Section 1

Focus

Overview

Before beginning this section review with your students the objectives listed in the Student Edition. This section introduces students to the nonspecific defenses of the human body, including skin and mucous membranes. Students will then learn that pathogens that make it past the first line of defense face the inflammatory and temperature responses that can be very effective in killing the invader.

Bellringer

Ask students to make a list of the many ways the body prevents infectious organisms from entering. (skin, mucous membranes, nasal hairs, etc.) When they are finished, have them share their lists. Ask them if the barriers on their lists can distinguish between the types of infections and can prevent specific ones. (no) TAKS 2 Bio 10A

Motivate

Discussion — BASIC

Ask students what happens when they get a wood splinter in their finger and they don't get it out within the first day or so. (The area turns red, becomes sore, and may swell.) What happens after several more days, if the splinter isn't removed? (Pus may form around the splinter; years ago this was called "festerling.") Ask them why they think the pus is whitish in color. (White blood cells are converging on the area of the wood splinter and it is being digested.) TAKS 2 Bio 10A; Bio 11B

Chapter Resource File

- Lesson Plan GENERAL
- Directed Reading BASIC
- Active Reading GENERAL

One-Stop Planner CD-ROM

- Reading Organizers BASIC
- Reading Strategies BASIC
- Occupational Application Worksheet Sanitarian GENERAL

TEKS/TAKS pp. 924–925

Student Edition
TAKS Obj 2 Bio 4B
TAKS Obj 2 Bio 10A
TAKS Obj 2 Bio 10B
TAKS Obj 3 Bio 4D
TEKS Bio 4B, 4D, 10A, 10B

Teacher Edition
TAKS Obj 2 Bio 10A, 10B
TEKS Bio 4B, 4D, 10A, 10B, 11B, 11D

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.

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.

Mucous membranes cover some body surfaces that come into contact with pathogens. Mucous (MYOO kuhz) 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.

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.

SCID

To illustrate our dependence on a functional immune system, show students a picture of David, the "boy in the bubble." David was born with severe combined immune deficiency (SCID), a disease characterized by the inability to produce B cells and T cells, which play key roles in the immune system. SCID patients must live in a protected environment because the slightest infection can lead to death. David died at the age of 12 after an unsuccessful bone marrow transplant.

TAKS 2 Bio 10A, 10B (grade 11 only)
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.

**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.

**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 (102.2°F) are considered dangerous, and those greater than 41°C (105°F) can be fatal.

---

**did you know?**

**Symbiotic Bacteria** Some of the body’s protection from pathogens comes from symbiotic bacteria. For example, in the vagina, beneficial bacteria inhibit the growth of harmful bacteria and fungi. Use of antibiotics to kill pathogens often kills the body’s beneficial bacteria as well, which can lead to vaginal and urinary tract infections. **TAKS 3 Bio 4D; Bio 11D**

---

**Teaching Tip** **ADVANCED**

**Mosquito Bites** Ask students why they think mosquito bites turn red, swell, and itch if a mosquito is simply sucking up blood? (The mosquito injects a small amount of saliva, which contains an anticoagulant. The anticoagulant initiates the inflammatory response, making the bite site swell, turn red, and itch.) **TAKS 2 Bio 10A, 10B**

---

**Group Activity** **GENERAL**

**Sequencing Lines of Defense** Work in groups of three or four. On index cards, have each group write the name of each defensive protector the body has which is considered a first line of defense. Do the same with the second line of defense. On the back of each card write the function that each particular defense has in the body. Have the groups shuffle the cards and then try to organize them into first and second lines of defense. They should check their answers in this section, then reshuffle the cards and try again until they get them right several times in a row. Next, they should turn the cards over and try to do the same thing with the functions of each defense. Finally, they should use the cards as flash cards to quiz each other on the various components of the first and second lines of defense and how they function. **TAKS 2 Bio 10A, 10B** (grade 11 only) **Kinesthetic**

---

**Transparencies**

TT Bellringer
TT Inflammatory Response
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 tuh 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.

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.

1. Neutrophils. A neutrophil (neu tro fil) 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 jet), 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 by 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.

Section 1 Review

1. Describe how the inflammatory and temperature responses help defend against infection.  

2. Identify the role of white blood cells in the second line of nonspecific defenses.

3. Critical Thinking Relating Concepts  
Explain why taking a drug that reduces fever might delay rather than speed up your recovery from an infection.

4. TAKS Test Prep In the inflammatory response, local blood vessels dilate when infected or injured cells release interferon. Histamine increases blood flow; this brings white blood cells to the infected area, where they can attack pathogens. Mucus does not cause blood vessels to dilate. Complement proteins move in the blood and are activated by pathogens.

Answers to Section Review

1. The inflammatory response increases blood flow; this brings white blood cells to an injury site. The temperature defense raises tissue temperature; this kills or inhibits some pathogens.

2. Neutrophils engulf pathogens. Macrophages ingest and kill them and rid the body of dead cells. Natural killer cells puncture membranes of infected cells.

3. The drug inhibits the temperature response. Reducing body temperature may allow pathogens to thrive.

4. TAKS Doctor A. Incorrect. Interferon causes cells to make an enzyme that prevents viruses from making proteins and RNA. B. Correct. Histamine increases blood flow; this brings white blood cells to the infected area, where they can attack pathogens. C. Incorrect. Mucus does not cause blood vessels to dilate. D. Incorrect. Complement proteins move in the blood and are activated by pathogens.
Immune Response

Section 2

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 is 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.

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 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.

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 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.
Teaching Tip

Immune Cells

Have students create a Graphic Organizer similar to the one at the bottom of this page. Along the top of the table they should list the following categories: Type of cell, Function, and Location in the body. In the first column, they should list all the types of cells that play a role in the body’s defenses. (macrophage, neutrophil, natural killer cell, helper T cell, cytotoxic T cell, B cell, plasma cell, and memory cell) Then ask students to complete the information in the second and third columns.

Using the Figure

Once you have discussed Figure 5, have students answer the following questions: What types of white blood cells are involved in the immune response? (helper T, cytotoxic T, and B cells) What type of cell is involved in a passive, humoral defense? (B cell) What type of cell is active and destroys pathogens? (cytotoxic T cell) What is the role of helper T cells? (They regulate the T- and B-cell actions.)

Graphic Organizer

Use this graphic organizer with Teaching Tip on this page.

<table>
<thead>
<tr>
<th>Type of cell</th>
<th>Function</th>
<th>Location in the body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macrophage</td>
<td>Ingests and kills pathogens</td>
<td>Spleen, lungs, blood, lymph, interstitial fluids</td>
</tr>
<tr>
<td>Neutrophil</td>
<td>Engulfs and destroys pathogens</td>
<td>Bloodstream, infection sites</td>
</tr>
<tr>
<td>Natural killer cell</td>
<td>Punctures infected cells</td>
<td>Infected cells</td>
</tr>
<tr>
<td>Helper T cell</td>
<td>Activates cytotoxic T and B cells</td>
<td>Bloodstream, infection sites</td>
</tr>
<tr>
<td>Cytotoxic T cell</td>
<td>Punctures infected cells</td>
<td>Infection sites</td>
</tr>
<tr>
<td>B cell</td>
<td>Labels invaders for destruction by macrophages</td>
<td>Infection sites</td>
</tr>
<tr>
<td>Plasma cell</td>
<td>Releases antibodies</td>
<td>Bloodstream</td>
</tr>
<tr>
<td>Memory cell</td>
<td>Protects against defeated pathogens</td>
<td>Bloodstream</td>
</tr>
</tbody>
</table>
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.

Section 2 Review

1. List the different kinds of white blood cells involved in the immune response.  
2. Describe how white blood cells recognize and bind to pathogens.  
3. Compare the roles of B cells and T cells in the immune response.  
4. Recognizing Relationships Explain the role of helper T cells in the immune response.

Answers to Section Review

1. macrophages, cytotoxic T cells, B cells, helper T cells  
2. White blood cells recognize invaders because infected cells display surface antigens. White blood cells have receptors that bind to these antigens.  
3. B cells become plasma cells that release antibodies that bind to antigens to mark them for destruction by macrophages. T cells are stimulated by interleukin-1 to produce interleukin-2, which activates helper T cells and cytotoxic T cells that puncture cell membranes.  
4. Helper T cells bind to viral antigens on macrophage surfaces, which stimulates the release of interleukin-1 by macrophages. Helper T cells also activate B cells and cytotoxic T cells.  
5. Destroying interleukins would short-circuit the immune response.  

Critical Thinking Predicting Outcomes

How would an enzyme that destroys interleukins affect the immune response?  
Which cells produce antibodies and release them into the blood?  
A. cytotoxic T cells  B. helper T cells  C. plasma cells  D. macrophages

Real Life

TAKS Test Prep

Reading Effectively

Antigens trigger an immune response. Remember that an antigen is an antibody-generating substance.

Close

Reteaching

Have students study the function of T cells in the immune response. Have them make index cards with sequential words and drawings depicting T-cell function. Have students pair off. One student should shuffle the cards, and the other student should put them in the correct order. Students should then switch roles.

Final Thoughts

Quiz

True or False:

1. The immune response of the body is a defense that is nonspecific. (false; it is specific)
2. Antigens trigger the immune response. (true)
3. Plasma cells make antibodies. (true)

Alternative Assessment

Make copies of Figure 5, but without the explanations at each step. Have students, without using their book, fill in the explanations of what is happening at each of the eight steps.
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 tattooing.

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.

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 shum) 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.

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...
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.

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.


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.

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 sera, 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?
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 sihts) 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.

### Table 1 Autoimmune Diseases

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

### Key Terms
- autoimmune disease
- AIDS
- HIV
- CD4
- allergy
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.

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.

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

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.

Number of Helper T Cells Following HIV Infection

<table>
<thead>
<tr>
<th>Number of helper T cells (per mL of blood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>700</td>
</tr>
<tr>
<td>600</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Infection  Time since infection (years)

Sir Frank Macfarlane Burnet  Sir Frank Macfarlane Burnet was an Australian scientist who discovered and described acquired immunological tolerance to transplanted tissues. He also developed techniques of virus culture in chick embryos, which have become standard laboratory practice. Sir Macfarlane Burnet was elected to the Royal Society in 1942, received the Order of Merit in 1958, and was awarded the Nobel Prize for medicine in 1960. His book, *Natural History of Infectious Disease*, was published by Cambridge University Press in 1972.
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

AIDS-related Infections  Some students may think that HIV itself causes the death of AIDS patients. Actually AIDS is a result of cancers and infections by opportunistic pathogens that are unusual in individuals with healthy immune systems. Infections and cancers associated with AIDS include Kaposi’s sarcoma, Pneumocystis carinii pneumonia, candidiasis, and others. Kaposi’s sarcoma is a cancer of the skin and mucous membranes that often spreads through other organs. Pneumocystis carinii pneumonia is the most common of these AIDS-related diseases. Candidiasis, commonly known as thrush, is a fungal infection producing a thick, white coating of the mouth, tongue, and other components of the digestive system. Other opportunistic pathogens include cytomegalovirus, which produces inflammation of the retina, colon, and adrenal glands; and tuberculosis and Salmonella infection, both caused by bacteria. TAKS 3 Bio 4C

Demonstration —— Basic

Invite a healthcare professional to give a presentation to the class about how HIV is transmitted and the best ways to protect yourself from transmission. Encourage students to take notes throughout the presentation. Afterwards, have students make an outline of the main points made by the speaker.

Analyzing the Spread of AIDS

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:

1. Describe how the number of people with AIDS has changed since 1996.
2. Infer the number of Americans infected with HIV most likely greater than or less than the number of people with AIDS? Explain why.
3. Evaluate the 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>New cases (adults and adolescents)</th>
<th>Cumulative cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>5</td>
<td>15,625</td>
</tr>
<tr>
<td>1997</td>
<td>25</td>
<td>3,125</td>
</tr>
<tr>
<td>1998</td>
<td>78,125</td>
<td>125</td>
</tr>
<tr>
<td>1999</td>
<td>1,953,125</td>
<td>625</td>
</tr>
<tr>
<td>2000</td>
<td>390,625</td>
<td>3,125</td>
</tr>
<tr>
<td>2001</td>
<td>7,765,625</td>
<td>125</td>
</tr>
</tbody>
</table>

Answers to Analysis

1. AIDS cases have risen sharply, from less than 50,000 cases to more than 600,000 cases.
2. Greater; everyone who has AIDS is infected with HIV, but not everyone who is infected with HIV has developed AIDS.
3. New drugs postpone the onset of AIDS in HIV-infected individuals.

Teacher’s Notes

Review with students how to read a bar graph.
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.

Section 4 Review

1. Describe the cause of autoimmune diseases. TAKS 2 Bio 10A

2. List two ways that HIV can be transmitted and two ways that it cannot. TAKS 3 Bio 4C

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. TAKS 2 Bio 10A; TAKS 3 Bio 4C

4. Distinguish between HIV infection and AIDS. TAKS 3 Bio 4C

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

Answers to Section Review

1. Autoimmune diseases occur because the body lacks the ability to distinguish between self and non-self cells. TAKS 2 Bio 10A

2. HIV can be transmitted by sexual contact, hypodermic needles, tainted blood, breast milk, and from a mother to a fetus. HIV cannot be transmitted by shaking hands, toilet seats, insect bites, or though the air. TAKS 2 Bio 10A; TAKS 3 Bio 4C

3. The immune system might take several weeks to build up enough HIV antibodies to be detected. TAKS 2 Bio 10A; TAKS 3 Bio 4C

4. HIV infection is diagnosed by the presence of antibodies in the blood. AIDS is diagnosed if there are less than 200 helper T cells/mL blood. TAKS 2 Bio 10A; TAKS 3 Bio 4C

5. Incorrect. An airborne antigen, like any antigen, would stimulate a strong immune response. Incorrect. Airborne antigens would likely cause swelling of nasal passages. Incorrect. Airborne antigens usually increase mucus production. Correct. A common symptom of an allergic reaction to airborne antigens is itchy eyes, caused by the release of histamine from cells exposed to the antigen. TAKS 2 Bio 10A; Bio 11B
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.

Alternative Assessment
Have students work in cooperative groups. Ask each group to develop a question to send to a newspaper health advice columnist dealing with any topic covered in this chapter. Collect the questions and redistribute them to other groups. Each group should then write an appropriate response to the question.  

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)

Answer to Concept Map
The following is one possible answer to the Performance Zone item 15.
ANSWERS

Using Key Terms
1. d. TAKS 2 Bio 10A
2. b. TAKS 2 Bio 10A
3. c. TAKS 2 Bio 10A
4. c. TAKS 2 Bio 10A
5. a. Macrophages ingest and destroy pathogens and clear debris. Neutrophils engulf and destroy pathogens.
   b. Helper T cells activate cytotoxic T cells, which seek and destroy pathogens.
   c. Immunity is the body’s resistance to pathogens that have been previously encountered. A vaccine is a dose of dead or deactivated pathogens given to stimulate immunity.
   d. An allergy is the body’s overreaction to a normally harmless antigen. Histamine causes an allergic response that includes swelling, redness, increased mucus production, runny nose, itchy eyes, and nasal congestion.

Using Key Terms
1. Nonspecific defenses include
   a. the T cell response.
   b. the B cell response.
   c. antibodies.
   d. the inflammatory response.
2. Mucous membranes
   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
   a. macrophages.
   b. helper T cells.
   c. produce antibodies.
   d. engulf pathogens.
4. Plasma cells
   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
   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
   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
   a. sexual contact.
   b. mosquito bites.
   c. shaking hands.
   d. vaccination only.
9. Rheumatoid arthritis is an example of
   a. an allergic reaction.
   b. an autoimmune disease.
   c. an AIDS-related infection.
   d. a bacterial infection.
10. HIV disables the immune system by
    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?

Assignment Guide

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

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.

Review and Assess
TAKS Obj 1 Bio/IPC 2C, 2D
TAKS Obj 2 Bio 10A, 10B
TAKS Obj 3 Bio 4C, 4D
TEKS Bio 3D, 3E, 3F, 4C, 10A, 11C
TEKS Bio/IPC 2C, 2D

pp. 938–939
Critical Thinking

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

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?  

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

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.

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.

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.

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.

TAKS Test Prep

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

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

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

3. Why do structures A and B interact with each other?  
   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.

   B. Incorrect. Antibodies are produced to fight viruses.  
   C. Incorrect. Interleukins are proteins released by the immune system to fight pathogens.  
   D. Incorrect. Receptor proteins are sites on the white blood cells that attach to complementary sites on viral particles.

2. F. Incorrect. Interferons are proteins released by cells that are infected by viruses.  
   G. Incorrect. Interleukins are proteins released by the immune system to fight pathogens.  
   H. Correct. White blood cells have receptor proteins on their surface that bind to specific antigens.  
   J. Incorrect. Antigens are proteins found on the surface of viruses that match to receptor proteins on white blood cells.

3. A. Correct. The matching shapes fit together and allow interaction between the white blood cell and virus.  
   B. Incorrect. Structure A is produced by the virus and structure B is produced by the white blood cell.  
   C. Incorrect. Only the invading virus would have antigens indicating “non-self.”  
   D. Incorrect. Structure B is not produced by a virus, but by the white blood cell.

TAKS Doctor

1. A. Correct.  
2. F. Incorrect.  
3. A. Correct.

22. Immunologists are scientists who diagnose, treat, and research immunological diseases and disorders. Immunologists attend medical school after college. Immunologists work in private practice, in hospitals, and for pharmaceutical companies. The growth potential of the field is excellent. Starting salary will vary by region.