Section 1 Nonspecific Defenses

Objectives

- **Describe** how skin and mucous membranes defend the body. 10A 10B TAKS 2
- **Compare** the inflammatory response with the temperature response. 10A 10B TAKS 2
- **Identify** proteins that kill or inhibit pathogens. 10A 10B TAKS 2
- **Analyze** the roles of white blood cells in combating pathogens. 10A 10B TAKS 2

Key Terms

pathogen
mucous membrane
inflammatory response
histamine
complement system
interferon
neutrophil
macrophage
natural killer cell

Two Lines of Nonspecific Defenses

Some animals, including turtles, clams, and armadillos, defend themselves with their hard armor shells. However, even armor will not protect against the most dangerous enemies that they or the human body faces—harmful bacteria, viruses, fungi, and protists. You, as well as most animals, survive because your body's immune system defends against these pathogens. A **pathogen** is a disease-causing agent. The immune system consists of cells and tissues found throughout the body. The body uses both nonspecific and specific defense mechanisms to detect and destroy pathogens, thereby preventing or reducing the severity of infection. 1

First Line of Nonspecific Defenses

The body's surface defenses are nonspecific, meaning they do not target specific pathogens. Your skin is the first of your immune system's nonspecific defenses against pathogens. Skin acts as a nearly impenetrable barrier to invading pathogens, keeping them outside the body. This barrier is reinforced with chemical weapons. Oil and sweat make the skin's surface acidic, inhibiting the growth of many pathogens. Sweat also contains the enzyme lysozyme, which digests bacterial cell walls. 1 2

Mucous membranes cover some body surfaces that come into contact with pathogens. **Mucous** *(MYOO kuhs)* **membranes** are layers of epithelial tissue that produce a sticky, viscous fluid called mucus. Mucous membranes line the digestive system, nasal passages, lungs, respiratory passages, and the reproductive tract. Like the skin, mucous membranes serve as a barrier to pathogens and produce chemical defenses. Cells lining the bronchi and bronchioles in the respiratory tract secrete a layer of mucus that traps pathogens before they can reach the warm, moist lungs, which are an ideal breeding ground for microorganisms. Cilia on cells of the respiratory tract continually sweep mucus toward the opening of the esophagus. Mucus then can be swallowed, sending pathogens to the stomach, where they are digested by acids and enzymes. 1

Skin and mucous membranes work to prevent any pathogens from entering the body. Occasionally these defenses are penetrated. You take pathogens into your body when you breathe, because many microbes and microbial spores are suspended in the air. Other pathogens may be present in the food you eat. Pathogens can also enter through wounds or open sores. When invaders reach deeper tissue, a second line of nonspecific defenses takes over. 3

Second Line of Nonspecific Defenses

What happens when pathogens break through your body's first line of defense? When the body is invaded, four important nonspecific defenses take action: the inflammatory response; the temperature response; special proteins that kill or inhibit pathogens; and white blood cells, which attack and kill pathogens. 2

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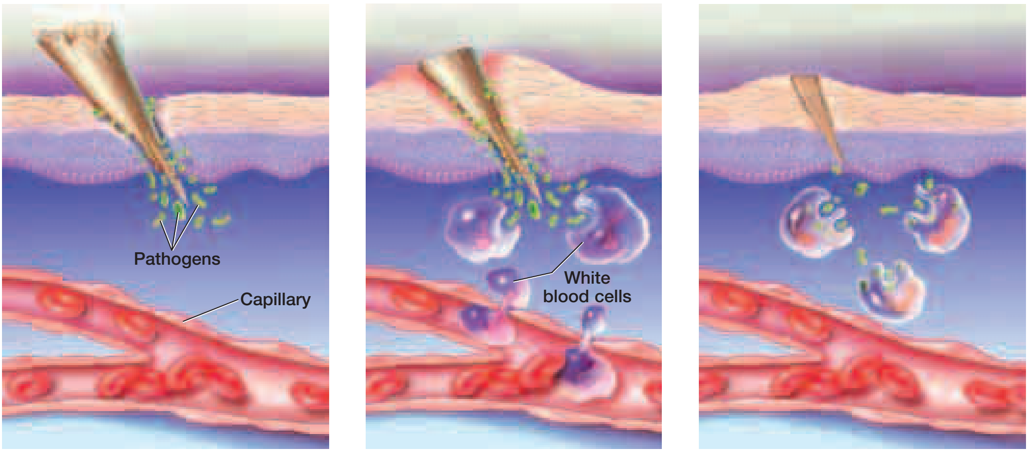
Inflammatory response Injury or local infection, such as a cut or a scrape, causes an inflammatory response. An **inflammatory response** is a series of events that suppress infection and speed recovery. Imagine that a splinter has punctured your finger, creating an entrance for pathogens, as shown in **Figure 1.** Infected or injured cells in your finger release chemicals, including histamine. **Histamine** *(HIHST uh meen)* causes local blood vessels to dilate, increasing blood flow to the area. Increased blood flow brings white blood cells to the infection site, where they can attack pathogens. This also causes swelling and redness in the infected area. The whitish liquid, or pus, associated with some infections contains white blood cells, dead cells, and dead pathogens. 1 2 4

Temperature response When the body begins its fight against pathogens, body temperature increases several degrees above the normal value of about 37°C (98.6°F). This higher temperature is called a fever, and it is a common symptom of illness that shows the body is responding to an infection. Fever is helpful because many disease-causing bacteria do not grow well at high temperatures. Although fever may slow the growth of bacteria, very high fever is dangerous because extreme heat can destroy important cellular proteins. Temperatures greater than 39°C (103°F) are considered dangerous, and those greater than 41°C (105°F) can be fatal. 2 3 4

Figure 1 Inflammatory response

When pathogens penetrate your body, an inflammatory response is triggered.



1. When the skin is punctured, pathogens enter the body.

2. Blood flow to the area increases, causing swelling and redness.

3. White blood cells attack and destroy the pathogens.

Magnification: 2,280×

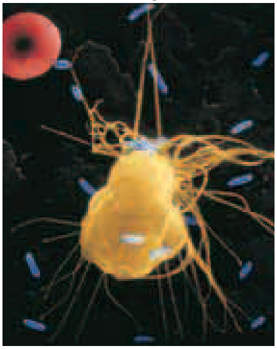


Figure 2 **Macrophage.** Cytoplasmic extensions of this macrophage (yellow) are capturing bacteria (blue).

Magnification: 14,250×

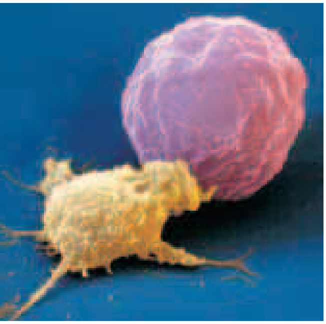


Figure 3 **Natural killer cell.** This natural killer cell (yellow) is attacking a cancer cell (pink).

Proteins Various proteins also provide nonspecific defenses. One defense mechanism, called the **complement system,** consists of about 20 different proteins. Complement proteins circulate in the blood and become active when they encounter certain pathogens. Then some of these proteins form a membrane attack complex (MAC), a ring-shaped structure. The MAC punches a hole in the cell membrane, causing the cell to leak and die. Another nonspecific defense is **interferon** *(in tuhr FEER ahn),* a protein released by cells infected with viruses. Interferon causes nearby cells to produce an enzyme that prevents viruses from making proteins and RNA. 1 2

White blood cells The most important counterattacks in the second line of nonspecific defenses are carried out by three kinds of white blood cells: neutrophils, macrophages, and natural killer cells. These cells patrol the bloodstream, wait within the tissues for pathogens, and then attack the pathogens. Each kind of cell uses a different mechanism to kill pathogens. 2

1. **Neutrophils.** A **neutrophil** *(NOO truh fihl)* is a white blood cell that engulfs and destroys pathogens. The most abundant type of white blood cell, neutrophils engulf bacteria and then release chemicals that kill the bacteria—and themselves. Neutrophils can also squeeze between cells in the walls of capillaries to attack pathogens at the site of an infection.
2. **Macrophages.** White blood cells called **macrophages** *(MA kroh fay jez),* shown in **Figure 2,** ingest and kill pathogens they encounter. They also clear dead cells and other debris from the body. Most macrophages travel through the body in blood, lymph, and fluid between cells. Macrophages are concentrated in particular organs, especially the spleen and lungs.
3. **Natural killer cells.** A **natural killer cell** is a large white blood cell that attacks cells infected with pathogens. Natural killer cells destroy an infected cell by puncturing its cell membrane. Water then rushes into the infected cell, causing the cell to swell and burst. One of the body's best defenses against cancer, natural killer cells can detect and kill cancer cells, as shown in **Figure 3,** before a tumor can develop. 1 2 3

Section 1 Review

1. **Describe** how the inflammatory and temperature responses help defend against infection. 10A 10B
2. **Identify** the role of white blood cells in the second line of nonspecific defenses. 10A 10B
3. **Critical Thinking** **Relating Concepts** Explain why taking a drug that reduces fever might delay rather than speed up your recovery from an infection. 10A 10B
4. **TAKS Test Prep** In the inflammatory response, local blood vessels dilate when infected or injured cells release 10A
   A interferon.
   B histamine.
   C mucus.
   D complement proteins.

Specific Defenses

What happens when pathogens occasionally overwhelm your body's nonspecific defenses? Pathogens that have survived the first and second lines of nonspecific defenses still face a third line of specific defenses—the immune response. The immune response consists of an army of individual cells that rush throughout the body to combat specific invading pathogens. The immune response is not localized in the body, nor is it controlled by a single organ. It is more difficult to evade than the nonspecific defenses. 1

Cells Involved in the Immune Response

White blood cells are produced in bone marrow and circulate in blood and lymph. Of the 100 trillion or so cells in your body, about 2 trillion are white blood cells. Four main kinds of white blood cells participate in the immune response: macrophages, cytotoxic T cells, B cells, and helper T cells. Each kind of cell has a different function. Macrophages consume pathogens and infected cells. **Cytotoxic** *(sie toh TAHKS ihk)* **T cells** attack and kill infected cells. **B cells** label invaders for later destruction by macrophages. **Helper T cells** activate both cytotoxic T cells and B cells. Macrophages can attack any pathogen. B cells and T cells, however, respond only to pathogens for which they have a genetically programmed match. These four kinds of white blood cells interact to remove pathogens from the body. 1 3

Objectives

- **List** four kinds of immune-system cells, and describe their functions. 10A TAKS 2
- **Describe** how white blood cells recognize pathogens. 10A 10B TAKS 2
- **Identify** the role of helper T cells in the immune response. 10A TAKS 2
- **Compare** the role of T cells with that of B cells in the immune response. 10A TAKS 2

Key Terms

cytotoxic T cell
B cell
helper T cell
antigen
plasma cell
antibody

Recognizing Invaders

To understand how the third line of defenses works, imagine that you have just come down with influenza—the flu. You have inhaled influenza virus particles, but they were not all trapped by mucus in the respiratory tract. The virus has begun to infect and kill your cells. At this point, macrophages begin to engulf and destroy the virus.

An infected body cell will display antigens of an invader on its surface. An **antigen** *(AN tih jihn)* is a substance that triggers an immune response. Antigens typically include proteins and other parts of viruses or pathogen cells. Antigens are present on the surface of the infected body cell. White blood cells of the immune system are covered with receptor proteins that respond to infection by binding to specific antigens on the surfaces of the infecting microbes. These receptors recognize and bind to antigens that match their particular shape, as shown in **Figure 4.** 2

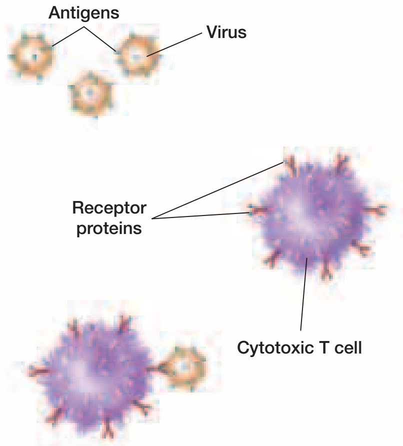


Figure 4 Antigens. Some cells of the immune system have receptor proteins that bind to specific antigens.

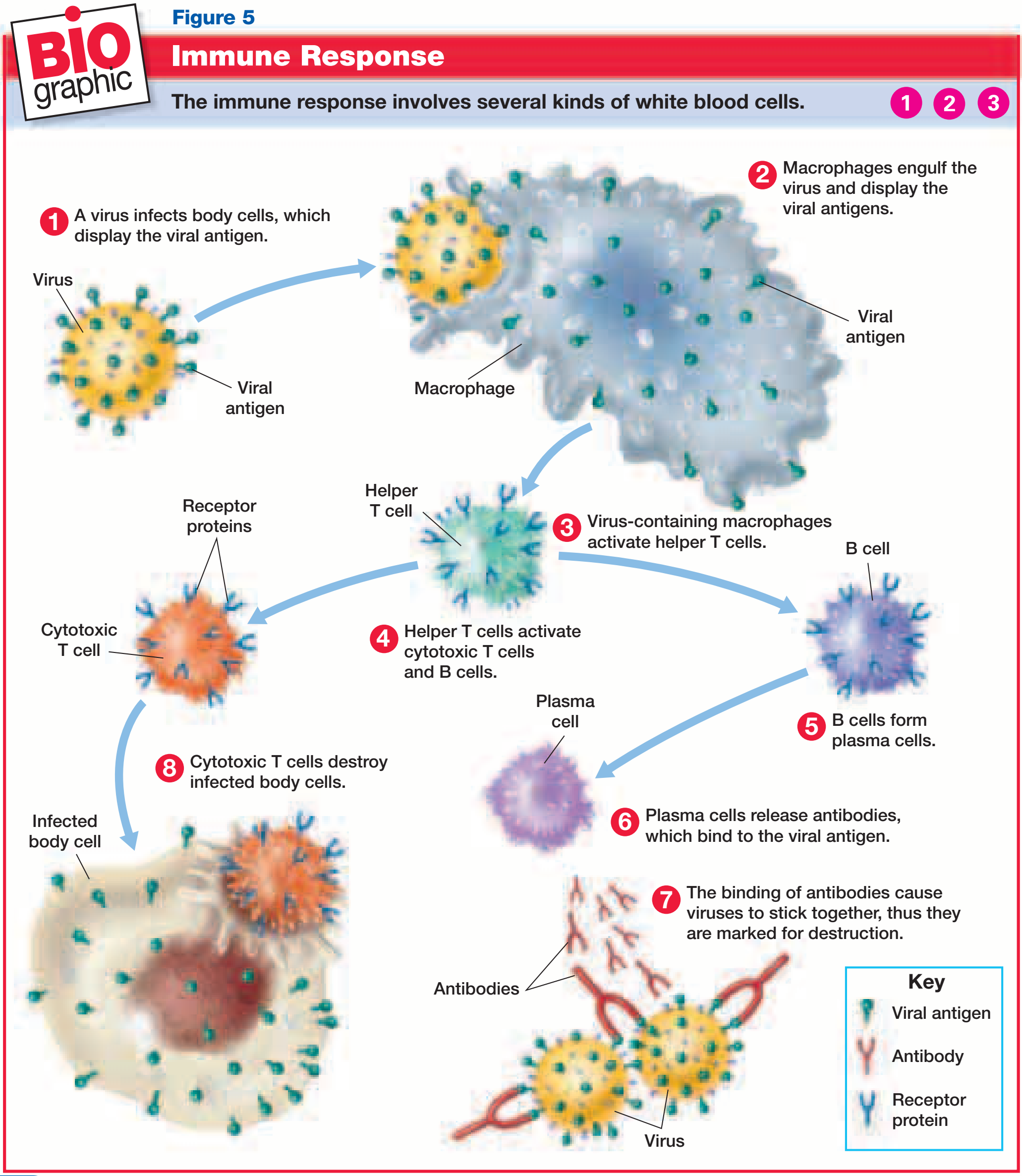
The Immune Response Has Two Main Parts

Two distinct processes work together in an immune response. One is the B cell response, a defense that aids the removal of extracellular pathogens from the body. The other is the T cell response, a defense that involves the destruction of intracellular pathogens by cytotoxic T cells. Both the T cell response and the B cell response are regulated by helper T cells. Both responses, which happen simultaneously, are summarized in **Figure 5.** 1

Figure 5

Immune Response

The immune response involves several kinds of white blood cells. 1 2 3



Step 1 When a virus infects body cells, the infected cells display the viral antigen on their surfaces.

Step 2 Macrophages engulf the virus and display the viral antigens on their surfaces.

Step 3 Receptor proteins on helper T cells bind to the viral antigen displayed by the macrophages. The macrophages release a protein called interleukin-1 *(ihn tuhr LOO kihn)*.

Step 4 Interleukin-1 activates helper T cells, but helper T cells do not attack pathogens directly. Instead, helper T cells activate cytotoxic T cells and B cells. Stimulation by interleukin-1 causes helper T cells to release interleukin-2. Interleukin-2 stimulates further division of helper T cells and cytotoxic T cells, amplifying the body's response to the infection.

Step 5 Interleukin-2 released by helper T cells also activates B cells. Activated B cells divide and develop into plasma cells. **Plasma cells** are cells that release Y-shaped antibodies into the blood. An **antibody** is a defensive protein produced upon exposure to a specific antigen, which can bind to that antigen.

Step 6 Plasma cells divide repeatedly and make large numbers of antibodies. Plasma cells release antibodies into the bloodstream where they attach to the viruses. Antibodies bind to the viral antigen and mark the virus for destruction.

Step 7 The binding of antibodies cause viruses and antigens to stick together, forming clumps that can be easily identified and destroyed by macrophages.

Step 8 Activated cytotoxic T cells destroy infected cells by puncturing their cell membranes. Your body makes millions of different T cells, each with receptor proteins that bind to a specific antigen. Receptor proteins on cytotoxic T cells bind to the viral antigen displayed by infected cells. For example, any of your body's cells that bear traces of an influenza virus will be destroyed by cytotoxic T cells with receptor proteins that bind to the antigen of that virus. 1 2

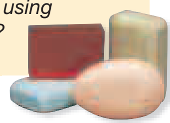
Real Life

How often do you wash your hands?

Hand washing is an effective way to prevent the spread of disease. A recent study found that only 68 percent of adults wash their hands after using public restrooms.

Inferring Relationships

Why is it crucial that food preparers wash their hands after using a restroom?



Study TIP

Reading Effectively

Antigens trigger an immune response. Remember that an antigen is an *anti*body-*gen*erating substance.

Section 2 Review

1. **List** the different kinds of white blood cells involved in the immune response. 10A 10B
2. **Describe** how white blood cells recognize and bind to pathogens. 10A 10B
3. **Compare** the roles of B cells and T cells in the immune response. 10A
4. **Recognizing Relationships** Explain the role of helper T cells in the immune response. 10A
5. **Critical Thinking** **Predicting Outcomes** How would an enzyme that destroys interleukins affect the immune response? 10A 10B
6. **TAKS Test Prep** Which cells produce antibodies and release them into the blood? 10A 10B

   A cytotoxic T cells
   B helper T cells
   C plasma cells
   D macrophages

Section 3

Disease Transmission and Prevention

Objectives

- **List** five ways diseases can be transmitted to humans. 4C 4D TAKS 3
- **Summarize** Koch's postulates for identifying pathogens. 3F 4C 4D TAKS 3
- **Analyze** how the body produces immunity to pathogens. 4C 4D TAKS 3
- **Describe** how vaccines produce immunity to pathogens. 4C 4D TAKS 3

Key Terms

Koch's postulates
immunity
vaccination
vaccine
antigen shifting

Disease Transmission

In general, you can get infectious diseases in any of five different ways: through person-to-person contact, air, food, water, and animal bites. Diseases transferred from person to person are considered contagious, or communicable. For example, when a person sneezes, droplets of saliva and mucus carrying pathogens are expelled from the mouth and nose, as shown in **Figure 6.** If another person breathes these droplets, the pathogens can infect that person. People directly transmit some diseases by kissing, shaking hands, touching sores, or having sexual contact. People can also transmit diseases indirectly through objects contaminated with pathogens, such as drinking glasses, toys, plumbing, and needles used to inject drugs or in tatooing.

By minimizing exposure to pathogens, you can decrease your chances of becoming ill. For example, to prevent illnesses caused by bacteria found in foods that contain animal products, these foods should always be cooked thoroughly. Utensils and other surfaces that foods touch should be sanitized. 1 2

Detecting Disease

The German physician Robert Koch (1843–1910) established a procedure for diagnosing causes of infection. Koch determined that bacteria cause anthrax, a disease that afflicts cattle, sheep, goats, and humans. Anthrax is a serious disease although it is not passed from person to person. In an experiment, Koch isolated bacteria from a cow with anthrax and then infected a healthy cow with the bacteria. The healthy cow developed anthrax and had the same bacteria that the first cow had. In his research, Koch developed the following four-step procedure, known as **Koch's postulates**, as a guide for identifying specific pathogens.

1. The pathogen must be found in an animal with the disease and not in a healthy animal.
2. The pathogen must be isolated from the sick animal and grown in a laboratory culture.
3. When the isolated pathogen is injected into a healthy animal, the animal must develop the disease.
4. The pathogen should be taken from the second animal and grown in a laboratory culture. The cultured pathogen should be the same as the original pathogen. 2

Figure 6 Disease transmission. When a person sneezes, pathogens are expelled from the mouth and nose.

Long-Term Protection

The specific immune response is very powerful, and it can be a long-lasting defense. After an immune response, some B cells and T cells become memory cells that continue to patrol your body's tissues. Some memory cells provide lifelong protection against previously encountered pathogens. If a pathogen ever appears again, memory cells activate antibody production against that pathogen. As shown in **Figure 7,** a second exposure to the same pathogen causes a sharp increase in antibody concentration. This enables macrophages to destroy the pathogen before you become ill. You are said to be "immune," or resistant, to the disease caused by that pathogen. 3

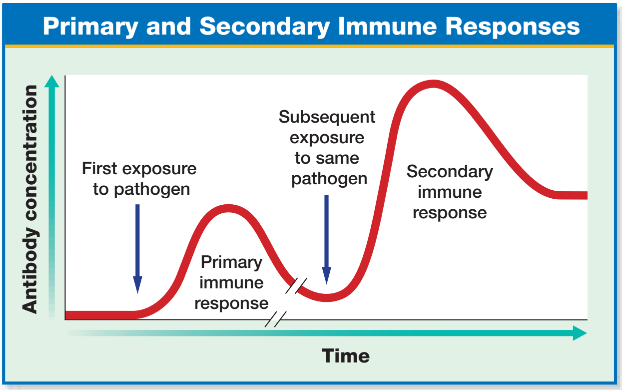


Figure 7 Immune responses. The first time you are exposed to a pathogen, your immune system responds normally. If you become exposed to the same pathogen again, antibody production increases quickly.

Resistance to Disease

Resistance to a particular disease is called **immunity.** It has long been observed that individuals who recover from an infectious disease develop an immunity to that disease. This knowledge preceded the development of immunology, a branch of science that deals with antigens, antibodies, and immunity. Immunologists study the body's defenses and ways to help protect against disease.

In 1796, an English doctor named Edward Jenner performed an experiment that marks the beginning of immunology. Smallpox, which is caused by a virus, was a common and deadly disease then. Jenner observed that milkmaids who had contracted cowpox, a mild form of smallpox, rarely became infected with smallpox. Jenner hypothesized that cowpox produced protection against smallpox. To test his hypothesis, Jenner infected healthy people with cowpox. As Jenner had predicted, many of the people he infected never developed smallpox, even though they had been exposed to the virus. We now know that smallpox and cowpox are caused by two similar viruses. The cowpox infection caused an immune response that later prevented smallpox infection in Jenner's patients.

Vaccination Jenner's procedure of injecting the cowpox virus to produce resistance to smallpox is called vaccination. **Vaccination** *(vak sih NAY shuhn)* is a medical procedure used to produce immunity. You have probably been to the doctor for vaccination to guard against various diseases. Modern vaccination usually involves an injection, or "shot," of a vaccine under the skin. A **vaccine** *(vak SEEN)* is a solution that contains a dead or modified pathogen that can no longer cause disease. 3

A vaccine triggers an immune response against the pathogen without symptoms of infection. For several days after you are vaccinated, your immune system develops antibodies and memory

Real Life

Flu can be deadly.

In 1918, an influenza (flu) epidemic killed more than 20 million people. To prevent this from happening again, scientists track the antigen shifting of flu viruses and target the new viral antigens for vaccines.

cells against the pathogen. You develop a long-lasting immunity to the disease. In 1977, smallpox became the first infectious disease to be eradicated from the public by vaccination. Vaccination has also reduced the incidence of many other diseases, including measles, polio, tetanus, and diphtheria.

Antigen shifting You can get the flu even if you have already been infected or vaccinated. Influenza viruses constantly mutate over time. The viruses produce new antigens that your immune system does not recognize, a process known as **antigen shifting.** With subsequent exposure to the virus, your body must make new antibodies. 1

QUICK LAB

Simulating Antigen Activity

Using simulated blood, you can see what happens when antigens encounter specific antibodies.

Materials TAKS 1, TAKS 2

safety goggles, disposable gloves, lab apron, 2 blood-typing trays, simulated blood (types AB and O), simulated anti-A and anti-B blood-typing serums, 4 toothpicks

Procedure

1. Put on safety goggles, disposable gloves, and a lab apron.
2. Place 3–4 drops of type AB simulated blood into each well in a clean blood-typing tray. **CAUTION: Use only simulated blood provided by your teacher.**
3. Add 3–4 drops of anti-A blood-typing serum to one well. Stir the mixture for 30 seconds using a toothpick. Add 3–4 drops of anti-B blood-typing serum to the other well. Use a new toothpick to stir the mixture. Look for clumps separating from the mixtures.
4. Repeat steps 2 and 3 using simulated type O blood.
5. Dispose of your materials according to your teacher's directions. Clean up your work area and wash your hands.

Analysis

1. **Determine** which blood type has antigens that are recognized by the blood-typing sera.
2. **Evaluating Results** What does clumping of the blood mixtures indicate?
3. **Predicting Outcomes** What would happen if you did the same experiment using type A blood and type B blood?

Section 3 Review

1. **List** two ways that diseases can be transmitted between people. 4C 4D
2. **Summarize** Koch's postulates for identifying specific pathogens. 3F 4C 4D
3. **Describe** how vaccination produces immunity. 4C 4D
4. **Critical Thinking** **Relating Concepts** Explain why you cannot get many diseases more than once. 4C 4D
5. **TAKS Test Prep** Smallpox is caused by a 4C
   - **A** virus.
   - **B** bacterium.
   - **C** fungus.
   - **D** protist.

Disorders of the Immune System

Section 4

Autoimmune Diseases

The ability of your immune system to distinguish cells and antigens of your body from foreign cells and antigens is crucial to the fight against pathogens. In some people, the immune system cannot distinguish between the body's antigens and foreign antigens, causing an autoimmune disease. In an **autoimmune disease**, the body launches an immune response against its own cells, attacking body cells as if they were pathogens. The immune system cannot distinguish between antigens of "self" and "nonself." This effect may be caused by the inappropriate production of antibodies specific to the antigens of body cells.

Autoimmune diseases affect organs and tissues in various areas of the body. For example, multiple sclerosis *(skleh ROH sihs)* usually strikes people between the ages of 20 and 40. Multiple sclerosis (MS) is generally thought to be an auto-immune disease. In people with multiple sclerosis, the immune system attacks and gradually destroys insulating material surrounding nerve cells in the brain, in the spinal cord, and in the nerves leading from the eyes to the brain. This impairs and may eventually stop the functioning of these nerve cells. Multiple sclerosis causes problems with vision, speech, and coordination. **Table 1** lists and describes several autoimmune diseases. 2 3

Objectives

- **Describe** several autoimmune diseases. 10A TAKS 2
- **Summarize** how HIV disables the immune system. 4C 10A TAKS 2
- **List** five ways HIV is transmitted. 4C 10A TAKS 2
- **Identify** causes of an allergic reaction. 11B

Key Terms

autoimmune disease
AIDS
HIV
CD4
allergy

Table 1 Autoimmune Diseases

Disease	Areas affected	Symptoms
Graves' disease	Thyroid gland	Weakness, irritability, heat intolerance, increased sweating, weight loss, insomnia
Multiple sclerosis (MS)	Nervous system	Weakness, loss of coordination, problems with vision and speech
Rheumatoid arthritis	Joints	Severe pain, fatigue, disabling inflammation of joints
Systemic lupus erythematosus (SLE)	Connective tissue, joints, kidneys	Facial skin rash, painful joints, fever, fatigue, kidney problems, weight loss
Type I diabetes	Insulin-producing cells in pancreas	Increased blood glucose level, excessive urine production, problems with vision, weight loss, fatigue, irritability

HIV Infection

Before 1981, **AIDS,** or acquired immunodeficiency syndrome, was unknown. Between 1981 and 2001, more than 460,000 Americans died of AIDS, and since then the total number of AIDS cases reported in the United States has increased to more than 810,000. AIDS is a disease caused by **HIV,** or the human immunodeficiency virus. Many scientists think HIV evolved from a virus similar to one that infects nonhuman primates in Africa. A mutation enables HIV to recognize a receptor protein called **CD4** on some human cells. HIV, shown in **Figure 8,** enters white blood cells by binding to CD4. HIV usually invades helper T cells, which begin to produce HIV soon after infection. As helper T cells die, the immune system gradually weakens and becomes overwhelmed by pathogens that it would normally detect and destroy. The body becomes susceptible to other diseases, called opportunistic infections, that generally cause illness only in people with weakened immune systems. 1

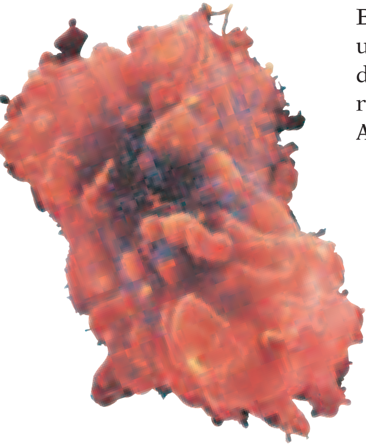


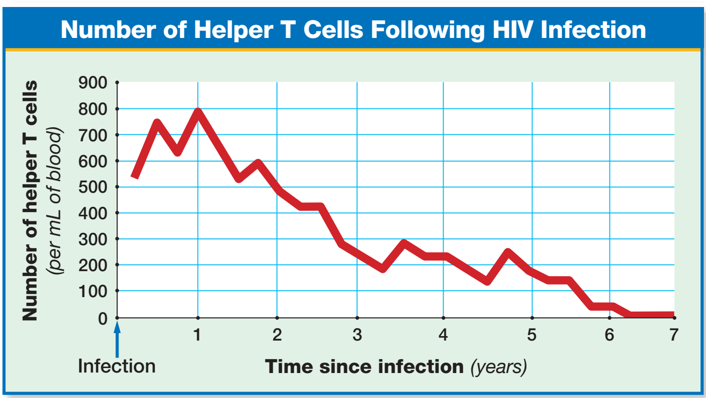
Figure 8 **HIV.** Small HIV particles (purple) surround a helper T cell (orange).

Testing for HIV

Antibodies to HIV can be detected in blood. Someone whose blood contains antibodies to HIV is said to be HIV positive. A diagnosis of AIDS may be made based on several criteria, including a helper T cell count less than 200 cells/mL of blood. **Figure 9** shows how the number of helper T cells may decline over time in an HIV-positive person. 1 2

The time between HIV infection and the onset of AIDS can exceed 10 years, and this time period is increasing as new treatments for HIV infection are developed. A person with HIV may feel and appear healthy but can infect other people. In the United States, the number of deaths caused by AIDS has dropped from more than 51,000 in 1995 to about 38,000 in 1996, and to about 22,000 in 1997. This decrease does not reflect a decline in HIV infection, but rather more effective drug therapies, which postpone onset of the disease.

Figure 9 **Onset of AIDS.** The graph at right shows the decline over time in the number of helper T cells in a person infected with HIV.



Transmission of HIV

You can become infected with HIV if you come in contact with body fluids—including the blood—of an infected person. The most common method of HIV transmission is through sexual contact. Use of a latex condom during sexual contact reduces but does not eliminate the risk of getting or spreading HIV. Many people infected with HIV do not know they are infected. The only sure way to prevent HIV infection is through abstinence (the conscious decision to refrain from sexual activity). [1]

HIV can be passed between drug users who share a hypodermic needle because HIV-infected blood often remains in the needle or syringe. Several years ago, many people became infected with HIV after receiving transfusions of HIV-contaminated blood. This is very unlikely now because blood made available for transfusion is tested for HIV. In addition, pregnant or nursing mothers can pass HIV to their infants through blood and breast milk. [1] [3]

HIV is not transmitted through the air, on toilet seats, by kissing or handshaking, or by any other medium where HIV-infected white blood cells could not survive. Although HIV has been found in saliva, tears, and urine, these body fluids usually contain too few HIV particles to cause an infection. Mosquitoes and ticks do not transmit HIV because they do not carry HIV-infected white blood cells. [1]

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DATA LAB

Tracking the Spread of AIDS

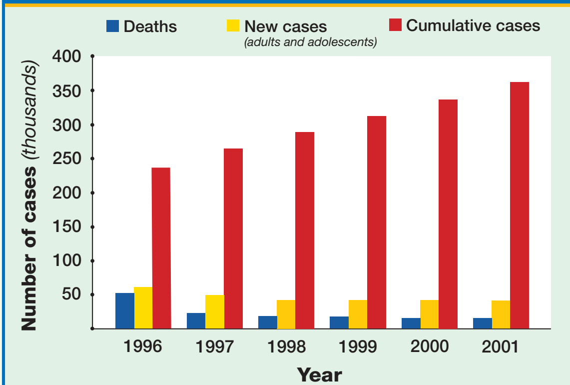
Background TAKS 1

The graph below shows the total AIDS cases reported in the United States between 1996 and 2001. Use the graph to answer the following questions:

Analysis

1. **Describe** how the number of people with AIDS has changed since 1996.
2. **Inferring Relationships** Is the number of Americans infected with HIV most likely greater than or less than the number of people with AIDS? Explain why.
3. **Evaluating Data** The graph indicates that the number of new AIDS cases reported each year has decreased since 1996. Suggest a possible reason for this decline.

AIDS Cases in the United States, 1996-2001



Estimated data from Centers for Disease Control and Prevention

Allergic Reactions

Many health problems are caused by inappropriate responses of the immune system. One example is an allergic reaction. An **allergy** is the body's inappropriate response to a normally harmless antigen. Allergy-causing antigens include pollen, the feces of dust mites, fungal spores, and substances found in some foods and drugs. Most allergic reactions are merely uncomfortable. Cells exposed to allergy-causing antigens release histamine. Histamine causes swelling, redness, increased mucus production, runny nose, itchy eyes, and nasal congestion. Most allergy medicines contain antihistamines, which are drugs that prevent the action of histamine. Severe allergic reactions, such as asthma, can be life threatening if they are not treated immediately. 1 2

BIOWatch

Asthma TAKS 2

Asthma is an inflammation of the respiratory tract often caused by an allergic reaction to substances in the air. Asthma affects about 15 million Americans and causes more than 5,000 deaths each year. Inner-city residents get asthma three times as often as people who live outside cities. In some cities, the death rate from asthma is eight times the national average. Some scientists think increased asthma rates in inner-city residents is related to pollution, emotional stress, and limited access to health care. One study suggests that cockroach feces may cause asthma in many inner-city children.

Asthma Attack

During an asthma attack, the respiratory passages become inflamed and swollen. Then mucus collects in the lungs, restricting airflow. Finally, muscles that surround the bronchial tubes tighten, causing shortness of breath.

Treating Asthma

Asthma sufferers can take medicines that increase airflow by relaxing bronchial-tube muscles, but their effects wear off after a few hours. Other medicines provide long-lasting relief by preventing or reducing inflammation.

Measuring lung capacity

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Section 4 Review

1. **Describe** the cause of autoimmune diseases. 10A

2. **List** two ways that HIV can be transmitted and two ways that it cannot. 4C 10A

3. **Critical Thinking Recognizing Relationships** Explain why it might take several weeks after exposure to HIV for a person's HIV antibody test to be positive. 4C 10A

4. **Distinguish** between HIV infection and AIDS. 4C 10A

5. **TAKS Test Prep** One common symptom of an allergic reaction to airborne antigens is 10A 11B
   - **A** a weakened immune response.
   - **B** opening nasal passages.
   - **C** reduced mucus production.
   - **D** itchy eyes.

Key Concepts

1 Nonspecific Defenses

- Skin and mucous membranes act as barriers to pathogens.
- The inflammatory response increases blood flow to an infected area, while the temperature response inhibits bacterial growth.
- Complement proteins form a membrane attack complex (MAC). Interferon stimulates cells and inhibits viruses.
- Neutrophils, macrophages, and natural killer cells use different methods to attack and destroy invading pathogens.

2 Immune Response

- Receptors on white blood cells bind to specific antigens.
- The T cell response is a defense in which cytotoxic T cells destroy pathogens.
- The B cell response is a defense in which antibodies mark pathogens for destruction by white blood cells.

3 Disease Transmission and Prevention

- Diseases are transmitted to humans through person-to-person contact, air, food, water, and animal bites.
- Biologists use Koch's postulates to identify pathogens.
- Memory cells can produce long-term immunity to pathogens.
- Vaccination produces long-term immunity to pathogens.
- Antigen shifting makes the immune response of memory cells ineffective.

4 Disorders of the Immune System

- In an autoimmune disease, the immune system attacks body cells as if they were pathogens.
- HIV, the virus that causes AIDS, invades helper T cells, causing them to produce more HIV particles and eventually die.
- HIV is transmitted by HIV-infected white blood cells in body fluids, through sexual contact or by the sharing of a hypodermic needle with an infected person.
- An allergic reaction is an inappropriate response to normally harmless antigens.

Key Terms

Section 1

pathogen (924)
mucous membrane (924)
inflammatory response (925)
histamine (925)
complement system (926)
interferon (926)
neutrophil (926)
macrophage (926)
natural killer cell (926)

Section 2

cytotoxic T cell (927)
B cell (927)
helper T cell (927)
antigen (927)
plasma cell (929)
antibody (929)

Section 3

Koch's postulates (930)
immunity (931)
vaccination (931)
vaccine (931)
antigen shifting (932)

Section 4

autoimmune disease (933)
AIDS (934)
HIV (934)
CD4 (934)
allergy (936)

Using Key Terms

1. Nonspecific defenses include 10A
a. the T cell response.
b. the B cell response.
c. antibodies.
d. the inflammatory response.

2. Mucous membranes 10A
a. activate helper T cells.
b. secrete mucus, which traps pathogens.
c. prevent blood clots.
d. produce antibodies.

3. B cells and cytotoxic T cells are stimulated by interleukin-2, which is released by 10A
a. macrophages. **c.** helper T cells.
b. neutrophils. **d.** natural killer cells.

4. Plasma cells 10A
a. are directly stimulated by interleukin-1.
b. result from cytotoxic T cells.
c. produce antibodies.
d. engulf pathogens.

5. For each pair of terms, explain the differences in their meanings.
a. macrophage, neutrophil
b. helper T cell, cytotoxic T cell
c. immunity, vaccine
d. allergy, histamine

Understanding Key Ideas

6. Robert Koch 3F
a. treated smallpox patients.
b. established a four-step procedure for identifying pathogens.
c. perfected vaccination.
d. identified complement proteins.

7. Flu vaccinations are given each year because 4C
a. influenza viruses mutate often.
b. influenza is caused by bacteria.
c. very few memory cells are produced.
d. macrophages cannot engulf flu viruses.

8. HIV can be transmitted by 4C
a. sexual contact. **c.** shaking hands.
b. mosquito bites. **d.** vaccination only.

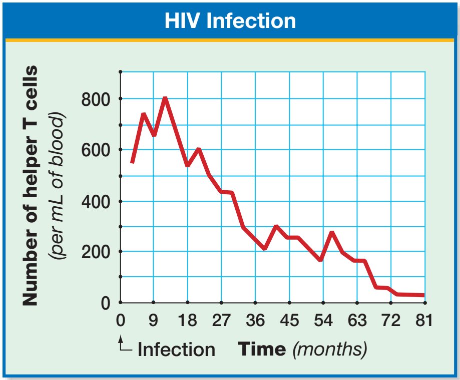
9. Rheumatoid arthritis is an example of 10A
a. an allergic reaction.
b. an autoimmune disease.
c. an AIDS-related infection.
d. a bacterial infection.

10. HIV disables the immune system by 4C
a. blocking the action of macrophages.
b. destroying helper T cells.
c. activating production of B cells.
d. All of the above

11. Name three types of white blood cells, and explain their roles in the immune system.

12. How do cytotoxic T cells recognize antigens?

13. The graph below shows the decrease in the number of helper T cells in a person with AIDS. How many months after infection did the onset of AIDS occur? 10A



14. BIOWatch What symptoms are usually associated with an asthma attack? 11C

15. Concept Mapping Make a concept map that describes the immune response. Include the following terms in your map: *pathogen, macrophage, helper T cell, cytotoxic T cell, B cell, plasma cell,* and *antibody.* 3E

Critical Thinking

16. Recognizing Relationships Under what circumstances can a child be born with HIV? 4C

17. Analyzing Information Plasma cells contain a large Golgi apparatus and large amounts of rough endoplasmic reticulum. How is the presence of these organelles related to the function of plasma cells? 10A 10B

18. Inferring Relationships People who are severely burned often die from infection. Given what you know about disease transmission, explain why this is common. 4D 10A

19. Forming Reasoned Opinions A government agency is reviewing two proposals for HIV research but can fund only one. Which proposal would you recommend that the agency fund? You should consider not only the likely effectiveness of the treatment but also possible side effects. Explain how you made your choice. **Proposal 1:** Develop a drug that interferes with protein production. **Proposal 2:** Develop a substance that binds to CD4 receptors on helper T cells. 4C 10A

Alternative Assessment

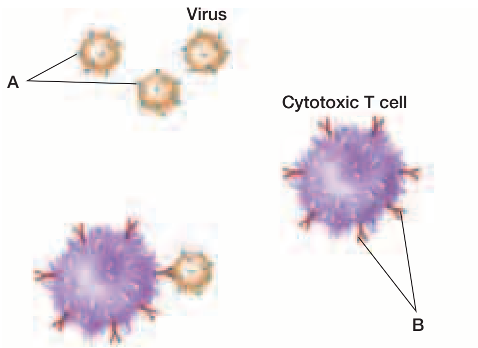
20. Finding Information Scientific research into treatments and a possible cure for AIDS is an ongoing process. Find out about the latest research into HIV and prospective cures for AIDS. Research the most recent pharmaceutical developments and other treatments. Evaluate public awareness and education programs and campaigns. Present your findings in a written report. 4C

21. Summarizing Information Use the media center or the Internet to research three different vaccines. Make a large chart or table on poster board listing the pathogens they protect against, their effectiveness, side effects, and boosters required, if any. Present your chart to your class. 2C 2D 3F

22. Career Focus Immunologist Research the field of immunology, and write a report on your findings. Your report should include a job description, education and training required, kinds of employers, growth prospects, and starting salary. 3D

TAKS Test Prep

Use the diagram below and your knowledge of science to answer questions 1–3.



1. What are the structures labeled *A*? 10A
   - **A** antigens
   - **B** antibodies
   - **C** interleukins
   - **D** receptor proteins

2. What are the structures labeled *B*? 10A
   - **F** interferons
   - **G** interleukins
   - **H** receptor proteins
   - **J** antigens

3. Why do structures *A* and *B* interact with each other? 10A
   - **A** They have matching shapes.
   - **B** They are produced by the same cells.
   - **C** Both of them are "nonself."
   - **D** Both of them are viral proteins.

Test TIP

Whenever possible, highlight or underline important numbers or words critical to correctly answering a question.