


40-1 Infectious Disease



BI 10.d. Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.


Good health is something that you might take for granted—until you or someone close to you gets sick. Then, the value of good health becomes all too obvious. Why do you get sick? How do you get better? What is the best way for you to avoid getting sick in the first place? These are questions that people have been asking for centuries. Today, in most cases, these questions can be answered.

A **disease** is any change, other than an injury, that disrupts the normal functions of the body.  **Some diseases are produced by agents, such as bacteria, viruses, and fungi. Others are caused by materials in the environment, such as cigarette smoke. Still others, such as hemophilia, are inherited.** Disease-causing agents are called **pathogens**, which means “sickness-makers.” Diseases caused by pathogens are generally called infectious diseases.

The Germ Theory of Disease

For thousands of years, people believed that diseases were caused by curses, evil spirits, or night vapors. In the mid-nineteenth century, a new explanation was put forth based on the work of the French chemist Louis Pasteur and the German bacteriologist Robert Koch. The observations of Pasteur and Koch led them to conclude that infectious diseases were caused by microorganisms of different types, commonly called germs. This idea is now known as the **germ theory of disease**.

The world is filled with microorganisms of every shape and description. How can scientists be sure that a particular organism causes a certain disease? In 1975, Allen Steere of Yale University had a chance to ask that question. In a small area of Connecticut, Steere found 39 children and several adults suffering from pain and joint inflammation. Their symptoms looked like a rare form of childhood arthritis. However, Steere thought that there were far too many cases of arthritis for such a small population. He looked for another explanation. The rural location of the outbreak and the fact that most of the cases had started in summer or early fall made Steere suspect, at first, that this could be an infectious disease carried by an insect.

Figure 40-1  Diseases can be inherited, caused by materials in the environment, or produced by pathogens. Certain species of ticks often carry bacteria or viruses that are transmitted when they bite a host.

Guide for Reading



Key Concepts

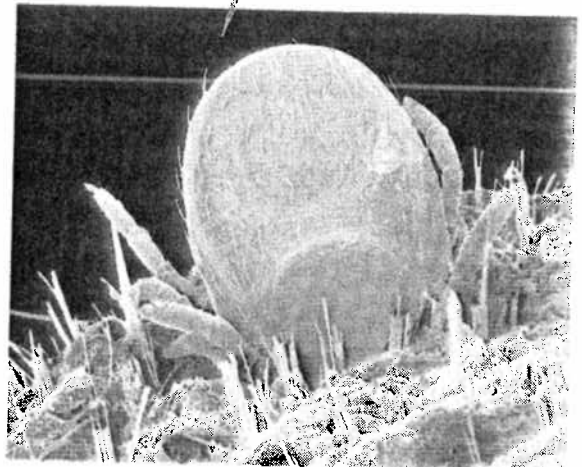
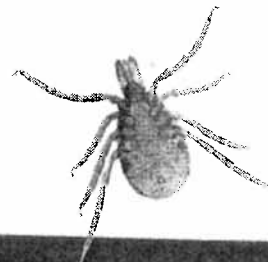
- What causes disease?
- How are infectious diseases transmitted?

Vocabulary

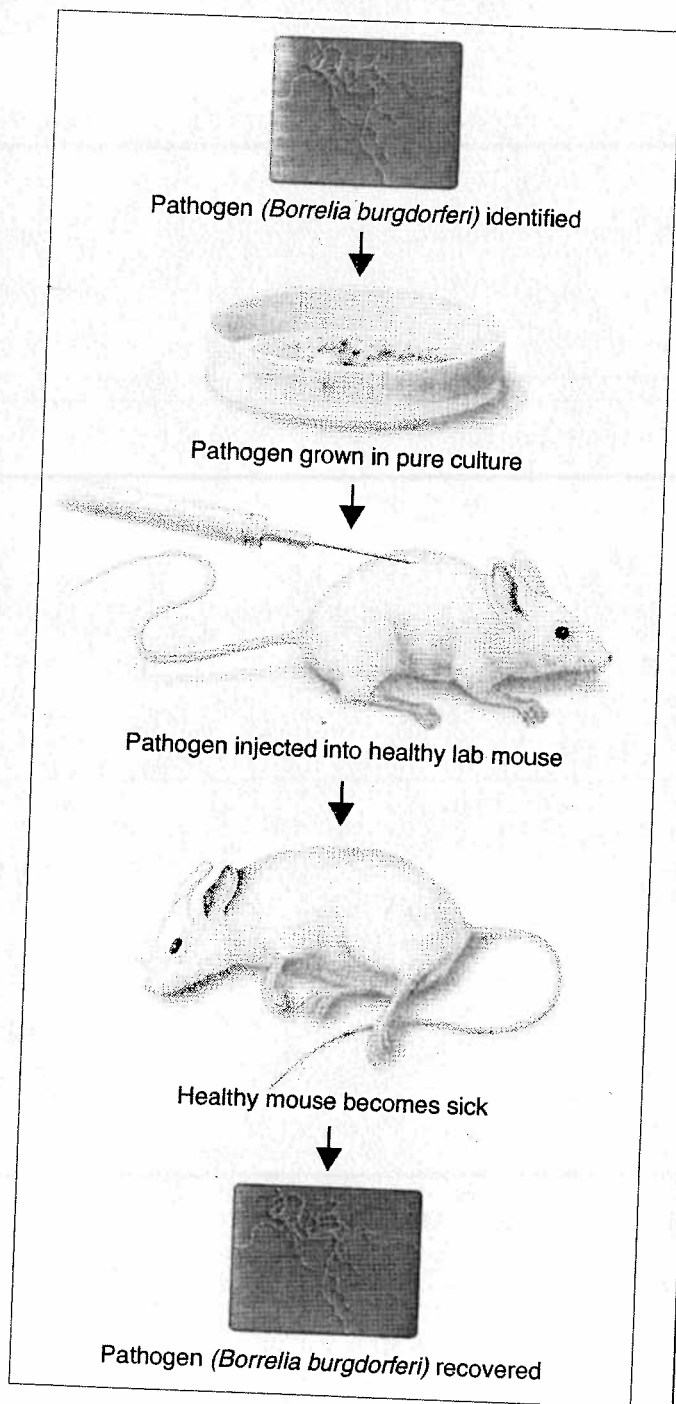
disease
pathogen
germ theory of disease
Koch's postulates
vector
antibiotic

Reading Strategy: Using Prior Knowledge

Before you read, make a list of some of the diseases that you have had. As you read, determine which pathogen might have caused each disease.



(magnification: about 30×)



▲ **Figure 40-2** Allen Steere followed Koch's postulates to test his theory that the bacterium *Borrelia burgdorferi* caused Lyme disease. **Inferring** Why must the pathogen be grown in a pure culture?

Sure enough, many of the children reported that their problems began with what they thought was an insect bite. The bite was followed by an expanding skin rash. Steere called the infection Lyme disease after the town of Lyme, Connecticut, where it was first discovered.

Steere and his colleagues were able to link the skin rash to the bite of the tiny deer tick (*Ixodes scapularis*). One of Steere's colleagues, Dr. Willy Burgdorfer, found an unusual spiral-shaped bacterium (*Borrelia burgdorferi*) in the ticks. Steere found the same bacterium in patients with Lyme disease. Could this bacterium be the cause of Lyme disease?

For ethical reasons, Steere did not try to infect healthy children with the bacterium. However, when the bacterium was injected into laboratory mice, they developed arthritis and other symptoms, just as the children had. From the sick mice, Steere recovered the bacteria, which were then injected into healthy mice. The healthy mice then developed the disease. Steere and his colleagues had found the organism that caused Lyme disease. The process Steere used is shown in **Figure 40-2**.

Koch's Postulates

The groundwork for Allen Steere's work with Lyme disease was actually laid more than a hundred years earlier by Robert Koch. From his studies with various bacteria, Koch developed a series of rules still used today to identify the microorganism that causes a specific disease. These rules are known as **Koch's postulates**. Koch's postulates can be stated as follows:

1. The pathogen should always be found in the body of a sick organism and should not be found in a healthy one.
2. The pathogen must be isolated and grown in the laboratory in pure culture.
3. When the cultured pathogens are placed in a new host, they should cause the same disease that infected the original host.
4. The injected pathogen should be isolated from the second host. It should be identical to the original pathogen.

Why are these rules important? Because identifying pathogens that cause disease is the first step toward preventing or curing the ailments they produce.

Agents of Disease

For many pathogens, the human body provides just the right conditions for growth—a suitable body temperature, a watery environment, and an abundance of nutrients. The large intestine, for example, harbors dense colonies of bacteria that help in the process of digestion. Bacteria and yeast are also found in the mouth and throat. Fortunately, most of these organisms are harmless, and many are actually beneficial.

If this is true, then exactly how do pathogens cause disease? Some pathogens, including viruses and some bacteria, destroy cells as they grow. Other bacteria release toxins that harm an organism. Still others, especially parasitic worms, produce sickness when they block the flow of blood, remove nutrients from the digestive system, and disrupt other bodily functions. The *Ascaris* worm in **Figure 40–3** is a parasitic worm.

Viruses Viruses are tiny particles that invade and replicate within living cells. Viruses attach to the surface of a cell, insert their genetic material in the form of RNA or DNA, and take over many of the functions of the host cell. Viruses can infect nearly every type of organism—including plants, animals, and bacteria. Diseases caused by viruses include the common cold, influenza, smallpox, and warts.

Bacteria Most bacteria are harmless to humans. Unfortunately, the few that are pathogens cause serious diseases. Bacteria cause disease in one of two ways—either by breaking down the tissues of the infected organism for food or by releasing toxins that harm the body. Bacterial diseases include streptococcus infections, diphtheria, botulism, and anthrax.

Protists You may not associate protists with disease, but a protist causes what may be the single most damaging infectious disease afflicting humans—malaria. Malaria is caused by *Plasmodium*, a protist that is spread from person to person by mosquitoes. Insects also spread another protist known as *Trypanosoma*. *Trypanosoma* protists live in the bloodstreams of vertebrate animals. The protist feeds off the nutrients in the host organism's blood. *Trypanosoma* causes African sleeping sickness. Contaminated water supplies are responsible for amebic dysentery, a serious infection caused by the protist *Entamoeba*.

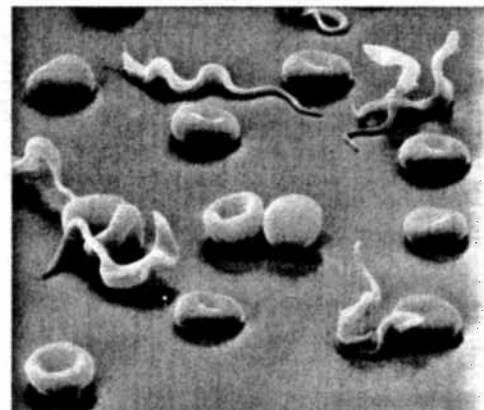
Worms Flatworms and roundworms are also responsible for a number of serious human diseases. People in many tropical regions of the world can become infected by a parasitic flatworm known as *Schistosoma*. These flatworms live part of their lives in snails and then leave the snails to enter the fresh water of streams and rice paddies. *Schistosoma* worms frequently infect people working in rice fields. Other parasitic worms that infect humans include tapeworms and hookworms.

CHECKPOINT What are three diseases caused by protists?

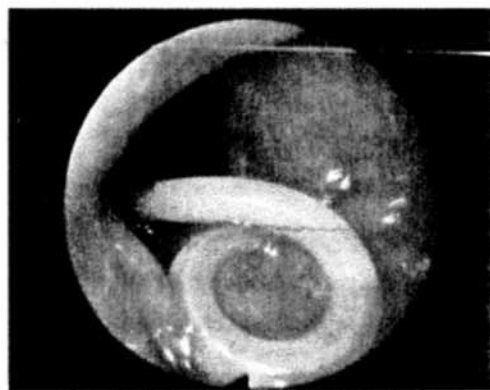
Quick View Video

Discovery School Video To see how scientists test a hypothesis about how a disease is caused and transmitted, view track 7 “Hantavirus: A Tale of Mice and People” on the *BioDetectives* DVD.

Figure 40–3 Protists and worms often cause disease in humans and other animals. The protist *Trypanosoma* (purple objects) causes African sleeping sickness. The *Ascaris* worm matures in the intestine and causes severe malnutrition in its hosts.



Trypanosoma Among Red Blood Cells



Ascaris Worm in Intestine



▲ **Figure 40-4** Some infectious diseases are spread from person to person by sneezing. Thousands of pathogen particles can be released by a sneeze.

Fungi Most fungi are harmless, but a few are capable of causing serious problems. One genus of fungi, *Tinea*, is particularly adept at penetrating the outer layers of skin. When it attacks the skin between the toes it produces the infection known as athlete's foot. The same fungus can infect the scalp, where it results in rough, scaly patches known as ringworm. Other types of fungi infect the mouth, the throat, and even the fingernails and toenails.

How Diseases Are Spread

Infectious diseases can be transmitted in a number of ways.

➤ **Some infectious diseases are spread from one person to another through coughing, sneezing, or physical contact. Other infectious diseases are spread through contaminated water or food. Still others are spread by infected animals.**

Physical Contact Some infectious diseases can be spread by direct physical contact. For example, a disease may be transmitted when a healthy person touches a person with a disease. Some of the most dangerous pathogens are spread from one person to another by sexual contact.

Most diseases are spread by indirect contact. For example, some pathogens can be carried through the air. If a person with a cold or virus coughs or sneezes, thousands of droplets are released, as shown in **Figure 40-4**. The pathogens can also settle on objects. If you touch those objects, the pathogens can be transferred to your hands, and you can infect yourself by touching your mouth or nose.

Some behaviors can help to control transmission of diseases spread by physical contact. Simple measures, such as covering your mouth with a tissue when you cough, can limit the spread of infection. Washing your hands thoroughly and often also helps to prevent the spread of many pathogens.

Contaminated Food and Water Have you ever had food poisoning? Food poisoning is caused by eating food that contains pathogens. Bacteria are always present in uncooked meat. Bacteria also grow quickly in warm, partially cooked food. If food is cooked thoroughly, the risk of food poisoning due to contamination may be reduced. Contaminated water also causes disease, especially in parts of the world with poor sanitation and untreated sewage.

Infected Animals Animals, such as the mosquito shown in **Figure 40-5**, also spread infectious disease. Animals that carry pathogens from person to person are called **vectors**. Malaria, Lyme disease, West Nile virus, and rabies are diseases carried by vectors. Avoiding tall grass and wooded areas where deer and field mice dwell will limit your exposure to ticks that carry Lyme disease. Staying away from wild animals can reduce your risk of being bitten by a rabid animal.

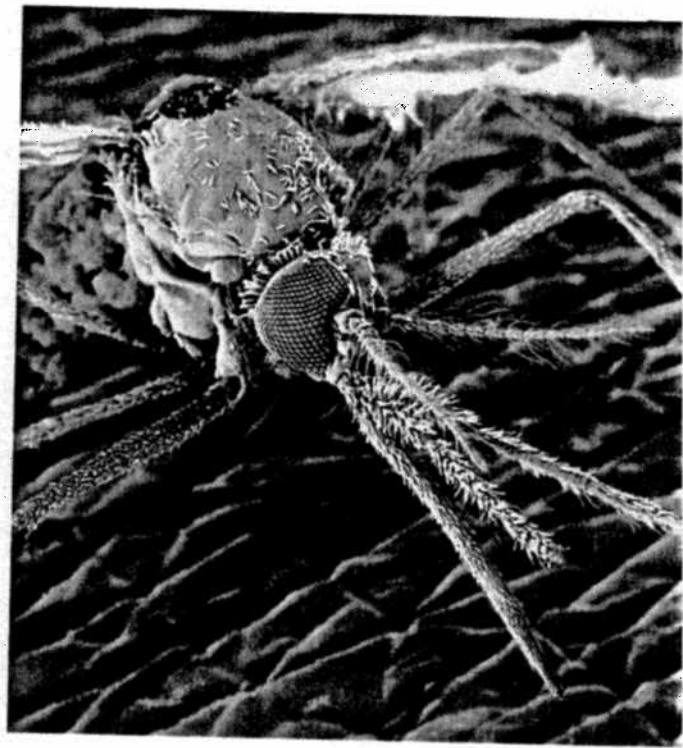
Fighting Infectious Diseases

Because prevention isn't always possible, drugs have been developed for use against some types of pathogens. Antibiotics are perhaps the most useful single class of infection-fighting drugs. **Antibiotics** are compounds that kill bacteria without harming the cells of the human or animal hosts. Antibiotics work by interfering with the cellular processes of microorganisms.

Discovery of Antibiotics Many antibiotics are produced naturally by living organisms. Other antibiotics are synthetic. One antibiotic, penicillin, was discovered accidentally in 1928 by the Scottish bacteriologist Alexander Fleming. Fleming had been growing *Staphylococcus* bacteria in a culture dish. One day, he noticed that the culture of bacteria had been contaminated by a species of green mold called *Penicillium notatum*. On closer observation, Fleming saw something surprising. The bacteria were not growing near the mold. Something produced by the mold was apparently inhibiting their growth. Later, researchers discovered that penicillin—the name Fleming gave the antibiotic—interferes with the growth of bacteria.

Antibiotics have no effect on viruses. However, antiviral drugs have been developed to fight certain viral diseases. These drugs generally inhibit the ability of viruses to invade cells and to multiply once inside cells.

Over-the-Counter Drugs You probably know that you can buy many medicines without a prescription. These medicines, called over-the-counter drugs, treat only the symptoms of the disease—including cough, congestion, and fever. These medicines help you feel better, but they do not actually treat the cause of the infection. The best treatment for most infections includes rest, a well-balanced diet, and plenty of fluids.



▲ **Figure 40-5** Some infectious diseases are spread by insects. This *Anopheles* mosquito may be a carrier of the protist that causes malaria.

40-1 Section Assessment

Writing in Science

1. **Key Concept** Describe some of the causes of disease.
2. **Key Concept** What are the ways in which infectious diseases are spread?
3. How do vectors spread disease?
4. What are antibiotics?

5. **Critical Thinking: Inferring** Why did Koch require all four steps in determining the cause of an infectious disease? Could you eliminate one of the steps? Explain your answer.

Descriptive Writing

Describe how Allen Steere used Koch's postulates to discover the cause of Lyme disease. You may want to start by listing the postulates in one column of a table and, in another column, listing the steps used by Steere.

40-2 The Immune System



BI 10.a. Students know the role of the skin in providing nonspecific defenses against infection. **BI 10.b.** Students know the role of antibodies in the body's response to infection. **BI 10.c.** Students know how vaccination protects an individual from infectious diseases. ***BI 10.f.** Students know the roles of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system.

Guide for Reading

Key Concepts

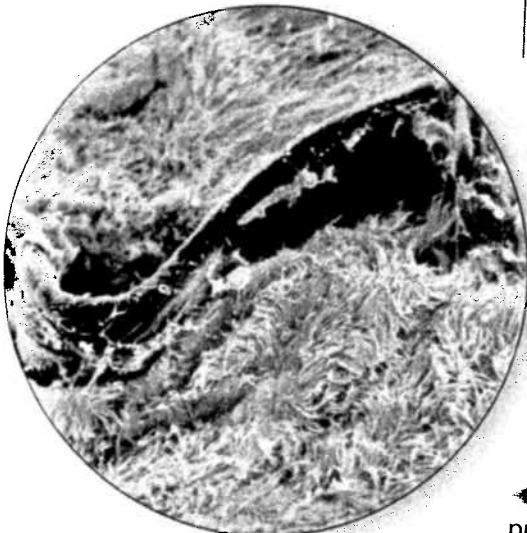
- What is the function of the immune system?
- What are the body's non-specific defenses against invading pathogens?

Vocabulary

immunity
inflammatory response
fever
interferon
immune response
antigen
humoral immunity
cell-mediated immunity
antibody
vaccination
active immunity
passive immunity

Reading Strategy:

Finding Main Ideas Before you read, skim the section to identify the key ideas. Then, carefully read the section, making a list of supporting details for each main idea.



(magnification: 1100×)

With pathogens all around us, it might seem like a miracle that you aren't sick all of the time. There's a reason, of course, why most of us enjoy good health. Our bodies have a protective system—a series of defenses that guard against disease.

The immune system is the body's main defense against pathogens. The immune system recognizes, attacks, destroys, and “remembers” each type of pathogen that enters the body. It does this by producing specialized cells that inactivate pathogens. For each kind of pathogen, the immune system produces cells that are specific to that pathogen. **The function of the immune system is to fight infection through the production of cells that inactivate foreign substances or cells.** This process is called **immunity**.

The immune system includes two general categories of defense mechanisms against infection: nonspecific defenses and specific defenses. Nonspecific defenses are like the fortress walls of the system. They guard against infections by keeping most things out of the body. Specific defenses work like security guards. They track down harmful pathogens that have managed to break through the body's nonspecific defenses.

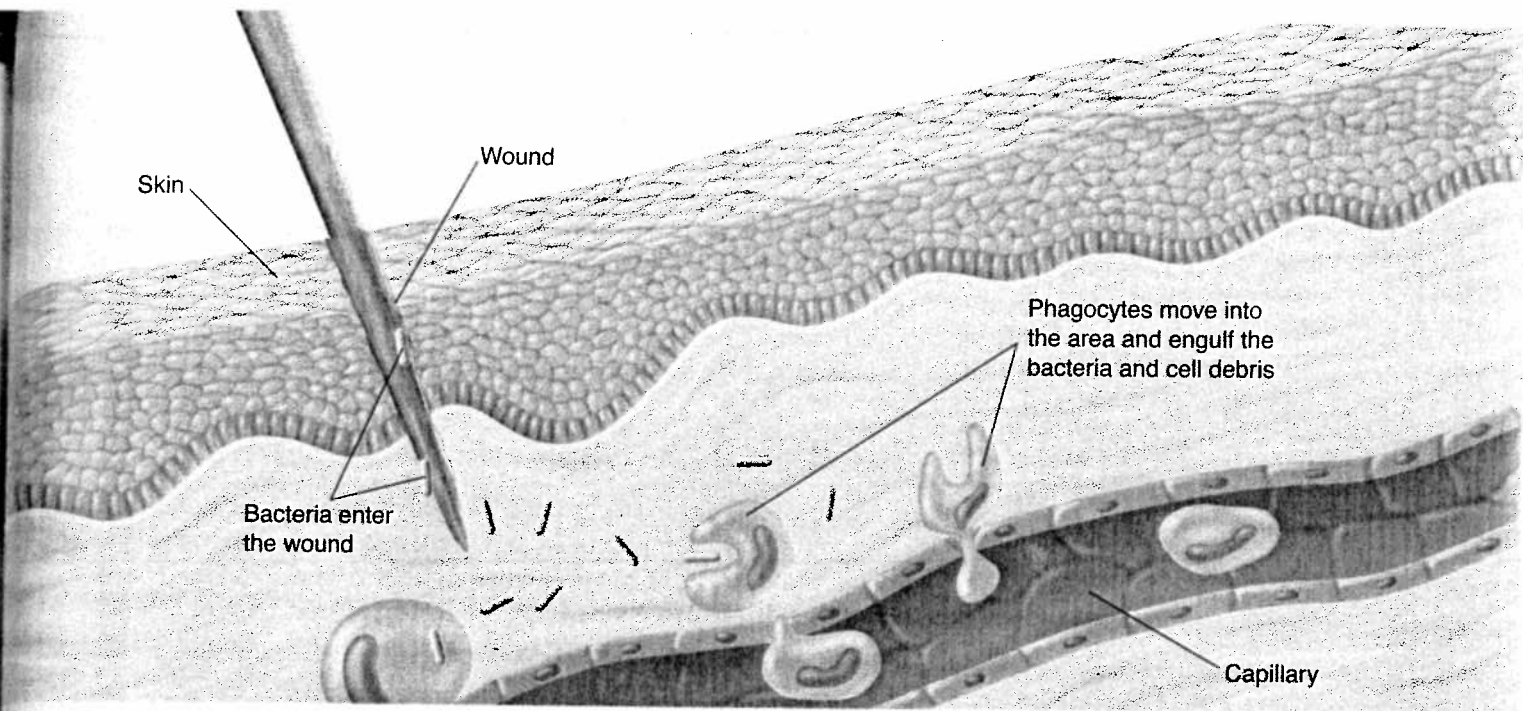
Nonspecific Defenses

Nonspecific defenses do not discriminate between one threat and another. These defenses include physical and chemical barriers.


First Line of Defense The function of the first line of defense is to keep pathogens out of the body. This role is carried out by skin, mucus, sweat, and tears. **Your body's most important nonspecific defense is the skin.** Very few pathogens can penetrate the layers of dead cells at the skin's surface. The importance of the skin as a barrier against infection becomes obvious as soon as the skin is broken. When that happens, pathogens can enter your body and multiply. As they grow, they cause the symptoms of an infection, such as swelling, redness, and pain.

Many secretions of the body, including mucus, saliva, and tears, contain lysozyme, an enzyme that breaks down the cell walls of many bacteria. In addition, oil and sweat glands in the skin produce an acidic environment that kills many bacteria.


Figure 40-6 The immune system fights infection. The production of mucus is one of your body's defenses. Pathogens can get trapped in mucus the way the long brown strand of dirt shown in the micrograph is trapped.




Pathogens can also enter your body through other body openings, including your mouth and nose. Your body has other nonspecific defenses that protect these openings. Mucus in your nose and throat helps to trap pathogens. The cilia that line your nose and throat help to push pathogens away from your lungs. Stomach acid and digestive enzymes destroy many pathogens that make their way to your stomach.

Second Line of Defense If pathogens do manage to enter your body, they may multiply quickly, releasing toxins into your tissues. When this happens, the **inflammatory response**—a second line of defense—is activated.  **The inflammatory response is a nonspecific defense reaction to tissue damage caused by injury or infection.** When pathogens are detected, the immune system produces millions of white blood cells, which fight the infection. Blood vessels near the wound expand, and white blood cells move from the vessels to enter the infected tissues. Many of these white blood cells are phagocytes, which engulf and destroy bacteria. The infected tissue may become swollen and painful. The inflammatory response is summarized in **Figure 40-7**.

The immune system also releases chemicals that increase the core body temperature. You may have experienced this elevated body temperature, called a **fever**. The increased body temperature is advantageous because many pathogens can survive only within a narrow temperature range. An elevated temperature slows down or stops the growth of such pathogens. The higher body temperature also increases the heart rate so that the white blood cells get to the site of infection faster. Physicians know that a fever and an increased number of white blood cells are two indications that the body is hard at work fighting infection.

 **CHECKPOINT** What is the role of phagocytes in the inflammatory response?

▲ Figure 40-7  The inflammatory response is a nonspecific defense reaction to tissue damage caused by injury or infection. When pathogens enter the body, phagocytes move into the area and engulf the pathogens. In addition, platelets and clotting factors leak from the capillaries.

Word Origins

Phagocyte comes from the Greek *phag*, meaning “eat,” and *kutos*, meaning “cell.” Thus, a phagocyte is a cell that eats or engulfs. If the Greek prefix *macro-* means “large,” what might the word *macrophage* mean?

Interferon When viruses enter the body, the body sometimes reacts in a different way. Sometimes, virus-infected cells produce a group of proteins that help other cells resist viral infection. Scientists named these proteins **interferons** because they “interfere” with the growth of the virus. Interferons inhibit the synthesis of viral proteins in infected cells and help block viral replication. This process slows down the progress of infection and often gives the specific defenses of the immune system time to respond.

Specific Defenses

If a pathogen is able to get past the body’s nonspecific defenses, the immune system reacts with a series of specific defenses that attack the particular disease-causing agent. These defenses are called the **immune response**. A substance that triggers this response is known as an **antigen**. Viruses, bacteria, and other pathogens may serve as antigens.

The cells of the immune system that recognize specific antigens are two types of lymphocytes: B lymphocytes (B cells) and T lymphocytes (T cells). B cells provide immunity against antigens and pathogens in the body fluids. This process is called **humoral immunity**. T cells provide a defense against abnormal cells and pathogens inside living cells. This process is called **cell-mediated immunity**.

Humoral Immunity When a pathogen invades the body, its antigens are recognized by a small fraction of the body’s B cells. These B cells grow and divide rapidly, producing large numbers of plasma cells and memory B cells.

Plasma cells release antibodies. **Antibodies** are proteins that recognize and bind to antigens. The antibodies are carried in the bloodstream to attack the pathogen that is causing the infection. As the antibodies overcome the infection, the plasma cells die out and stop producing antibodies.

Once the body has been exposed to a pathogen, millions of memory B cells remain capable of producing antibodies specific to that pathogen. These memory B cells greatly reduce the chance that the disease could develop a second time. If the same antigen enters the body a second time, a secondary response occurs. The memory B cells divide rapidly, forming new plasma cells. The plasma cells produce the specific antibodies needed to destroy the pathogen.

Antibody Structure As shown in **Figure 40-8**, an antibody is shaped like the letter Y and has two identical antigen-binding sites. Small differences in the amino acids affect the shapes of the binding sites. The shape of the binding site makes it possible for the antibody to recognize a specific antigen with a complementary shape. The different shapes give antibodies the ability to recognize a large variety of antigens. It is estimated that a healthy adult can produce about 100 million different types of antibodies.

▼ **Figure 40-8** An antibody molecule has two identical antigen-binding sites. It is at these sites that one or two specific antigens bind to the antibody. **Applying Concepts** How do antibodies help in the immune response?

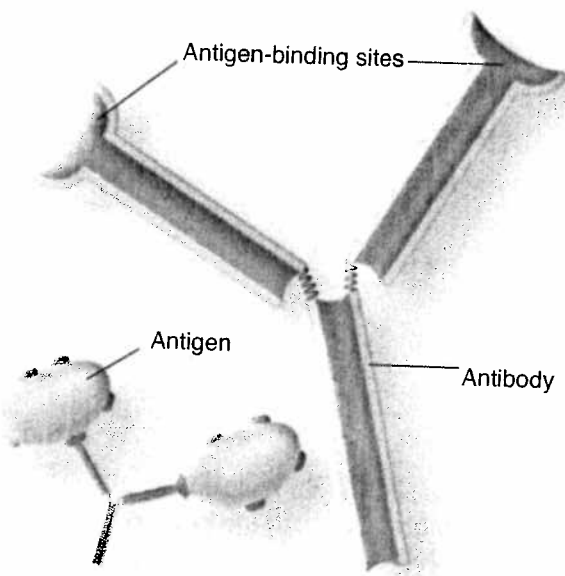
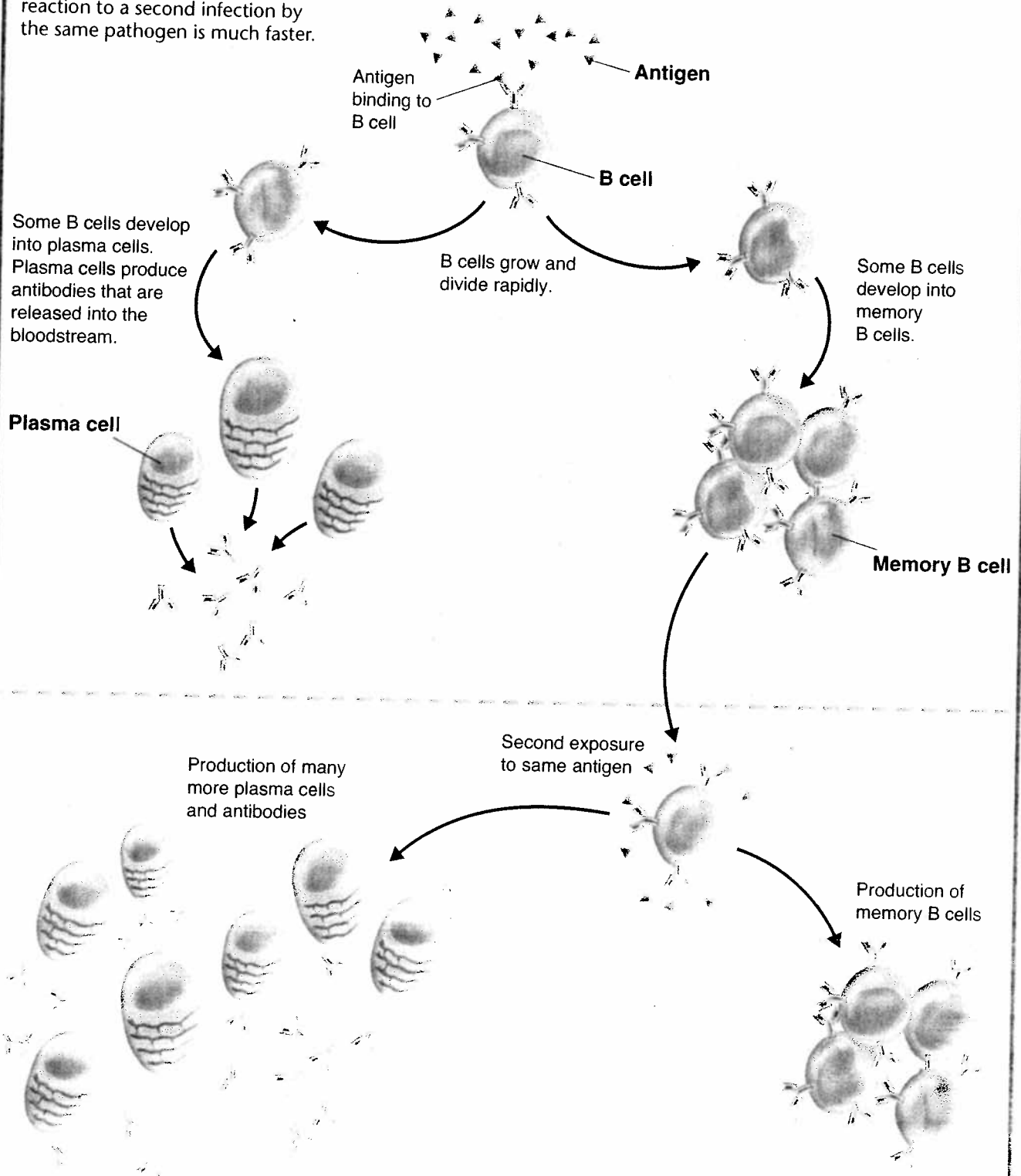
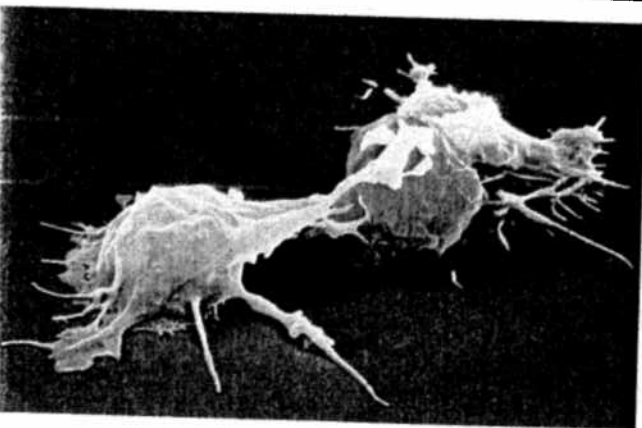
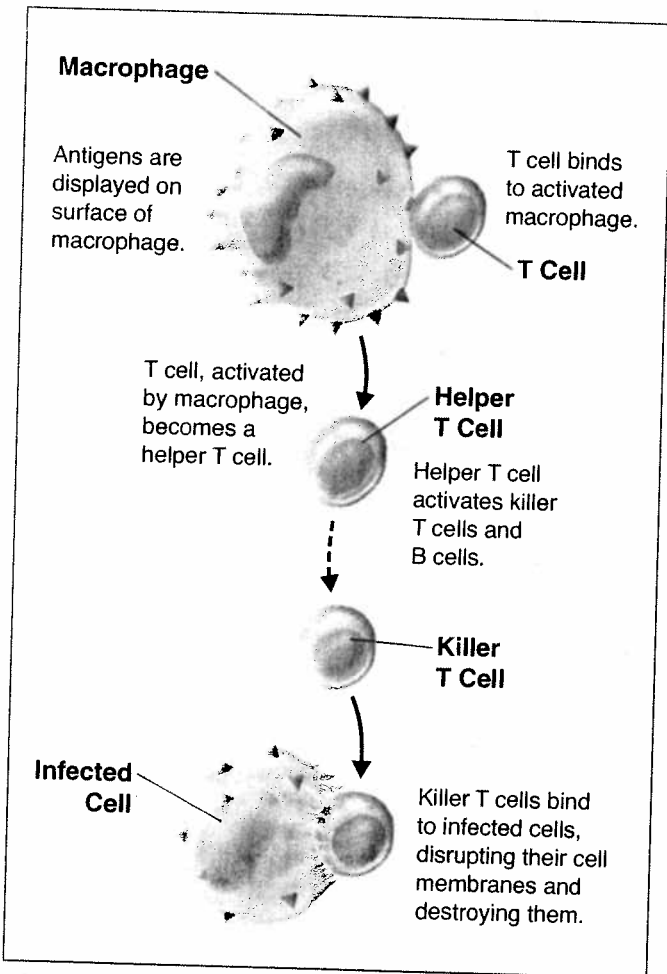


FIGURE 40-9 HUMORAL IMMUNITY

Once the body has been exposed to a pathogen, it remains capable of producing specific antibodies to attack that pathogen. The reaction to a second infection by the same pathogen is much faster.





Cell-Mediated Immunity The body's primary defense against its own cells when they have become cancerous or infected by viruses is known as cell-mediated immunity. Cell-mediated immunity is also important in fighting infection caused by fungi and protists. When viruses or other pathogens get inside living cells, antibodies alone cannot destroy them.

During cell-mediated immunity, T cells divide and differentiate into killer T cells (cytotoxic T cells), helper T cells, suppressor T cells, and memory T cells. Killer T cells track down and destroy the bacteria, fungi, protozoan, or foreign tissue that contains the antigen. Helper T cells produce memory T cells. The memory T cells, like the memory B cells, will cause a secondary response if the same antigen enters the body again. As the pathogenic cells are brought under control, suppressor T cells release substances that shut down the killer T cells. The process of cell-mediated immunity is summarized in **Figure 40-10**.

CHECKPOINT What is cell-mediated immunity?

Transplants Although killer T cells are helpful in the immune system, they make the acceptance of organ transplants difficult. Body cells have marker proteins on their surfaces that allow the immune system to recognize the cells. If an organ was going to be transplanted into your body, your immune system would recognize the transported organ as foreign and attack it. Your immune system damages and destroys the transplanted organ. This process is known as rejection. To prevent organ rejection, doctors search for a donor whose cell markers are nearly identical to the cell markers of the recipient. Recipients must take drugs—usually for the rest of their lives—to suppress the cell-mediated immune response.

Figure 40-10 During the cell-mediated immune response, T cells provide defense against abnormal cells and pathogens inside living cells. The yellow objects in the scanning electron micrograph are killer T cells attacking a cancer cell. **Comparing and Contrasting** How are humoral immunity and cell-mediated immunity similar? How are they different?

Quick Lab

How does cell-mediated immunity work?

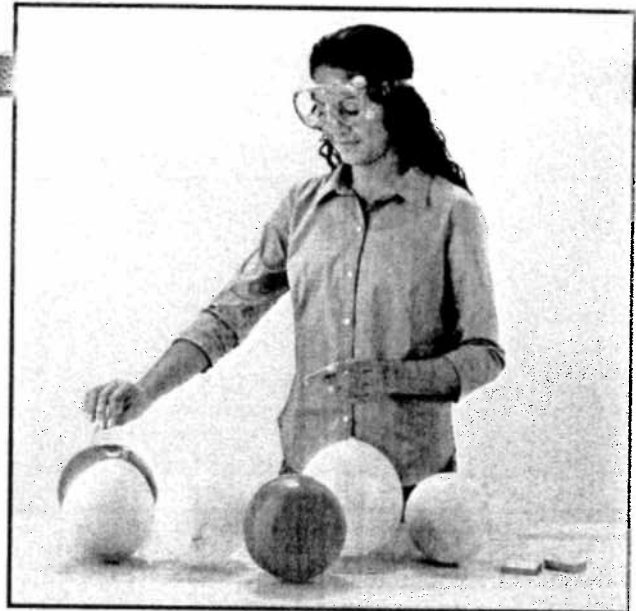


BI 10.d

Materials 3 red balloons; 3 yellow balloons; 3 light-blue balloons; red, purple, and light-blue adhesive notes; toothpick

Procedure

1. Partially inflate and tie the balloons. The balloons represent pathogens. The different colors represent different surface antigens. Put the inflated balloons on the table.
2. The adhesive notes represent antibodies that can bind to antigens on the surface of a pathogen of the same color. Use the adhesive notes to model the binding of antibodies to antigens on pathogens.
3. The toothpick represents a killer T cell. Use the toothpick to burst any balloons marked by adhesive notes.



Analyze and Conclude

1. **Using Models** How did you model the binding of antibodies to matching antigens in step 2?
2. **Using Models** What signals a killer T cell to attack a pathogen?
3. **Using Models** What do the yellow balloons and purple adhesive notes represent in the model?

Acquired Immunity

More than 200 years ago, the English physician Edward Jenner wondered if it might be possible to produce immunity against one of the deadliest diseases of the day—smallpox. Jenner knew that a mild disease called cowpox was often contracted by milkmaids. Jenner observed that the milkmaids who contracted cowpox developed an immunity to smallpox. Was there a way, he wondered, to deliberately infect people with cowpox and thus protect them from getting the more serious disease of smallpox?

To answer this question, Jenner took fluid from one of the sores of a cowpox patient and put the fluid into a small cut that he made on the arm of a young farm boy named Jamie Phipps. As expected, Jamie developed a mild cowpox infection. Two months later, Jenner performed a daring experiment. He injected Jamie with fluid from a smallpox infection. Fortunately for Jamie, the experiment was a success—the boy did not develop smallpox. His cowpox infection had made him immune to smallpox.

Active Immunity The injection of a weakened form of a pathogen to produce immunity is known as a **vaccination**. *Vacca* is the Latin word for “cow,” reflecting the history of Jenner’s first vaccination experiment. Today, more than 20 serious human diseases can be prevented by vaccination. Like early vaccines, modern vaccines stimulate the immune system to create millions of plasma cells ready to produce specific types of antibodies.



▲ **Figure 40-11** Vaccines stimulate the immune system to produce plasma cells. **Applying Concepts** What type of immunity do vaccines produce?

The type of immunity produced by the body's reaction to a vaccine is known as **active immunity**. Active immunity appears after exposure to an antigen, as a result of the immune response. Active immunity may develop as a result of natural exposure to an antigen (fighting an infection) or from deliberate exposure to the antigen (through a vaccine).

Passive Immunity In active immunity, the body makes its own antibodies in response to an antigen. The body can also be temporarily protected from disease in another way. If antibodies produced by other animals against a pathogen are injected into the bloodstream, the antibodies produce a **passive immunity** against the pathogen. Passive immunity lasts only a short time because eventually the body destroys the foreign antibodies.

Like active immunity, passive immunity can develop naturally or by deliberate exposure. One kind of natural immunity occurs when antibodies produced by the mother are passed to the fetus during development (across the placenta) or in early infancy through breast milk. This immunity protects a child against most infectious diseases for the first few months of its life, or longer if the infant is breast-fed.

Sometimes, antibodies are administered to fight infection or prevent disease. For example, travelers to certain regions of the world are given vaccines before leaving home. These vaccines may contain antibodies against tropical diseases, such as malaria. People who have been bitten by rabid animals are injected with antibodies that attack the rabies virus. This is another example of passive immunization.

40-2 Section Assessment

1. **Key Concept** Describe the body's nonspecific defenses against pathogens.
2. **Key Concept** Describe the function of the immune system.
3. How do interferons protect the body against viruses?
4. How are antigens related to antibodies?
5. **Critical Thinking Comparing and Contrasting** How are active and passive immunity similar? How are they different?

Focus on the BIG Idea

Science, Technology, and Society Getting vaccinated is much safer than getting the disease that the vaccine prevents. However, like any drug, vaccines are capable of causing serious problems. Interview five people about their thoughts on vaccinations. As a class, arrange a debate that addresses both the benefits and risks of vaccinations.

40-3 Immune System Disorders



BI 10.e. Students know why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections by microorganisms that are usually benign.

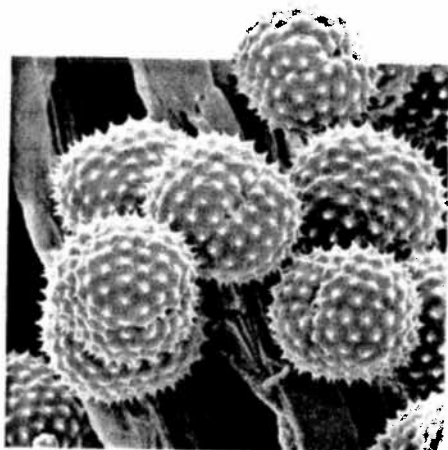
Although the immune system defends the body from a wide range of pathogens, sometimes disorders occur in the immune system itself. There are three different types of disorders. These disorders include allergies, autoimmune diseases, and immunodeficiency diseases.

Allergies

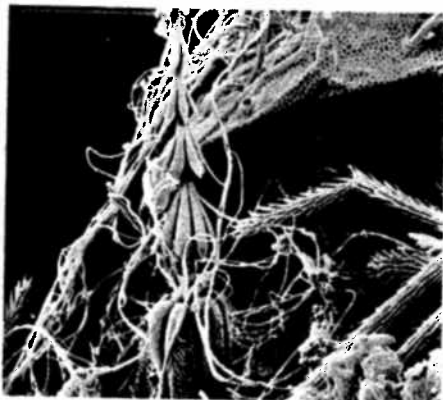
The most common overreactions of the immune system to antigens are known as **allergies**. Common allergies include those to pollen, dust, mold, and bee stings. Antigens that cause allergic reactions are called allergens. Some common allergens are shown in **Figure 40-12**.

When allergy-causing antigens enter the body, they attach themselves to mast cells. Mast cells are specialized immune system cells that initiate the inflammatory response. The activated mast cells release chemicals known as **histamines**. Histamines increase the flow of blood and fluids to the surrounding area. They also increase mucous production in the respiratory system. The increased mucous production brings on the sneezing, watery eyes, runny nose, and other irritations that make a person with allergies so uncomfortable. If you have allergies, you may have taken *antihistamines*. Antihistamines are drugs that are used to counteract the effects of histamines.

Figure 40-12 Common allergens include ragweed pollen, dust, and dust mites. In the SEM of the dust ball, notice the insect parts, gray spider webbing, and other dirt. Dust mites live in furniture, mattresses, and even pillows. **Inferring** Why do you think it is recommended that people wash their bed coverings in hot water?



Ragweed Pollen (magnification: 770×)



Dust Ball (magnification: 760×)



Dust Mite (magnification: 900×)

Guide for Reading



Key Concepts

- What is an autoimmune disease?
- How can AIDS be prevented?

Vocabulary

allergy
histamine
asthma

Reading Strategy:

Using Prior Knowledge

Do you or someone you know have allergies? As you read this section, use what you learn to explain the causes and symptoms of allergies.

▼ **Figure 40-13** When the immune system makes a mistake and attacks the body's own cells, it produces an autoimmune disease. Multiple sclerosis is one example of an autoimmune disease in which axons in the optic nerve, brain, or spinal cord are affected. Symptoms of multiple sclerosis include problems with balance and motor coordination.



Asthma

Some allergic reactions can create a dangerous condition called asthma. **Asthma** is a chronic respiratory disease in which the air passages become narrower than normal. This narrowing of the air passages causes wheezing, coughing, and difficulty in breathing. Many factors, including both heredity and environment, play a role in the onset of the symptoms of asthma.

Asthma is a leading cause of serious illness among children, and can be a life-threatening disease. If treatment is not started early enough or if medications are not taken properly, asthma can lead to permanent damage or destruction of lung tissue.

Asthma attacks can be triggered by respiratory infections, exercise, emotional stress, and certain medications. Other triggers include cold air, pollen, dust, tobacco smoke, pollution, molds, and pet dander.

There is no cure for asthma; however, people who have asthma can sometimes control the condition. If the attacks are caused by an allergy, a series of tests can identify what substances cause the problem. Medications are sometimes used to relieve the symptoms of asthma. Often, these medications relax the smooth muscles around the airways, making breathing easier.

CHECKPOINT What happens in the lungs during an asthma attack?

Autoimmune Diseases

The immune system could not defend your body against a host of invading pathogens unless it was able to distinguish those pathogens from the cells and tissues that are part of your body. In other words, the immune system usually has the ability to distinguish “self” from “nonself.” **When the immune system makes a mistake and attacks the body's own cells, it produces an autoimmune disease.** In an autoimmune disease, the immune system produces “antiself” antibodies.

Some examples of autoimmune diseases include Type I diabetes, rheumatoid arthritis, myasthenia gravis, and multiple sclerosis (MS). In Type I diabetes, antibodies attack the insulin-producing cells of the pancreas. In rheumatoid arthritis, antibodies attack connective tissues around the joints. In myasthenia gravis, antibodies attack neuromuscular junctions. Multiple sclerosis is an autoimmune disease in which antibodies destroy the functions of the neurons in the brain and spinal cord.

Some autoimmune diseases are treated with medications that alleviate specific symptoms. For example, people who have Type I diabetes can be given insulin injections. Other autoimmune diseases are treated with medications that suppress the immune response. However, these medications also affect the normal immune response against pathogens, so this type of therapy is not used often or is carefully monitored. As researchers find out more about autoimmune diseases, they hope to develop more effective treatments.

AIDS, an Immunodeficiency Disease

Another type of immune system disorder is immunodeficiency disease. In one type of immunodeficiency disease, the immune system fails to develop normally. A second type of immunodeficiency disease is AIDS. AIDS results from a viral infection that destroys helper T cells. As the number of helper T cells declines, the normal immune response breaks down.

During the late 1970s, some physicians in Europe and the United States were bewildered. Some of their patients were dying from infections produced by benign microorganisms that didn't normally cause disease. Previously healthy people began to suffer from unusual illnesses such as *Pneumocystis carinii* (a kind of pneumonia), Kaposi's sarcoma (a rare form of skin cancer), and severe fungal infections of the mouth and throat. Normally, such infections are prevented by the immune system. Individual doctors realized that the symptoms were a signal that the immune systems of their patients had been weakened.

Some doctors recognized that these illnesses were actually symptoms of a new disease. Doctors in Los Angeles suggested the name AIDS—for acquired immune deficiency syndrome. As more cases appeared, researchers realized that this "syndrome" was actually an infectious disease caused by a pathogen that was unknown to the scientific community.

The Virus That Causes AIDS In 1983, researchers identified the cause of AIDS—a virus that they named HIV for human immunodeficiency virus. HIV is a retrovirus—a virus that carries its genetic information in RNA, rather than DNA. HIV turned out to be a deadly and efficient virus for two reasons. First, HIV evades the defenses of the immune system. Second, HIV attacks key cells in the immune system, destroying the body's defenses and leaving the body with no protection against other pathogens.

Among HIV's main targets are the helper T cells. When the HIV virus attacks a helper T cell, it attaches to receptor molecules on the cell membrane. This allows the virus to enter the cell, as shown in **Figure 40-14**. Once the viral core is inside the cell, it forces the host cell to make DNA copies of the virus's RNA. Some of those copies insert themselves into host cell DNA and stay there permanently. Other copies remain in the cytoplasm. The viral DNA may remain inactive in the host cell for varying periods of time. When activated, it directs the production of viral RNA and proteins that are assembled into new virus particles. These viruses eventually leave the infected cell and infect new cells. The immune system produces antibodies for HIV. Unfortunately, these antibodies are not effective in stopping the progression of the disease.

Despite the production of antibodies, HIV destroys ever-increasing numbers of T cells, crippling the immune system. By counting the number of the helper T cells, the progression of HIV infection can be monitored. The fewer helper T cells, the more advanced the disease.

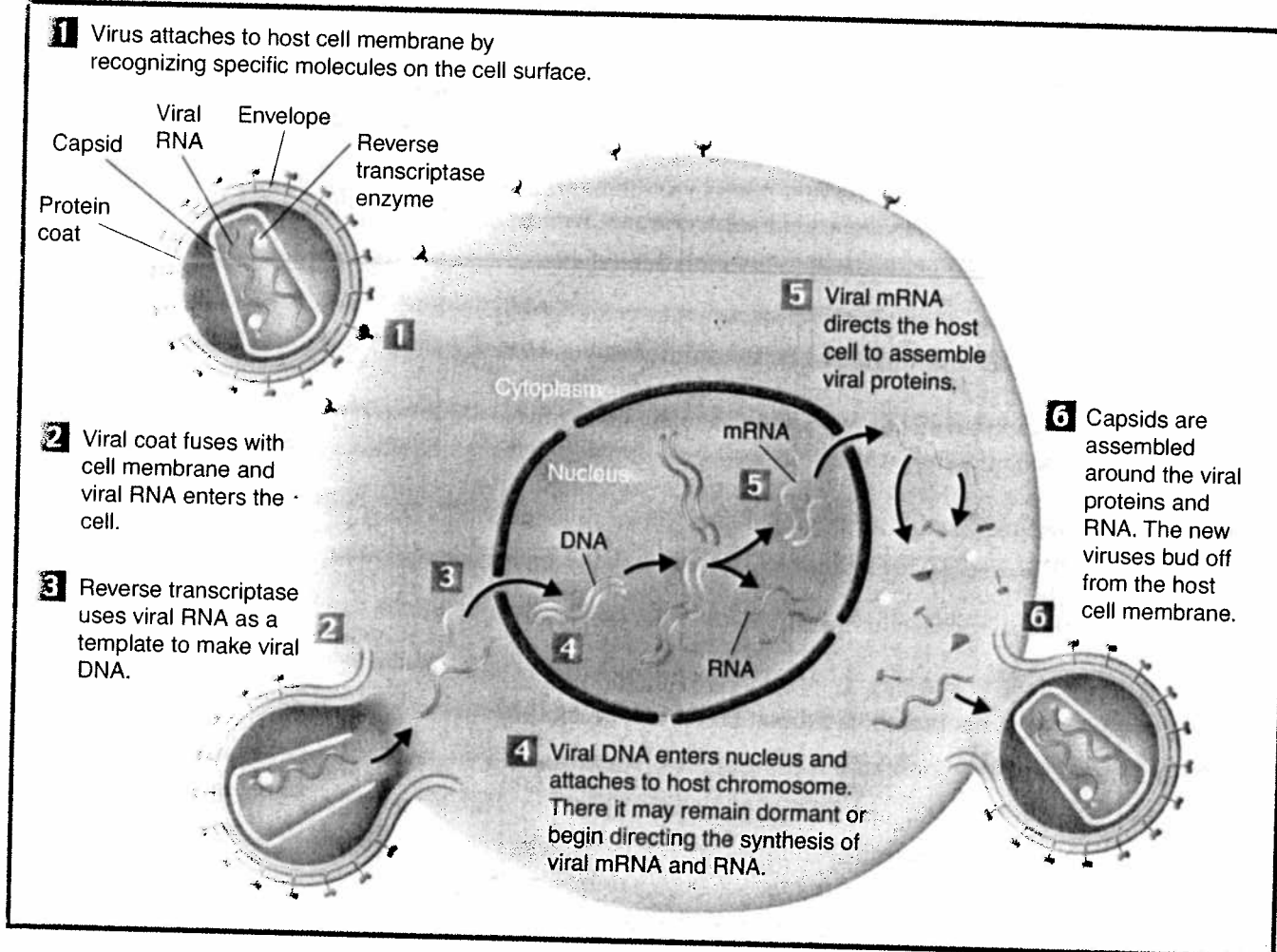


(magnification: about 5000 \times)

▲ Figure 40-14 HIV is an example of a retrovirus, which contains RNA as its genetic material. Retroviruses get their name because their genetic information is first copied backward from RNA to DNA. **Interpreting Graphics** In the micrograph, what type of blood cell are the red HIV particles attacking?

FIGURE 40-15 HIV Infection

HIV travels through the bloodstream, where it binds to receptors on helper T cells. Once inside the cell, the virus directs the cell to produce many new viruses. These new viruses are quickly released back into the bloodstream, where they travel to new cells and destroy them.




As the number of helper T cells decreases, the body becomes more and more susceptible to other diseases. The diseases that attack a person with a weakened immune system are called opportunistic diseases.

Transmission of HIV Although HIV is a deadly disease, it is not easily transmitted. It is not transmitted through casual contact. HIV can only be transmitted through the exchange of blood, semen, vaginal secretions, or breast milk.

There are four main ways that HIV can be transmitted:

- through any form of sexual intercourse with an infected person;
- through shared needles or syringes that are contaminated with the blood of an infected person;
- through contact with blood or blood products of an infected person; and
- from an infected mother to child, either during pregnancy, during birth, or during breast-feeding.

Preventing HIV Infection Fortunately you can choose behaviors that will help you reduce your risk of becoming infected with HIV.  **The only no-risk behavior with respect to HIV and AIDS is abstinence.** Within a committed sexual relationship such as marriage, sexual fidelity between two uninfected partners presents the least risk of becoming infected with HIV.

Avoiding drug use is also important for reducing the risk of HIV infection. People who share contaminated needles to inject themselves with drugs are at a high risk for contracting HIV. People who have sex with drug abusers are also at high risk.



Before 1985, HIV was transmitted to some hemophiliacs and surgical patients through transfusions of infected blood or blood products. Such cases have been nearly eliminated by screening the blood supply for HIV antibodies and by discouraging potentially infected individuals from donating blood.

Can AIDS Be Cured? At present, there is no cure for AIDS. However, progress has been made in developing drugs that make it possible to survive HIV infection for years. Unfortunately, HIV mutates and evolves very rapidly. For this reason, the virus has been able to evolve into many different strains that are resistant to virtually all drugs used against them. Because HIV evolves so rapidly, no one has developed a vaccine that offers protection for any length of time.

At present, the only way to control the virus is to use expensive multidrug and multivitamin “cocktails” that fight the virus in several ways. Thanks to these drugs, more HIV-infected people are now living with HIV rather than dying from it.

Unfortunately, the knowledge that HIV can be treated (though not cured) has given people the idea that HIV infection is not as serious as it was a decade ago. In one year, more than 5 million people around the world became infected with HIV, including roughly 800,000 people under the age of 15. That same year, more than 3 million people around the world died of AIDS, bringing the total number of deaths worldwide to more than 20 million people.

40-3 Section Assessment

-  **Key Concept** What happens in an autoimmune disease?
-  **Key Concept** Describe the various ways HIV is transmitted from person to person.
- What are the two main types of immune system disorders?
- Why is it difficult for a person with HIV to fight off infections?
- Critical Thinking Applying Concepts** In treating asthma, the first thing many physicians do is ask patients to list times and places they have experienced asthmatic reactions. Why do you think doctors do this?

Focus on the BIG Idea

Structure and Function

Compare the process of HIV replication with that of other viruses. You may wish to review **Figure 40-14** as well as Chapter 19.



Slowing a Worldwide Epidemic

AIDS is a threat on every continent in the world, but nowhere has its effect been more devastating than in Africa. Thirty million of the world's 42 million people infected with HIV live in Africa. In some African countries, the HIV-infection rate is as high as one in three people. Leaders from around the world disagree on how the AIDS epidemic should be handled. Some argue that generic drugs should be made available. Others argue that the focus should be on AIDS prevention and education. Still others think that some money needs to be spent on the millions of AIDS orphans.

The Viewpoints

Make Drugs More Affordable

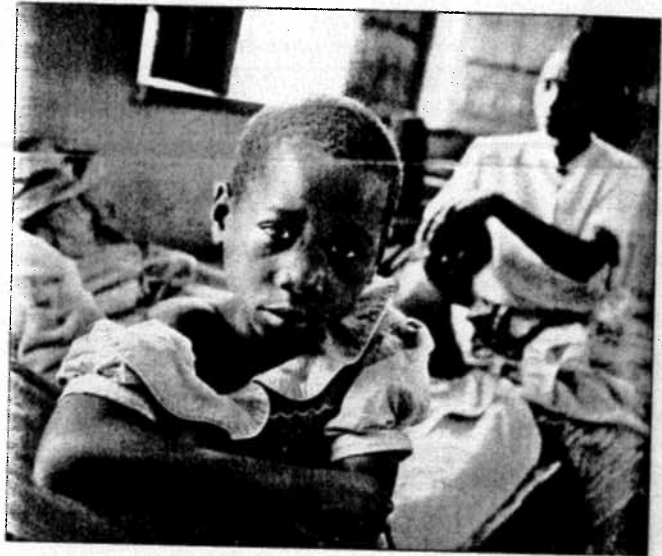
AIDS workers in Africa believe that more affordable drugs should be the top priority. HIV-infected people in Africa do not have access to the advanced medicines that people have in the United States. In Africa, the use of antiviral drugs is not common. Although the antiviral drugs do not cure AIDS, they help prolong life as long as they are taken on a regular basis. To increase access to these drugs, activists are looking for generic drugs, which would be lower in cost. Large pharmaceutical companies, however, don't like this idea because they say that generic drugs violate the companies' patents on such antiviral drugs.

Spend Money for Prevention

Many people in HIV-infected populations do not have basic knowledge about AIDS, including how HIV is spread. Thus, what is needed is an intensive program of public health education to stop the spread of the virus. If prevention programs including education and counseling were available, the incidence of new HIV infections could be reduced.

Spend Money on AIDS Orphans

More than 11 million children have lost parents to AIDS. Orphanages are overflowing with children who have no one to look after them. It is expected in Ethiopia—the country with the fastest-growing



HIV-infection rate—that the number of orphans could increase about 150 percent over the next ten years. Because of this growing problem, a number of people feel that some of the money used to fight AIDS should be given to care for these orphans.

Research and Decide

- 1. Analyzing the Viewpoints** To make an informed decision, learn more about this issue by consulting library or Internet resources. Then, list the key arguments for each of the viewpoints.
- 2. Forming Your Opinion** Given limited resources to fight HIV, how would you decide the allocation of those resources? Would you spend all of the money on one area, or would you split it up among the different areas? What are the reasons for your decision?

Go  Online

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40-4 The Environment and Your Health

Staying healthy involves more than the battles against pathogens. You interact constantly with both living and nonliving parts of your environment. Aspects of your environment that are important to health include the buildings in which you live, the people with whom you share those spaces, the air you breathe, the water you drink, and the food you eat.

Factors that have the potential to affect health in a negative way are called risk factors. A **risk factor** is anything that increases the chance of disease or injury. Both heredity (the genes you carry) and environmental factors can affect your health.  **Environmental factors that can affect your health include air and water quality, poisonous wastes in landfills, and exposure to solar radiation.**

Air Quality

The air you breathe comes into very close contact with your delicate lung tissue and blood. It shouldn't be surprising, therefore, that the quality of the air is very important to your health. But what is meant by "air quality"? Air quality refers to the number and concentrations of various gases present, as well as the nature and amount of tiny particles suspended in the air. Gases that are important to air quality include carbon monoxide and ozone. Particles in the air include dust, pollen, or particulates produced by cars and trucks or the burning of coal. If the concentration of these impurities gets too high, they can become risk factors for various health problems.

Carbon Monoxide Carbon monoxide (CO) is an odorless gas produced when certain compounds are burned. Carbon monoxide is found in automobile exhaust and cigarette smoke. Carbon monoxide also can be produced by the furnace of a heating system or by space heaters that burn fuel.

Recall that hemoglobin in red blood cells usually helps carry oxygen to the cells of your body. If you inhale carbon monoxide, that gas binds to hemoglobin, preventing it from carrying oxygen. As a result, the body does not receive the oxygen it needs. Overexposure to carbon monoxide can be fatal.

Ozone Ozone (O₃), a highly reactive form of oxygen, is another gas found in the air that is a potential risk factor when it occurs at ground level. Ozone is produced by vehicle exhaust and factory emissions. When the air is stagnant, ozone accumulates. When ozone levels are high, you should limit your time outdoors as much as possible, especially if you have a respiratory condition such as asthma, bronchitis, or emphysema.

Guide for Reading



Key Concepts


- What environmental factors affect your health?
- How can you maintain your health?

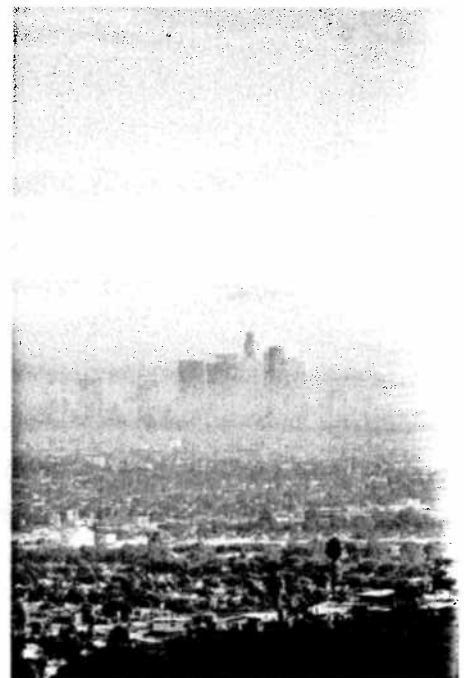
Vocabulary

risk factor
tumor
carcinogen

Reading Strategy:

Hypothesizing Before you read, hypothesize about how the environment can affect your health. As you read, list evidence that supports or rejects your hypothesis.

▼ **Figure 40-16**  **Poor air quality can affect your health.** Smog is a mixture of chemicals that appears in the atmosphere as a gray-brown haze. Smog is particularly dangerous for people with respiratory conditions.



Airborne Particulates Airborne particulates of many different kinds can also be risk factors. Tiny dust mites, pollen, mold spores, and animal dander can trigger allergic reactions that can lead to respiratory problems or make existing health problems worse. Some potential sources of airborne particulates that can be found indoors are shown in **Figure 40-17**.

Another type of particulate that can cause serious harm is the metal lead. Lead can poison the liver, kidneys, and nervous system. Lead poisoning in babies and young children can also result in slow mental development.

Lead became a serious problem because for many years it was added to gasoline to improve the performance of engines. When that gas was burned, tiny particulates of lead were released into the air. People inhaled lead particulates as they breathed. Many more lead particulates were washed into rivers and streams. When research revealed the health problems that resulted, leaded gasoline was phased out and replaced with unleaded gasoline. Within a few years, levels of lead in surface waters dropped dramatically.

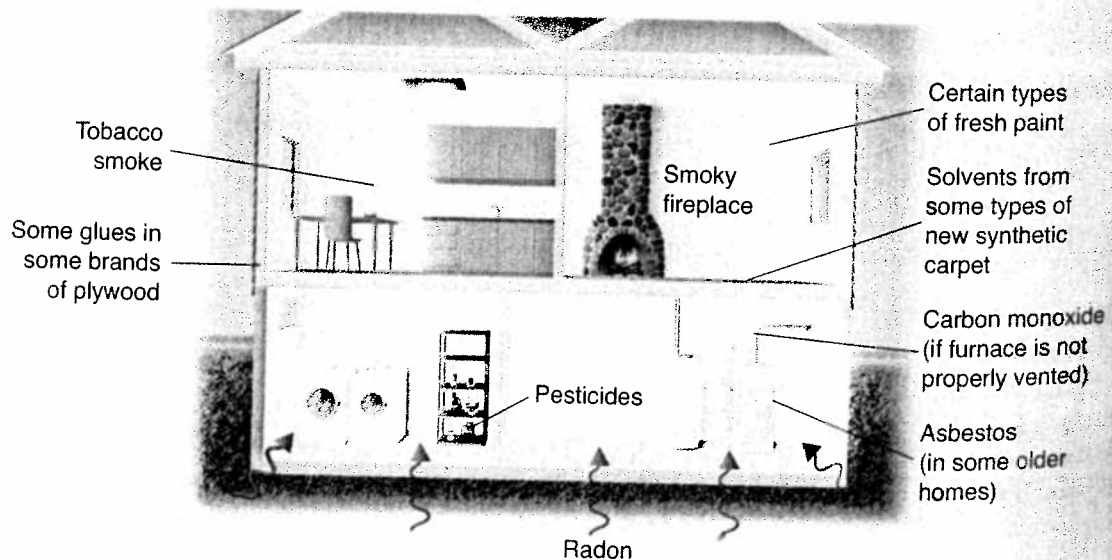
Another particulate that can be carried in air is asbestos, which was commonly used for insulation. Asbestos can fragment into tiny fibers that are small enough to remain suspended in air for some time. When inhaled repeatedly, asbestos fibers can cause lung cancer.

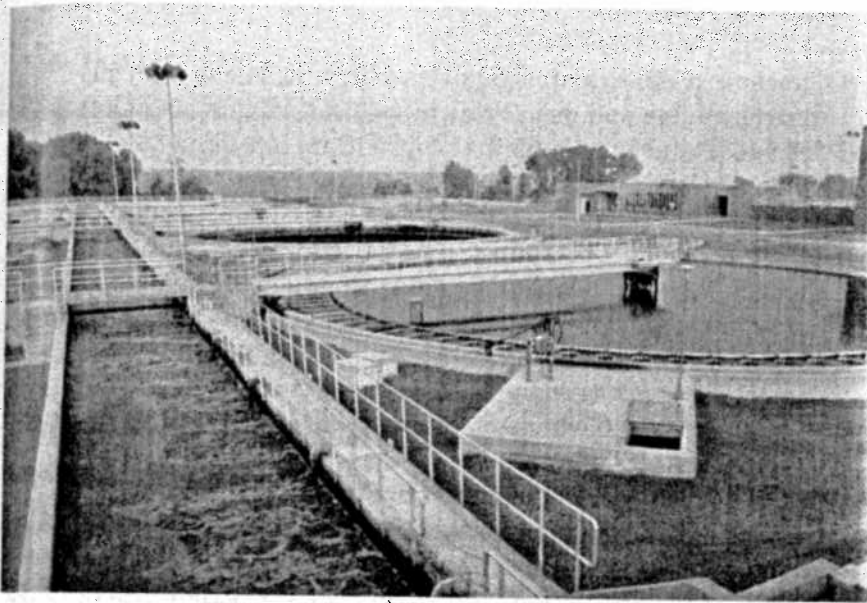
Water Quality

Water, like air, can carry biological and chemical pollution. Biological pollutants in water, such as human and animal wastes, can contain bacteria or viruses that can cause cramps, vomiting, diarrhea, or diseases such as hepatitis or cholera.

Some chemical pollutants can cause organ damage. Others interfere with the development of organs and tissues, causing birth defects. Still others can damage DNA, causing normal cells to become cancerous.

▼ **Figure 40-17** Air pollution can occur indoors as well as outdoors. Indoor air pollutants include fumes and vapors given off by carpets, paints, and household cleaning products.





◀ **Figure 40–18** Many cities and towns have sewage-treatment plants that process household waste water. In huge outdoor tanks, water is treated with chemicals and microorganisms and then aerated.

Applying Concepts *What is the role of microorganisms in treating waste water?*

Fortunately, regulations requiring proper treatment of residential and industrial sewage, for example, have led to significant decreases in the amount of sewage-related bacteria in drinking-water supplies across the nation. In the United States, for example, public water systems supply clean, safe drinking water to cities and many towns. Providing safe drinking water has probably been the single most important factor in nearly doubling human life expectancy over the last century or so.

Bioterrorism

In recent years, bioterrorism has become a new health threat. Bioterrorism is the intentional use of biological agents to disable or kill individuals. Bioterrorism can involve the intentional release of infectious agents—viruses (such as smallpox) or bacteria (such as anthrax)—or the spread of toxic compounds (such as botulinus toxin) extracted from living organisms.

Some forms of bioterrorism pose risks in part because research and public health measures have been so successful in the past. For example, worldwide vaccination programs eliminated smallpox around the world years ago. As a result, almost no one has been vaccinated against the virus for decades. Thus, the release of smallpox virus could cause serious problems.

Other forms of bioterrorism involve treating pathogens to maximize their ability to infect and cause disease. Anthrax is a disease that is common in cattle-ranching areas, but it is usually present in a form that either is not easily transmitted or is not life-threatening. The spores of anthrax bacteria, however, can be treated to make them light and fine enough to be spread through the air and inhaled—which produces a possibly fatal infection. Medical, research, and military establishments are still in the process of performing research and evaluating the best ways to minimize the risks of bioterrorism.

Go Online

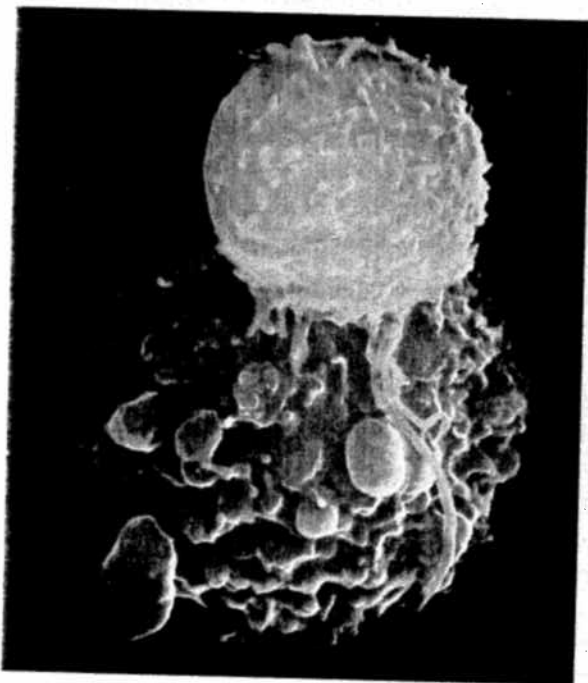
NSTA SciLINKS

For: Links on cancer cells

Visit: www.SciLinks.org

Web Code: cbn-0404

▼ **Figure 40-19** The body recognizes cancer cells as foreign and tries to destroy them. In this color-enhanced SEM, a killer T cell (orange) is attacking a cancer cell (purple).



(magnification: about 3000×)

Cancer

Cancer is a life-threatening disease in which cells multiply uncontrollably and destroy healthy tissue. Cancer is a unique disease because the cells that cause it are not foreign cells but rather the body's own cells. This fact has made cancer difficult to treat and to understand.

All forms of cancer are ultimately caused by harmful mutations in genes that control cell growth and development. Sometimes, cancer arises almost entirely because some factor in the environment damages DNA. An increased likelihood of developing some cancers can be inherited.

Cancers begin when something goes wrong with the controls that normally regulate cell growth and reproduction. A single cell or a group of cells begin to grow and divide uncontrollably, often resulting in the formation of a mass of growing tissue known as a **tumor**. However, not all tumors are cancerous. Some tumors are benign, or noncancerous. A benign tumor does not spread to surrounding healthy tissue or to other parts of the body. Cancerous tumors, on the other hand, are malignant, which means that they can invade and destroy surrounding healthy tissue.

As the cancer cells spread, they absorb the nutrients needed by other cells, block nerve connections, and prevent the organs they invade from functioning properly. Soon, the delicate balances that exist in the body are disrupted, and life-threatening illness results.

Causes of Cancer Cancers are caused by defects in the genes that regulate cell growth and division. There are several sources of such defects. They may be inherited, be caused by viruses, or may result from mutations in DNA that occur spontaneously or are produced by chemicals or radiation.

Chemical compounds cause cancer by triggering mutations in the DNA of normal cells. Chemical compounds that are known to cause cancer are called **carcinogens**. Some carcinogens are produced in nature. One of these, aflatoxin, is produced by molds that grow on peanuts. Others, such as chloroform and benzene, are synthetic compounds. Some of the most powerful chemical carcinogens are found in tobacco smoke. In the United States, cigarette smoking is responsible for nearly half the cancers that occur.

Most forms of radiation—including sunlight, X-rays, and nuclear radiation—cause cancer by producing mutations in DNA. If mutations occur in genes that control cell growth, a normal cell may be transformed into a cancer cell. Most cases of skin cancer, for example, are caused by the ultraviolet radiation in sunlight. For this reason, it is important to avoid prolonged exposure to the sun.

Analyzing Data



6HE 7.c, 7IIIE 7.c

Cancer Mortality

Cancer is a disease that is easier to treat if it is detected early. There are also things you can do to decrease your risk of cancer, such as eating a diet high in fruits, vegetables, and fiber; staying out of the sun; and not smoking. The data in the table show the 5-year mortality rates of five different types of cancer since 1950. Use the data to answer the questions.

- Using Tables and Graphs** Construct a line graph of the data in the table.
- Using Tables and Graphs** Which type of cancer has shown the greatest increase in mortality rate?
- Inferring** What can you infer about the use of tobacco in men over the last 50 years? In women?
- Predicting** Given the trend in melanoma cancer deaths over the past 50 years, predict the incidence in 1995–1998 in both men and women.
- Inferring** Why do you think the incidence of death from breast cancer has stayed relatively stable over the last 50 years?

Cancer Mortality Rates (per 100,000 people)

Year	Lung		Colon		Melanoma		Breast	Prostate
	Male	Female	Male	Female	Male	Female	Female	Male
1950–54	25.51	4.98	16.94	18.49	1.20	0.92	26.42	20.85
1960–64	42.15	6.39	17.86	17.48	1.67	1.19	26.22	19.78
1970–74	60.79	12.80	19.49	16.43	2.18	1.40	26.92	20.05
1980–84	71.30	23.33	21.22	15.52	2.95	1.64	26.90	21.29
1990–94	71.71	33.43	18.79	12.85	3.49	1.69	26.19	24.37
1995–98	68.00	34.30	20.50	14.10	?	?	24.20	23.70

Radon is another source of radiation. Radon is a radioactive gas that is found naturally in some rocks and that sometimes leaks into the foundations of buildings. If your home is located in an area where radon is present, it can be tested for the presence of radon.

Treating Cancer As with other diseases, prevention is the best defense. The best way to fight cancer is by protecting your DNA from agents that cause cancer. For example, you can dramatically reduce your risk of developing lung cancer by not smoking. In addition, regular exercise and a balanced diet with plenty of fruits and vegetables can help to lower your cancer risk.

Physicians also stress that if a cancer is detected early the chances of treating it successfully may be as high as 90 percent. Regular checkups and tests are an important preventive measure. Recommended tests depend on a person's age, gender, and family history. Self-examinations for skin, breast, or testicular cancer are also helpful when combined with regular checkups. Your doctor can give you instructions for performing these self-examinations.



▲ **Figure 40–20** 🐾 Getting regular exercise is one way to maintain your health. You should try to get a minimum of 30 minutes of aerobic exercise each day.

Maintaining Health

To keep your immune system working efficiently, you can practice behaviors that reduce your exposure to pathogens and maintain overall good health. 🐾 **Healthful behaviors include eating a healthful diet, getting plenty of exercise and rest, abstaining from harmful activities, and having regular checkups.**

Healthful Diet Food provides the nutrients and energy your cells need to function properly. To help all your body systems work at their best, it is important to eat a balanced diet that provides essential nutrients. Eating foods that are low in saturated fat and cholesterol may help prevent obesity. Eating plenty of fruits, vegetables, and whole grains will also help protect you from certain cancers, especially colon and rectal cancers.

Exercise and Rest Regular exercise helps move blood throughout the body and maintains cardiovascular fitness. Exercise also helps maintain an appropriate body weight, which helps prevent certain kinds of heart disease. Adequate rest is important for keeping your body functioning well. For most people, adequate rest means getting about eight hours of sleep each night.

Abstaining From Harmful Activities Drugs, including alcohol and tobacco products, can have harmful effects on the body. Many types of drugs, including alcohol, can slow or suppress the immune system. Smoking and tobacco products also cause a variety of respiratory conditions as well as certain cancers, including cancers of the lung, mouth, and throat.

Some diseases can be spread through sexual contact with an infected person. These sexually transmitted diseases (STDs) include HIV, chlamydia, and gonorrhea. The only way to absolutely prevent exposure to sexually transmitted diseases is to abstain from all sexual activity.

Regular Checkups It usually is easier to treat a disease if it is discovered early. You can perform regular self-examinations for skin cancer, breast cancer, and testicular cancer. By getting regular checkups, you can help maintain your health.

40–4 Section Assessment

1. 🐾 **Key Concept** Describe the environmental factors that affect your health.
2. 🐾 **Key Concept** Name three things you can do to maintain your health.
3. List some of the causes of cancer.
4. Why are regular medical checkups and self-examinations important?
5. **Critical Thinking Classifying** Should cancer be considered an infectious disease? Explain your answer.

Focus on the BIG Idea

Cellular Basis of Life Recall the cell cycle from Section 10–2. In which phase do you think cells would be most vulnerable to damage from radiation? Explain your choice. What characteristic of cancer cells might make them especially vulnerable?



Testing the Specificity of Antibodies

Antibodies are very selective. They will bind only to specific antigens. An antibody that binds strongly to a certain protein or carbohydrate may not bind at all to another molecule that has a very similar structure. In this investigation, you will determine the specificity of an antibody.

Problem How specific is the binding of antibodies to antigens?

Materials

- Strep A diagnostic kits with control samples (materials for three tests)
- sterile water

Skills Predicting, Evaluating, Drawing Conclusions

Procedure



- 1 Make a copy of the data table shown. To see how the antibody-based Strep A diagnostic kit reacts to an antigen found in the cell wall of *Streptococcus* group A (the bacterium that causes the infection known as “strep throat”), follow the instructions in the kit to test the positive control sample. Record the result of this test.
- 2 **Predicting** *Streptococcus* group C is closely related to *Streptococcus* group A but does not cause disease. Record your prediction of how the diagnostic kit will react to antigens from the cell wall of *Streptococcus* group C.
- 3 Test the *Streptococcus* group C sample as you did the *Streptococcus* group A sample in step 1. Record the result of this test.
- 4 **Predicting** Record your prediction of whether *Streptococcus* group A is present on the tabletops in your lab.
- 5 Use sterile water to moisten the tip of one of the test swabs supplied with your diagnostic kit and rub it on the tabletop. Then, test the sample on the swab and record your results.



- 6 Wash your hands with soap and warm water before leaving the classroom.

Analyze and Conclude

1. **Observing** Did the antibody-based test react to the antigen of *Streptococcus* group A? To the antigen of group C?
2. **Analyzing Data** Did your results support the idea that an antibody can be used to distinguish between two similar antigens, such as those of *Streptococcus* group A and group C?
3. **Evaluating** Assess the quality and appropriateness of the data from steps 1 through 3 by stating whether the results enable you to answer the Problem question. Did your data enable you to determine whether *Streptococcus* group A was present on the tabletop? Explain your reasoning.
4. **Drawing Conclusions** Use what you have learned about the specificity of antibodies to explain what happens in autoimmune diseases such as multiple sclerosis.

Data Table

Sample	Result (Positive or Negative)
<i>Streptococcus</i> Group A	
<i>Streptococcus</i> Group C	
Tabletop Swab	

Go Further

Interviewing a Professional Interview a health professional to find out how antibody-based tests are used to determine blood types and to diagnose diseases.

40-1 Infectious Disease

Key Concepts

BI 10.d

- Some diseases are produced by pathogens. Others are caused by materials in the environment. Still others are inherited.
- Some infectious diseases are spread from one person to another through coughing, sneezing, or physical contact. Other infectious diseases are spread through contaminated water or food. Still others are spread by infected animals.

Vocabulary

disease, p. 1031 • pathogen, p. 1031
germ theory of disease, p. 1031
Koch's postulates, p. 1032
vector, p. 1034 • antibiotic, p. 1035

40-2 The Immune System

Key Concepts

BI 10.a, BI 10.b,
BI 10.c, *BI 10.f

- The function of the immune system is to fight infection through the activation of specific defenses.
- Your body's most important nonspecific defense is the skin.
- The inflammatory response is a nonspecific defense reaction to tissue damage caused by injury or infection.

Vocabulary

immunity, p. 1036
inflammatory response, p. 1037 • fever, p. 1037
interferon, p. 1038 • immune response, p. 1038
antigen, p. 1038 • humoral immunity, p. 1038
cell-mediated immunity, p. 1038
antibody, p. 1038 • vaccination, p. 1041
active immunity, p. 1042
passive immunity, p. 1042

40-3 Immune System Disorders

Key Concepts

BI 10.e

- When the immune system makes a mistake and attacks the body's own cells, it produces an autoimmune disease.
- The only no-risk behavior with respect to HIV and AIDS is abstinence.

Vocabulary

allergy, p. 1043 • histamine, p. 1043
asthma, p. 1044

40-4 The Environment and Your Health

Key Concepts

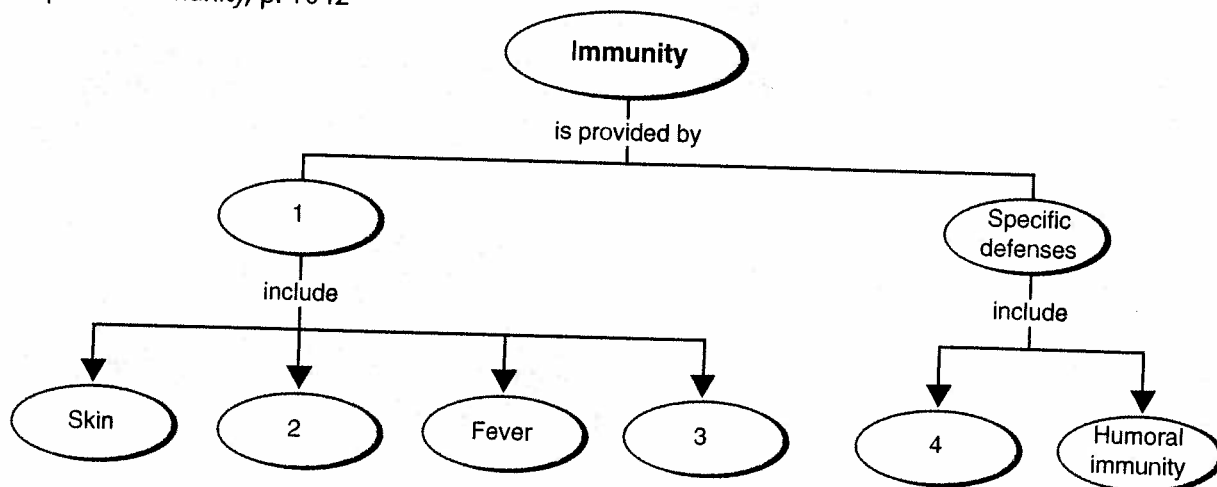
- Environmental factors that can affect your health include air and water quality, poisonous wastes in landfills, and exposure to solar radiation.
- Healthful behaviors include eating a healthful diet, getting plenty of exercise and rest, abstaining from harmful activities, and having regular checkups.

Vocabulary

risk factor, p. 1049
tumor, p. 1052
carcinogen, p. 1052

Thinking Visually

Using the information in this chapter, complete the following concept map:

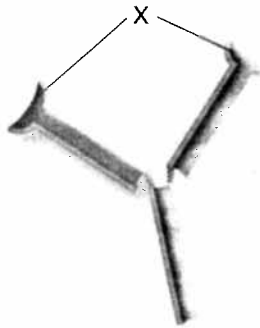


Chapter 40 Assessment

Reviewing Content

Choose the letter that best answers the question or completes the statement.

- Any change, other than an injury, that disrupts the normal functions of a person's body is a
 - disease.
 - pathogen.
 - toxin.
 - vector.
- Disease-causing agents such as viruses, bacteria, and fungi are known as
 - antibodies.
 - antigens.
 - pathogens.
 - toxins.
- The germ theory of disease was established by
 - Steere.
 - Koch.
 - Hooke.
 - Salk.
- The body's most important nonspecific defense against pathogens is
 - tears.
 - mucus.
 - saliva.
 - skin.
- A nonspecific defense reaction to tissue damage caused by injury or infection is known as
 - the inflammatory response.
 - active immunity.
 - cell-mediated immunity.
 - passive immunity.
- The swelling and pain associated with inflammation are caused by the
 - secretion of antibodies.
 - expansion of local blood vessels.
 - secretion of antigens.
 - destruction of bacteria by white blood cells.
- A protein that helps other cells resist viral infection is
 - interferon.
 - penicillin.
 - prednisone.
 - histamine.
- In the illustration below, label X is pointing to the



- antigen-binding sites.
- antigens.
- antibodies.
- interferons.

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- A substance that triggers an immune response is a(an)
 - antibody.
 - antigen.
 - B cell.
 - pathogen.
- Mast cells release chemicals known as
 - antibodies.
 - antigens.
 - histamines.
 - pathogens.

Understanding Concepts

- What is the germ theory of disease?
- What purpose do Koch's postulates serve?
- List the five types of pathogens that are responsible for the spread of infectious disease. Give an example of a disease that each specific pathogen may cause.
- What are vectors?
- What are some ways by which the spread of disease can be stopped?
- Describe how antibiotics work.
- How might a fever be beneficial to a person who is sick?
- What are antibodies? Describe how they are formed.
- Describe the roles of helper T cells and killer T cells.
- Distinguish between humoral immunity and cell-mediated immunity.
- How did people acquire immunity to a disease before the development of vaccines?
- Describe how passive immunity to a disease is obtained and why it lasts for only a short period of time.
- Explain why allergies are not classified as autoimmune diseases.
- Describe the specific action of HIV that makes the body unable to cope with other infections.
- What is air quality?
- What are three sources of radiation?

Chapter 40 Assessment

Critical Thinking

27. **Inferring** Why is the fourth step of Koch's postulates necessary to prove that a disease is caused by a specific pathogen?
28. **Making Judgments** Edward Jenner developed his smallpox vaccine in 1796. Jenner tested his immunization theory on a young boy. Do you think Jenner was justified in using the child as an experimental test subject? Support your answer.
29. **Interpreting Graphics** The chart below shows the relative 5-year cancer survival rates in the United States. Which type of cancer has the highest survival rate? The lowest? Why do you think the 5-year survival rates increased over the years shown in the chart?

Relative 5-Year Cancer Survival Rates (in %)

Site	1974-76	1983-85	1992-97
All sites	50	52	62
Brain	22	27	32
Breast (female)	75	78	86
Colon	50	58	61
Lung and bronchus	12	14	15
Leukemia	34	41	45
Prostate	67	75	96

30. **Inferring** Many people become alarmed if they have a slight fever. Why might a slight fever be considered beneficial, assuming it lasts for just a few days?
31. **Applying Concepts** The blood of a person with HIV often shows decreasing numbers of helper T cells. How do you explain this decrease?
32. **Problem Solving** Suggest some risks and benefits associated with gaining immunity to a disease by intentionally exposing yourself to it.
33. **Comparing and Contrasting** Compare the roles of B cells and T cells in the immune response.
34. **Applying Concepts** Why is a second bee sting more dangerous than the first for a person who is allergic to bee stings?

35. **Predicting** Bone marrow transplants are a method of treatment being considered for some AIDS patients. How might a bone marrow transplant benefit some AIDS patients? What might be some problems with this treatment?
36. **Applying Concepts** Cancer results from errors in the genetic information that regulates cell division. Explain the connection between cancer and the environment.

Focus on the BIG Idea

Homeostasis Use what you learned about homeostasis in Section 1-3 to explain how the immune system works to maintain homeostasis in the human body. Give a specific example.

Writing in Science

The ability of bacteria to resist antibiotics has become an increasing public health problem. This problem is due to the overuse and misuse of antibiotics. Suppose that one of your friends always takes antibiotics when sick. Write a letter to your friend explaining the problem of antibiotic resistance.

Performance-Based Assessment

Oral Presentation Prepare a radio broadcast in which you explain how a specific infectious disease invades the body. Describe how the body's immune system responds to the infectious disease. Your broadcast must include the following:

- How the pathogen comes in contact with the body.
- A description of the first symptom of the disease and the first defense response of the body.
- A description of further symptoms and immune responses as the disease moves to different sites within the body.
- The final results of the disease conflict.
- Any long-term effects of the disease on the body.

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Test-Taking Tip

When evaluating multiple-choice answers, be sure to read all of the answer choices, even if the first answer choice seems to be the correct one. By doing so, you can make sure that the answer you chose is the best one.

Directions: Choose the letter that best answers the question or completes the statement.

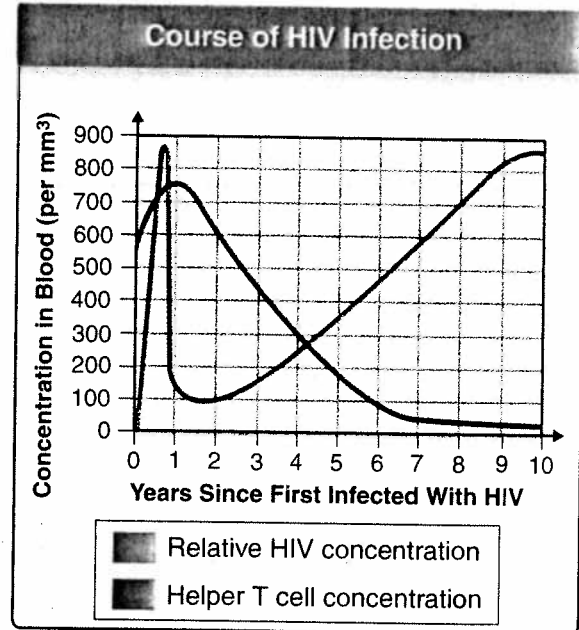
- All of the following prevent pathogens from entering the human body EXCEPT
 - red blood cells.
 - tears.
 - mucus.
 - skin.
- Which of the following is NOT a symptom of the inflammatory response?
 - White blood cells rush to infected tissues.
 - Blood vessels near the wound shrink.
 - Phagocytes engulf and destroy pathogens.
 - The wound becomes swollen.
- What is one effect of a fever?
 - It speeds up the growth of pathogens.
 - It decreases the heart rate.
 - It decreases the rate of chemical reactions.
 - It increases the heart rate.

Questions 4–7 Each of the lettered choices below refers to the following numbered statements. Select the best lettered choice. A choice may be used once, more than once, or not at all.

- Antibody
 - B cells
 - T cells
 - Phagocytes
- White blood cells that produce antibodies
 - White blood cells that activate plasma cells
 - Proteins that bind to surface antigens **BI 10.f**
 - White blood cells that can engulf pathogens ***BI 10.f**

Questions 8–10

A researcher measured the concentrations of HIV and T cells in 120 HIV-infected patients over a period of 10 years. Her data are summarized in the graph.



- Why does the T cell concentration decrease after two years? **BI 10.e**
 - HIV dies off after two years.
 - HIV destroys T cells.
 - T cells produce toxins.
 - An inflammatory response occurs.
- What happened to the HIV concentration over years 2 through 9? **BI 10.e**
 - It stayed about the same, and then suddenly increased.
 - It stayed about the same, and then suddenly decreased.
 - It steadily increased.
 - It steadily decreased.
- What is probably responsible for the change in HIV concentration during the first year? **BI 10.e**
 - immune response
 - inflammatory response
 - passive immunity
 - HIV vaccination