one percent of the fluid in the blood is alcohol. In some states, if car drivers have a BAC of 0.08 percent or more, they are legally drunk. In other states, drivers with a BAC of 0.1 are considered legally drunk.

Alcohol produces serious negative effects, including loss of normal judgment, at a BAC of less than 0.08 percent. This loss of judgment can have serious consequences. People who have been drinking may not realize that they cannot drive a car safely. About every two minutes, a person in the United States is injured in a car crash related to alcohol.

FIGURE 21
Alcohol's Effects
Alcohol affects every system of the body. It also impacts a person's thought processes, judgment, and reaction time. In the bottom photo, a police officer tests the blood alcohol concentration of a driver suspected of drinking.



Short-Term Effects of Alcohol

Body System	Effect
Cardiovascular system	First, heartbeat rate and blood pressure increase. Later, they may decrease.
Digestive system	Alcohol is absorbed directly from the stomach and small intestine, which allows it to enter the bloodstream quickly.
Excretory system	The kidneys produce more urine, causing the drinker to excrete more water than usual.
Nervous system	Vision blurs. Speech becomes unclear. Control of behavior is reduced. Judgment becomes poor.
Skin	Blood flow to the skin increases, causing rapid loss of body heat.

Long-Term Alcohol Abuse Many adults drink occasionally and in moderation, without serious safety or health problems. However, heavy drinking, especially over a long period, can result in significant health problems. **Alcohol abuse can cause the destruction of cells in the brain and liver, and can lead to addiction and emotional dependence.** Damage to the brain can cause mental disturbances, such as hallucinations and loss of consciousness. The liver, which breaks down alcohol for elimination from the body, can become so scarred that it does not function properly. In addition, long-term alcohol abuse can increase the risk of getting certain kinds of cancer.

Abuse of alcohol can result in **alcoholism,** a disease in which a person is both physically addicted to and emotionally dependent on alcohol. To give up alcohol, as with any addictive drug, alcoholics must go through withdrawal. To give up drinking, alcoholics need both medical and emotional help. Medical professionals, psychologists, and organizations such as Alcoholics Anonymous can help a person stop drinking.

Reading Checkpoint **What organs are affected by alcohol abuse?**

Healthy Liver

Alcohol-damaged Liver

FIGURE 22
Alcohol's Effect on the Liver
Long-term alcohol abuse can cause serious damage to the liver. **Relating Cause and Effect** *What other effects can alcohol abuse have on the body?*

Section 4 Assessment

Target Reading Skill **Relating Cause and Effect** Refer to your graphic organizer about commonly abused drugs to help you answer Question 2.

Reviewing Key Concepts

1. a. **Defining** In your own words, explain what a drug is. What is drug abuse?
   b. **Explaining** How can the repeated use of some drugs lead to addiction and emotional dependence?
   c. **Applying Concepts** What reasons would you give someone to not try drugs in the first place?
2. a. **Listing** Name two commonly abused depressants and two commonly abused stimulants.
   b. **Comparing and Contrasting** Contrast the effects that depressants and stimulants have on the body.
   c. **Inferring** Why might a person's risk of a heart attack increase with the use of stimulants?
3. a. **Reviewing** What type of drug is alcohol?
   b. **Explaining** What immediate effects does alcohol have on the body?
   c. **Relating Cause and Effect** Based on alcohol's effect on the nervous system, explain why drinking and driving is extremely dangerous.

Lab zone At-Home Activity

Medicine Labels Collect several medicine bottles and read the warning labels. Make a list of the kinds of warnings you find. Discuss these warnings with a family member. Why do you think medicines provide warnings?

Lab zone **Consumer Lab**

With Caffeine or Without?

Problem

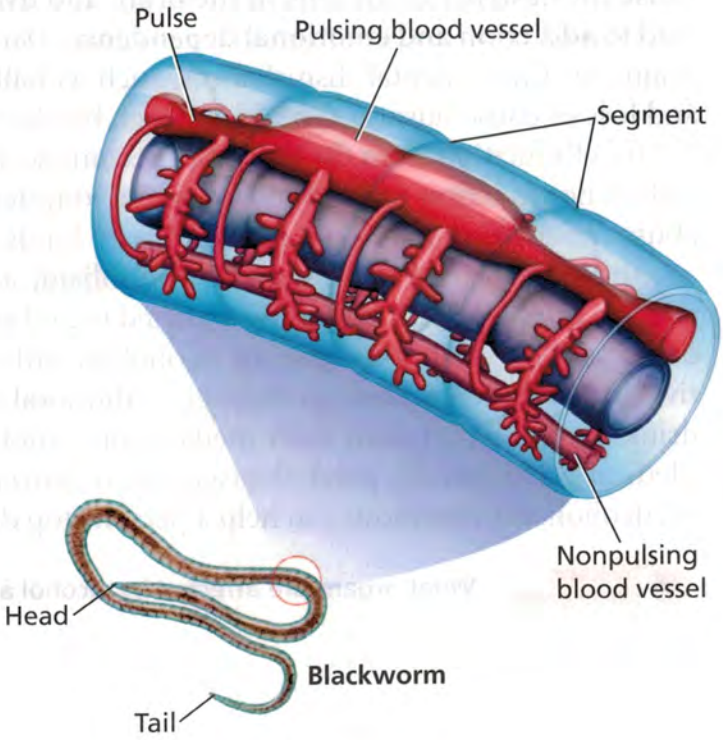
What body changes does caffeine produce in blackworms *(Lumbriculus)*?

Skills Focus

observing, controlling variables, drawing conclusions

Materials

- blackworms
- plastic dropper
- adrenaline solution
- stereomicroscope
- paraffin specimen trough
- noncarbonated spring water
- beverages with and without caffeine
- stopwatch or clock with second hand



Procedure

PART 1 Observing the Effects of a Known Stimulant

1. Copy the data table into your notebook. Use a dropper to remove one worm and a drop or two of water from the blackworm population provided by your teacher.
2. Place the worm and the water in the trough of the paraffin block. Use the dropper or the corner of a paper towel to remove any excess water that does not fit in the trough. Let the blackworm adjust for a few minutes.
3. Place the paraffin block under the stereomicroscope. Select the smallest amount of light and the lowest possible power to view the blackworm.
4. Look through the stereomicroscope and locate a segment near the middle of the worm. Count the number of times blood pulses through this segment for 30 seconds. Multiply this number by two to get the pulse in beats per minute. Record the pulse in your data table.

Data Table

Condition	Pulse Rate
No adrenaline	
With adrenaline	
Beverage without caffeine	
Beverage with caffeine	

5. Remove the block from the stereomicroscope. Use the dropper to add 1 drop of adrenaline solution to the trough. (Adrenaline is a substance produced by the human body that acts as a stimulant.) Let the worm sit in the adrenaline solution for 5 minutes.
6. Place the paraffin block under the stereomicroscope. Again locate a segment near the middle of the worm. Count the number of pulses through this segment for 30 seconds. Multiply this number by two to get the pulse in beats per minute. Record the blackworm's pulse with adrenaline.

PART 2 Testing the Effects of Caffeine

7. Using the procedures you followed in Part 1, design an experiment that tests the effect of caffeine on the blackworm's pulse. You can use beverages with and without caffeine in your investigation. Be sure to write a hypothesis and control all necessary variables.
8. Submit your experimental plan to your teacher for review. After making any necessary changes, carry out your experiment.

Analyze and Conclude

1. **Observing** In Part 1, what was the blackworm's pulse rate before you added adrenaline? After you added adrenaline?
2. **Interpreting Data** Use the data you collected in Part 1 to explain how you know that adrenaline acts as a stimulant.
3. **Controlling Variables** In the experiment you performed in Part 2, what was your control? Explain.
4. **Drawing Conclusions** Based on your results in Part 2, does caffeine act as a stimulant? Explain your answer.
5. **Communicating** Write a paragraph to explain how you think your body would react to drinks with caffeine and without caffeine. Use the results from this investigation to support your viewpoint.

Design an Experiment

Do you think that "decaffeinated" products will act as a stimulant in blackworms? Design a controlled experiment to find out. *Obtain your teacher's permission before carrying out your investigation.*

Chapter 19 Study Guide

The BIG Idea **Structure and Function** Structures that enable the nervous system to function include the brain, spinal cord, neurons, and sense organs, such as the eyes and ears.

1 How the Nervous System Works

Key Concepts

- The nervous system directs how your body responds to information about what is happening inside and outside your body. Your nervous system also helps maintain homeostasis.
- The three kinds of neurons found in the body are sensory neurons, interneurons, and motor neurons.
- For a nerve impulse to be carried along at a synapse, it must cross the gap between an axon and the next structure.

Key Terms

• stimulus • response • neuron
• nerve impulse • dendrite • axon
• nerve • sensory neuron • interneuron
• motor neuron • synapse

2 Divisions of the Nervous System

Key Concepts

- The central nervous system is the control center of the body. It includes the brain and spinal cord.
- The peripheral nervous system consists of a network of nerves that branch out from the central nervous system and connect it to the rest of the body.
- A reflex is an automatic response that occurs very rapidly and without conscious control.
- Concussions and spinal cord injuries are two ways the central nervous system can be damaged.

Key Terms

• central nervous system
• peripheral nervous system • brain
• spinal cord • cerebrum • cerebellum
• brain stem • somatic nervous system
• autonomic nervous system • reflex
• concussion

3 The Senses

Key Concepts

- The eyes convert light into nerve impulses that your brain interprets, enabling you to see.
- The ears convert sound into nerve impulses that your brain interprets, enabling you to hear. Structures in your inner ear control your sense of balance.
- The senses of smell and taste work together.
- The skin contains touch receptors that respond to a number of stimuli.

Key Terms

• cornea • pupil • iris • lens • retina
• nearsightedness • farsightedness • eardrum
• cochlea • semicircular canal

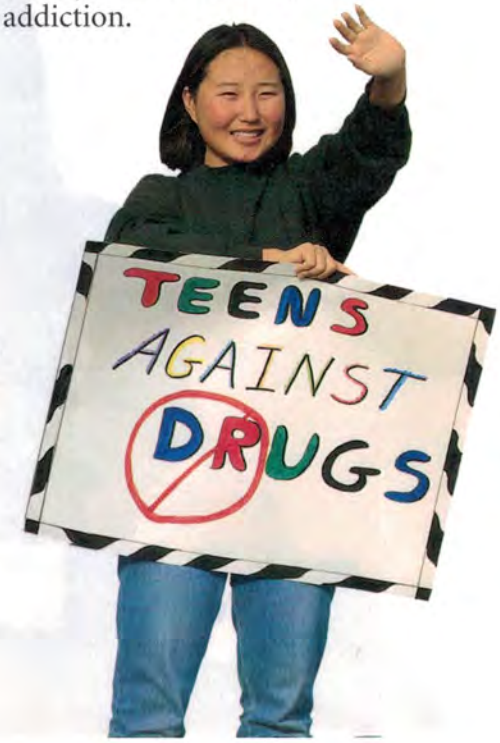
4 Alcohol and Other Drugs

Key Concepts

- Most abused drugs are dangerous because of their immediate effects on the nervous system. Long-term drug abuse can lead to addiction and other health and social problems.
- Commonly abused drugs include depressants, stimulants, inhalants, steroids, and alcohol.
- Alcohol use can destroy cells in the brain and liver, and lead to addiction.

Key Terms

drug
drug abuse
tolerance
addiction
withdrawal
depressant
stimulant
anabolic steroid
alcoholism



Review and Assessment

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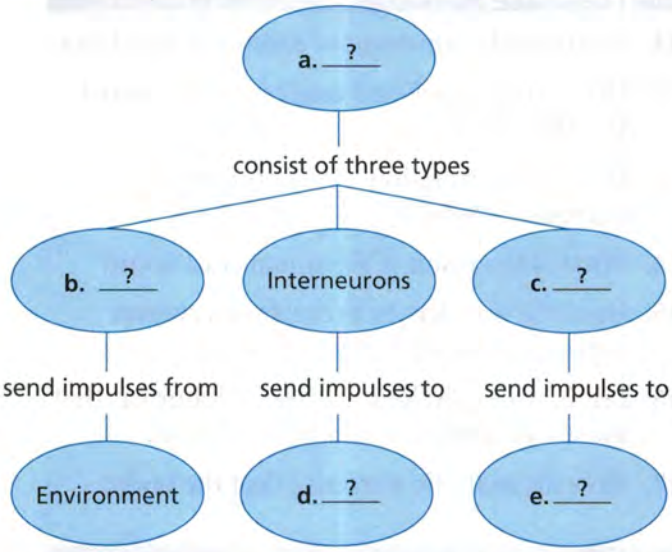
Organizing Information

Concept Mapping Copy the concept map about neurons and their functions onto a separate sheet of paper. Then, complete it and add a title. (For more on Concept Mapping, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. A change or signal in the environment that makes the nervous system react is called a
   a. stimulus.
   b. response.
   c. nerve impulse.
   d. synapse.
2. The structures that carry messages toward a neuron's cell body are
   a. axons.
   b. dendrites.
   c. nerves.
   d. nerve impulses.
3. Which structure links the brain and the peripheral nervous system?
   a. the cerebrum
   b. the cerebellum
   c. the cochlea
   d. the spinal cord
4. Which structure adjusts the size of the pupil?
   a. the cornea **b.** the retina
   c. the lens **d.** the iris
5. Physical dependence on a drug is called
   a. withdrawal. **b.** response.
   c. addiction. **d.** tolerance.

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

6. A nerve message is also called a synapse.
7. The cerebrum is the part of the brain that controls involuntary actions.
8. In nearsightedness, a person can see distant objects clearly.
9. The cochlea is part of the inner ear.
10. Alcohol is a depressant.

Writing in Science

Descriptive Paragraph Draw a diagram of the human eye, and label the key parts. Then, write a paragraph that describes how each part helps a person "see" an image.

Discovery CHANNEL SCHOOL
The Nervous System
Video Preview
Video Field Trip
▶ Video Assessment

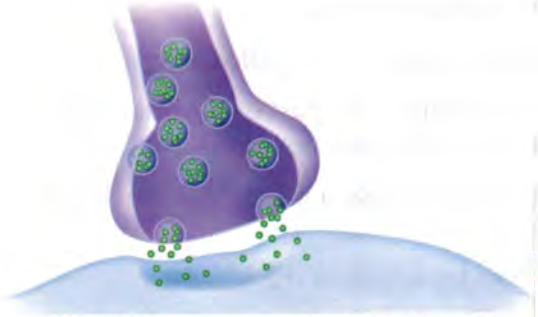
Review and Assessment

Checking Concepts

11. Compare the functions of axons and dendrites.
12. How do the cerebrum and cerebellum work together when you ride a bicycle?
13. What is the function of the autonomic nervous system?
14. What is the result if the spinal cord is cut?
15. Describe how lenses in eyeglasses correct nearsightedness and farsightedness.
16. List in order all the structures in your ear that must vibrate before you hear a sound.
17. How do anabolic steroids affect the body?

Thinking Critically

18. **Interpreting Diagrams** The diagram below shows a synapse. Explain how a nerve impulse crosses the gap.



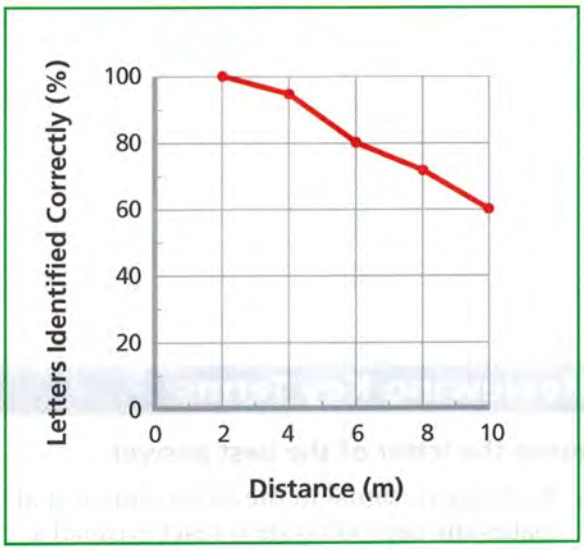
19. **Relating Cause and Effect** When a person has a stroke, blood flow to part of the brain is reduced, and some brain cells die. Suppose that after a stroke, a woman is unable to move her right arm and right leg. In which side of her brain did the stroke occur? Explain.
20. **Applying Concepts** As a man walks barefoot along a beach, he steps on a sharp shell. His foot automatically jerks upward, even before he feels pain. What process is this an example of? How does it help protect the man?
21. **Making Judgments** If someone tried to persuade you to take drugs, what arguments would you use as a way of refusing? Why do you think these arguments would be effective?

Applying Skills

Use the graph to answer Questions 22–25.

A person with normal vision stood at different distances from an eye chart and tried to identify the letters on the chart. The line graph gives the results.

Eye Chart Results



22. **Reading Graphs** What variable is plotted on the *x*-axis? On the *y*-axis?
23. **Interpreting Data** As the distance from the eye chart increases, what happens to the percentage of letters identified correctly?
24. **Controlling Variables** What was the manipulated variable in this experiment? What was the responding variable?
25. **Predicting** How would you expect the results to differ for a farsighted person? Explain.

Lab zone Chapter Project

Performance Assessment Explain to your classmates how you set up your experiment, which illusions you used, which senses were involved in the illusions, and why the illusions worked. Include information on how the nervous system was involved in your illusions.

Standardized Test Prep

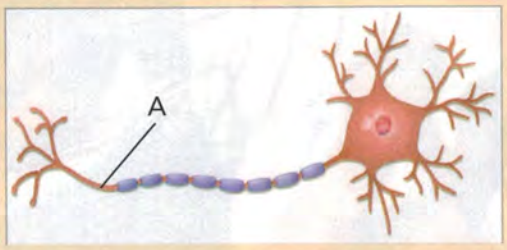
Test-Taking Tip

Interpreting a Diagram

When answering questions about diagrams, examine all parts of the diagram carefully, including any labels. Then read the question carefully to determine what you need to know. If you are asked to identify a particular structure, make sure you know exactly where the line or arrow is pointing.

Sample Question

What is the function of the part labeled *A* on the neuron shown below?



A It carries the nerve impulse toward the cell body.
B It protects the neuron from damage.
C It carries the nerve impulse away from the cell body.
D It picks up stimuli from the environment.

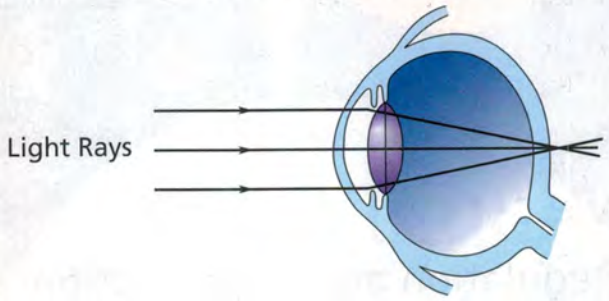
Answer

Choice **C** is correct. The part labeled *A* is an axon, which carries impulses away from the cell body. Choice **A** is incorrect because this is the function of a dendrite, not an axon. Choice **B** is incorrect because the axon does not protect a neuron. Choice **D** is incorrect because stimuli reach an axon.

Choose the letter of the best answer.

1. A scientist studying the brain is studying part of the
A peripheral nervous system.
B somatic nervous system.
C autonomic nervous system.
D central nervous system.

Use the diagram below and your knowledge of science to answer Questions 2 and 3.



2. To correct the vision of the eye shown above, a lens would have to make the light rays
F bend toward each other before they reach the eye's lens.
G spread out before they reach the eye's lens.
H focus on the eye's lens.
J focus behind the retina.

3. Which of the following correctly pairs the vision problem in the eye shown above with the proper corrective lens?
A farsightedness; convex lens
B farsightedness; concave lens
C nearsightedness; convex lens
D nearsightedness; concave lens

4. The brain stem is involved in controlling
F breathing.
G the ability to learn.
H movement of skeletal muscles.
J balance.

5. You can infer that a person who has lost his or her sense of smell is also likely to have a poor
A sense of balance.
B sense of touch.
C sense of taste.
D sense of hearing.

Constructed Response

6. Outline the path of the reflex action that takes place when you step on a tack. What is the advantage of the nerve impulse not needing to go through the brain before action is taken?