Immunity and Disease

How does the immune system help maintain the body’s homeostasis?

Your immune system protects your body against invaders. Notice the two small brown-yellow cells on the large green cell.

- Why might the small cells be attacking the large cell?
- How does your immune system help your body maintain homeostasis?
What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

1. Some diseases are infectious, and others are noninfectious.
2. Cancer is an infectious disease.
3. The immune system helps keep the body healthy.
4. All immune responses are specific to the invading germs.
5. Exercise and sleep can help keep you healthy.
6. Chemicals make you sick and should not be used.

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Lesson 1

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- Why do we get diseases?
- How do the two types of diseases differ?

Vocabulary

pathogen
pasteurization
infectious disease
vector
noninfectious disease
cancer

Diseases

A Bull’s-Eye?

Have you ever seen a bull’s-eye on someone’s skin? It is a rash caused by Lyme disease. The disease is spread by a tick like the one shown here.
Disease Through History

Imagine you are sick, and your doctor suggests scraping your skull with a rock until a hole is created, as shown in Figure 1. The doctor tells you that the hole in your skull will allow the cause of your illness to escape. Today you might think this was strange. But thousands of years ago, this was an accepted treatment for disease.

Today we know that many diseases are caused by bacteria and viruses. Disease-causing agents, such as bacteria and viruses, are called pathogens. Pathogens have always caused illnesses, but only in the last few hundred years has the relationship between pathogens and diseases been understood.

Before then little was known about disease and immunity, and superstitions were common. Today we know the hole-in-the-head treatment would be painful and would create an opportunity for even more pathogens to enter the body.

Launch Lab

**Which well is contaminated?**

Imagine that you live in a town with four wells. You get your water regularly from one well, but sometimes you also drink water from another well. People are getting sick. Some suspect the water in one well is causing the sickness. Which well is contaminated?

1. Take an envelope from your assigned well. Do not look inside the envelope.
2. Write your name on the envelope, and then pass it to another person from any well. You should also receive a different envelope from another person.
3. Repeat step 2.
4. Write your name on the third envelope and open it. If there is an “X” on the card inside, the three people who signed the envelope drank from the contaminated well and are sick. As a class, compile the results in a table.

**Think About This**

1. Which well was contaminated? How could you tell?
2. **Key Concept** What do you think you might do to stop the sickness from spreading?

**Word Origin**

*pathogen*

from Greek *pathos*, means “disease”

*Figure 1* Archaeologists have found skulls with smooth holes made while the patient was alive. Bone growth around the hole in this skull shows that the patient lived after the procedure.
Early Research on Diseases

Despite limited technology and equipment, doctors in the eighteenth and nineteenth centuries learned a lot about the causes and treatments of diseases. The research and experiments performed by a few scientists saved many lives.

First Vaccination

In 1796 a doctor in England named Edward Jenner developed the first vaccination—a procedure that helps the body defend itself against disease. Jenner knew that women who milked cows often developed a mild disease called cowpox. However, these women were resistant to the deadly disease smallpox. He made a cut in the arm of a young boy and inserted pus from a cowpox sore. Two weeks later, he infected the boy with smallpox, but the boy did not develop smallpox. Although the smallpox vaccination saved many lives, scientists did not understand why or how it worked.

Connecting Disease with a Source

In the mid-1800s people realized there was a connection between pathogens and disease. During this period, many people in London were dying from cholera, a bacterial disease of the intestinal tract. Dr. John Snow mapped outbreaks of the disease, as shown in Figure 2. He tracked the origin of one outbreak to a water pump. He had the pump closed, and new cases of cholera decreased immediately. John Snow thought a microscopic organism that he saw in the water—the cholera bacteria shown in Figure 2—caused the disease. Not everyone agreed, but people were beginning to think pathogens existed.
The Development of Microscopes

One of the reasons people were slow to accept the idea of pathogens was because they could not see them. The development of microscopes changed that. In the late 1600s, Dutch merchant Anton van Leeuwenhoek (LAY vun hook) made one of the first microscopes. He discovered bacteria in pond water, as illustrated in Figure 3. However, van Leeuwenhoek did not share how he made the lenses, so bacteria were not observed again until the nineteenth century.

Connecting Bacteria to Infections

When scientists first realized bacteria were present in wounds, they thought the wounds caused the bacteria to appear. When Louis Pasteur began doing experiments in the mid-1800s, he realized that this idea was backward. Instead, bacteria from outside the body caused the tissue in the wound to decay. Pasteur discovered that he could kill bacteria in boiling liquids. Pasteurization is the process in which a food is heated to a temperature that kills most harmful bacteria. It is based on the work of Pasteur.

Joseph Lister used Pasteur’s discoveries to make surgery safer for patients. He found that carbolic acid killed bacteria. He developed a misting system to spray carbolic acid throughout an operating room during surgery. Infection and death from surgeries decreased greatly. In the late 1800s, doctors improved on Lister’s idea. They used carbolic acid to sterilize tools before surgery and steam to sterilize the linens and clothes.

Reading Check  How did Lister make surgery safer?
Despite the research on bacteria in wounds, most people did not think bacteria could make a healthy person sick. In 1867, Robert Koch was one of the first scientists to argue that bacteria could cause illness in an animal as large as a cow. He developed a set of rules to determine if specific bacteria caused an illness. Koch’s rules are illustrated in Figure 4. The research based on these rules convinced most scientists that some bacteria were disease-causing pathogens. Although the roles of pathogens in disease are not as simple as Koch thought, current understandings are based on his findings.

Reading Check  What are Koch’s rules?

Bacteria are not the only pathogens that cause disease—viruses are others. However, they are so small that many years passed before scientists understood that viruses could be pathogens too. Some fungi and protists can also cause diseases. Some of the diseases in humans caused by different pathogens include the following:

- Viruses cause the flu, colds, chickenpox, and AIDS.
- Bacteria cause ear infections, strep throat, pneumonia, meningitis, whooping cough, and syphilis, a sexually transmitted disease.
- Fungi cause athlete’s foot, ringworm, and yeast infections.
- Protists cause malaria, African sleeping sickness, and dysentery.

Pathogens can be transmitted through food and water and carried by insects. They also can be passed directly among people by physical contact, sneezing, coughing, or exchange of bodily fluids. Some pathogens, such as the bacterium that causes syphilis, require a host to reproduce.
Types of Diseases

Have you ever heard anyone say they “caught” a cold? The common cold is contagious. This means that the pathogens that cause the common cold can be passed from person to person. Not all diseases are caused by pathogens. Your inherited traits are responsible for some diseases. Others can be caused by external factors, such as your environment and the choices you make about diet, exercise, and sleep.

Key Concept Check Why do we get diseases?

Infectious Diseases

Diseases caused by pathogens that can be transmitted from one person to another are infectious diseases. The way this happens can vary depending on the pathogen.

Flu and cold viruses can pass to others through direct contact, such as shaking hands. The human immunodeficiency virus (HIV) can pass through the exchange of blood or bodily fluids. HIV causes acquired immunodeficiency syndrome (AIDS), a disease that attacks the body system that fights pathogens.

The protist that causes malaria is transferred by a vector, a disease-carrying organism that does not develop the disease. The vector for malaria is a certain type of mosquito. The mosquito bites an animal that has the protist in its bloodstream. Then the pathogen enters the saliva of the mosquito but the mosquito does not develop malaria. When the mosquito bites another animal, the pathogen moves into that animal’s blood.

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How does an infectious disease spread through a population?

Imagine that one of the students in your class has a new disease, similar to a mild case of the flu. You can model the spread of this disease to indicate infection.

1. Read and complete a lab safety form.
2. Obtain a cup of clear liquid from your teacher.
3. Partner with another student in round 1. Pour the contents of your cup into his or her cup. Your partner should then pour the contents of his or her cup into your empty cup. Pour half the contents of your cup into your partner’s cup.
4. Repeat step 3 three more times with a different partner in each round.
5. Your teacher will add an indicator to your cup. If your liquid changes color, you are infected.

Analyze and Conclude

1. Determine how many students were infected in each round.

2. Key Concept Describe the pattern of how the number of infected persons changes as an infection progresses.
Diseases caused by genetic disorders are inherited.

**Visual Check** How many children inherited a gene for cystic fibrosis?

### Noninfectious Diseases

A disease that cannot pass from person to person is a **noninfectious disease**. For example, you cannot catch lung cancer from another person. Pathogens do not directly cause noninfectious diseases. Two common causes of noninfectious diseases include:

- genetics, or traits inherited in your DNA from your biological parents, and
- environmental conditions, including lifestyle choices.

In many cases of noninfectious disease, a person has a genetic trait for a disease that environmental conditions make worse. It is the combination of genetics and environment that causes the disease to develop.

### Childhood Diseases

Noninfectious diseases that affect children are primarily due to genetics. One genetic disease is cystic fibrosis. It causes the body to produce mucus thicker than normal. This affects breathing and other body functions. Children with cystic fibrosis inherit a form of the gene that causes this disorder. It is a recessive trait, which means a person must inherit the gene from each parent, as shown in Figure 5. The parents might not have the disease, but they each must carry at least one gene form, or allele (uh LEEL), for cystic fibrosis. Like many genetic disorders in children, environmental conditions can make the disease worse. A poor diet, air pollution, and lack of exercise can make the symptoms of cystic fibrosis worse.

### Inheritance of Cystic Fibrosis

![Diagram of cystic fibrosis inheritance](image)
Other Diseases  Many noninfectious diseases that affect adults are due primarily to environmental causes and life choices. For example, an unhealthful diet, obesity, a lack of regular exercise, and smoking cause most cases of heart disease. Osteoporosis is a disease in which bones become weak and less dense. People inherit a tendency to develop osteoporosis. However, years of poor lifestyle choices such as an unhealthful diet, lack of calcium and vitamin D, smoking, and a lack of exercise can all lead to weakened bones. There is also a type of diabetes that develops in adults that is strongly linked to environmental conditions, although there might also be a genetic link.

**Reading Check**  List some causes of noninfectious diseases.

**Cancer**  Tumors form when cells reproduce uncontrollably. **Cancer** is a disease in which cells reproduce uncontrollably without the usual signals to stop. For example, lung-cancer tumors form in the lungs and interfere with normal lung function. In **Figure 6**, notice the color difference of the lung that has not been functioning properly due to cancer. People can inherit forms of genes that make them more likely to develop lung cancer. However, if they are not exposed to such environmental conditions as poor air quality, or they do not smoke, they might not develop lung cancer.

**Key Concept Check**  How do infectious and noninfectious diseases differ?

**Review Vocabulary**  

- **vitamin**  nutrient needed for growth, regulation of body functions, and prevention of some diseases

**Figure 6**  Cancer cells in the lung form tumors and interfere with normal functioning.

**Visual Check**  Identify the differences between the healthy lungs and the diseased lungs.
Visual Summary

How a disease spreads depends on the pathogen. Some pathogens can be transmitted by a vector, such as a tick or a mosquito.

The two common causes of noninfectious diseases are environmental conditions and genetics.

People might inherit forms of genes that make them more likely to develop cancer.

Understand Key Concepts

1. List two main causes of disease.
2. Which is NOT a pathogen?
   A. bacterium  
   B. fungus  
   C. vector  
   D. virus

Interpret Graphics

6. Summarize Copy and fill in the table below using these terms: viruses, bacteria, unhealthful diet, smoking, protists, gene forms, fungus.

<table>
<thead>
<tr>
<th>Heredity</th>
<th>Environmental Conditions</th>
<th>Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tbody>
</table>

7. Explain the illustration below using one of Koch’s rules.

Critical Thinking

8. Design a plan to determine the source of a pathogen found in food.
9. Support the claim that genetics and environmental conditions can both contribute to a disease.
How would you prepare a work area for procedures that require aseptic techniques?

Aseptic techniques are methods used to prevent microbial contamination. Hospitals use aseptic techniques to reduce the risk of infection by microorganisms during surgery. Although their procedures might be less stringent than in an operating room, microbiologists also use aseptic techniques to prevent their work from becoming contaminated by unwanted microorganisms.

**Learn It**
You can practice aseptic techniques by disinfecting a bench top or desk. You will use a smooth, nonporous surface because rough surfaces are hard to clean and they provide many surfaces for microorganisms to grow.

**Try It**
1. Read and complete a lab safety form.
2. Thoroughly wash your hands. Then, wearing disposable gloves, prepare a bleach solution according to your teacher’s directions. Place the solution in a spray bottle.
3. Spray the entire work area and wipe it with a paper towel. Instead of drying the area with another paper towel, let it air dry. After disinfecting, do not recontaminate the area by touching or leaning over it.
4. Test the effectiveness of your cleaning procedure by using a black light. The invisible test solution your teacher applied will glow under the black light. In your Science Journal, draw a diagram to indicate the areas you missed.
5. Reclean the work area and check the effectiveness of your cleaning procedure again.
6. Thoroughly wash your hands after the activity.

**Apply It**
7. Some people think polished granite countertops are better for food preparation than rough tiles. Explain why this might be so.
8. **Propose** an argument to defend this statement: Hand washing is an essential part of aseptic techniques.

**Key Concept** How do aseptic techniques reduce the risk of infection and disease?

**Preparing a Work Area for Aseptic Procedures**

| **Wash your hands.** |
| **Choose an area with a smooth, dry surface.** |
| **Thoroughly disinfect the entire area.** |
| **Do not recontaminate.** |
Lesson 2

The Immune System

**Reading Guide**

**Key Concepts**

**Essential Questions**
- What does the immune system do?
- How do the parts of the immune system work together?
- How does the immune system interact with other body systems?

**Vocabulary**
- Inflammation
- Antigen
- Antibody
- B cell
- T cell
- Allergy
- Immunity
- Active immunity
- Vaccination
- Passive immunity

**Multilingual eGlossary**

- BrainPOP®
- What's Science Got to do With It?

**Inquiry**

**Mysterious Blobs?**

The large yellow blobs you see are bacteria. The bacteria grew after a human hand touched the red agar plate. With all that bacteria on your hand, what keeps you from getting sick? How does the body protect itself?
Can you escape the pox?
The loffpox disease is an imaginary disease. How might it affect you?

1. Your teacher will give you one of three cards: healthy, in poor health, or pox. Only one person will be given the pox card. Do not tell anyone which card you receive.

2. As you stand in a circle looking at each other, the person with the pox card will wink at the other students. If he or she winks at you and you have an in poor health card, you have caught the disease and you must sit down. If you have a healthy card, you do not catch the disease and you remain standing. However, if the person with the pox card winks at you a second time, you must sit down.

Think About This
1. Who is left standing?
2. Key Concept How does a person's state of health affect the pox disease? Why do you think it took the pox more than one wink to infect a healthy person?

Functions of the Immune System

Your body is constantly exposed to different pathogens. In Lesson 1 you read that disease-causing agents, such as bacteria and viruses, are pathogens. Pathogens also include fungi and protists. Pathogens are in the air, on objects, and in water. Like a spacesuit protects an astronaut, your immune system works to protect your body. There are many barriers to keep pathogens from entering your body.

Sometimes pathogens get past your body’s initial barriers. When this happens, your immune system also has defenses to stop any pathogens that get past the barriers. For example, there are cells in your body that can destroy the pathogens. The immune system interacts with other body systems and helps keep you healthy, even as the environment outside your body changes.

Key Concept Check What does the immune system do?

You can improve the effectiveness of these prevention methods by making healthful choices every day. Choices such as eating healthful food, getting enough sleep, exercising regularly, and using sunscreen support your immune system. As you read about the parts of the immune system, consider how the choices you make every day could affect how well your immune system functions.
How do different layers of your skin protect your body?

Your skin has three layers. The top layer, called the epidermis, is thin but tough. It helps prevent harmful microorganisms from getting into the tissues and provides physical protection. The middle layer, called the dermis, is the thickest layer. It provides strength and elasticity. The bottom layer, called the subcutaneous layer, insulates against heat and cold and helps cushion the skin. In this activity, you will build a model of skin.

MiniLab 20 minutes

Parts of the Immune System

Different parts of your body work together to keep pathogens from making you sick. The integumentary system (skin), the respiratory system, the circulatory system, the digestive system, and the nervous system all work with the immune system and protect you against disease.

First-Line Defenses

Keeping germs from reaching the parts of your body where they can make you sick is the function of first-line defenses. Skin, hair, mucus, and acids are first-line defenses. They are effective against many types of pathogens. An immune defense that protects against more than one type of pathogen is a nonspecific defense.

Skin

Often, the first nonspecific defense that protects you from pathogens is your skin, as shown in Figure 7. Your skin keeps dirt and germs from entering your body. Sweat and acids from skin cells kill some bacteria. Natural oils make skin waterproof so you can easily wash it.

You encounter pathogens every day, but your skin stops most of them from entering your body. Pathogens, such as cold and flu viruses, can survive for short periods on objects such as doorknobs or telephones. When you touch these objects, the pathogens can be transferred to your hand. If they reach your mouth, nose, eyes, or a cut, they can enter your body. Washing your hands often with soap and water easily removes most pathogens from your skin.

Your skin protects you from other dangers. It forms a chemical called melanin that protects you from the Sun’s ultraviolet (UV) rays. Nerve endings in your skin can help you sense the warmth of a stove or the sharpness of a pin to protect you from injury.

Reading Check

Why is your skin considered a first-line defense?
Respiratory System  You can inhale pathogens from the air through your nose or mouth. The hairs in your nose help protect you by trapping dirt and pathogens. This keeps them from reaching the rest of your respiratory system. Small hairlike structures called cilia, shown in Figure 7, also trap pathogens and move them up and out of the upper respiratory system. If pathogens get past the cilia, they might encounter mucus. Mucus traps pathogens and enables your respiratory system to remove them by coughing, sneezing, or swallowing.

Digestive System  Pathogens can enter your digestive system on or in the food you eat. The digestive system is effective at stopping bacteria from making you seriously ill. The stomach, also shown in Figure 7, contains strong acids. Stomach acids destroy many pathogens. Like the mucus in the respiratory system, mucus in the digestive system traps disease-causing bacteria and viruses, too.

Sometimes when you feel nauseated, it is actually your immune system clearing your body of pathogens. When disease-causing bacteria are not destroyed by stomach acids, your digestive system can reverse the usual direction of muscle contractions, and you vomit. Other times, muscle contractions speed up, and pathogens are removed through diarrhea.

Reading Check  List ways the digestive system helps defend against pathogens.

Figure 7  The skin, the respiratory system, the digestive system, and the circulatory system all support the immune system to provide the first line of protection against disease-causing pathogens. Blood vessels and white blood cells throughout the body help protect from pathogens.

Visual Check  How does the respiratory system trap pathogens?
Circulatory System and Nervous System  Your circulatory system also protects you from pathogens. Pathogens can be moved through the circulatory system to organs that fight infection. The nervous system and the circulatory system also work together and increase the body's temperature to fight pathogens more effectively. Certain foreign substances trigger the brain to increase body temperature. When this occurs, blood vessels narrow and a fever develops. Many pathogens cannot survive at this higher temperature. For those that do survive, the fever brings another line of defense. The fever also stimulates white blood cells, which are part of the second-line defenses against pathogens.

Second-Line Defenses

Sometimes pathogens get past the defenses of the skin, the respiratory system, the digestive system, and the circulatory system. When they do, the next line of defense goes into action. Like the first-line defense, second-line defenses are nonspecific, fighting against any type of pathogen.

White Blood Cells  Recall that the spongy tissue in the center of your bones is called bone marrow. This is where white blood cells form. These cells attack pathogens. White blood cells flow through the circulatory system. However, they do most of their work attacking pathogens in the fluid outside blood vessels. They fight infection several different ways. Some white blood cells, such as the one shown in Figure 8, can surround and destroy bacteria directly. Others release chemicals that make it easier to kill the pathogens. Another type of white blood cell produces proteins that destroy viruses and other foreign substances that get past the first-line defenses.

**Figure 8** White blood cells fight pathogens that get past the first-line defenses. This white blood cell can digest pathogens and damaged cells.
When skin is torn or cut, the damaged tissue triggers the inflammatory response. Special cells called mast cells release chemical signals into the surrounding tissue.

Some chemical signals attract more white blood cells to the area. Other chemical signals cause the capillary to dilate. White blood cells and plasma leak into the tissue, causing swelling.

The white blood cells surround and take in the bacteria and any dead cells. As the tissue heals, the white blood cells and the plasma flow back into the capillary, and swelling decreases. The area returns to normal.

**Inflammatory Response** When you have an injury, your body produces an inflammatory response, causing inflammation. **Inflammation** is a process that causes the area to become red and swollen. If the injury is to the surface of the skin, you can observe the inflammatory response, as shown in Figure 9. First, damaged cells release a protein that signals the capillaries to dilate, or widen. Blood flow to the area increases and the injury site becomes red and warmer than the surrounding area. Second, plasma and white blood cells leak into the area, causing swelling. Third, the white blood cells break down damaged cells and destroy any bacteria that might have entered the wound. The inflammatory response cleans the area of the injury and keeps the infection from spreading. The inflammation enables the damaged tissue to heal.

**Reading Check** Explain the inflammatory response.
Third-Line Defenses

If first- and second-line defenses do not destroy all invading pathogens, another type of immune response occurs. Third-line defenses are specific to foreign substances. Often the three lines of defense work together.

Antigens and Antibodies

An antigen is a substance that causes an immune response. An antigen can be on the surface of a pathogen. Proteins called antibodies can attach to the antigen and make it useless. Certain white blood cells, called B cells and T cells, form antibodies. B cells form and mature in the bone marrow and secrete antibodies into the blood. T cells form in the bone marrow and mature in the thymus gland. They produce a protein antibody that becomes part of a cell membrane. Antibodies match with specific antigens, as shown in Figure 10. Once your body has developed antibodies to an antigen, it can respond rapidly when the same pathogen invades your body again. This information is stored in antibodies on white blood cells called memory B cells.

Key Concept Check

How do the parts of the immune system work together?

An allergy is an overly sensitive immune response to common antigens. Most people do not produce antibodies to the proteins in dog saliva. However, the antigens in dog saliva do cause some people to have an immune response. These people have an allergy. Their bodies treat the dog saliva as if it were a pathogen. Inflammation and increased mucus production are common immune responses for people with allergies.
Immunity

The resistance to specific pathogens is immunity. There are two types of immunity—active immunity and passive immunity.

Active Immunity Your body produces antibodies in response to an antigen in active immunity. Your body recognizes the antigen, and the matching antibodies respond quickly. You can develop active immunity through illness or infection. After an illness or an infection is over, antibodies remain in your body. Because of this, you usually get certain diseases, such as chicken pox, only once. However, you can catch a cold many times because many different cold viruses cause similar symptoms.

You can also develop antibodies if you are exposed to an antigen through a vaccination. A vaccination is weakened or dead pathogens placed in the body, usually by injection or by mouth. A vaccination causes the body to develop specific antibodies that can rapidly fight a pathogen’s antigens when exposed to them. Table 1 lists the effects of vaccinations on the average annual number of cases of some diseases.

Passive Immunity You can also become resistant to specific antigens through passive immunity. Passive immunity is the introduction of antibodies that were produced outside the body. A fetus can get antibodies from its mother. Injections of some antibodies are available for adults. Passive immunity is temporary—the body does not continue to make these antibodies.

The Immune System and Homeostasis

You are exposed to many different pathogens every day. The immune system works to maintain your body’s homeostasis. Body systems, including the circulatory system and respiratory system, work together and protect against invaders.

Key Concept Check How does the immune system interact with other body systems?

<table>
<thead>
<tr>
<th>Disease</th>
<th>Cases Before Vaccination (annual average in the United States)</th>
<th>Year Vaccination Was Developed</th>
<th>Cases After Vaccination (annual average in the United States)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetanus</td>
<td>1,300</td>
<td>1927</td>
<td>34</td>
</tr>
<tr>
<td>Polio</td>
<td>18,000</td>
<td>1955/1962</td>
<td>8</td>
</tr>
<tr>
<td>Measles</td>
<td>425,000</td>
<td>1963</td>
<td>90</td>
</tr>
<tr>
<td>Mumps</td>
<td>200,000</td>
<td>1967</td>
<td>610</td>
</tr>
<tr>
<td>Rubella</td>
<td>48,000</td>
<td>1970</td>
<td>345</td>
</tr>
</tbody>
</table>

Use Percentages

Table 1 shows that the number of tetanus cases fell from 1,300 cases before the vaccine was developed to 34 cases after the vaccine was developed. What percent change does this represent?

Subtract the starting value from the final value.

\[34 - 1,300 = -1,266\]

Note that the value is negative because the number of cases decreased.

Divide the difference by the starting value.

\[-1,266 \div 1,300 = -0.974\]

Multiply the answer by 100 and add a percent sign.

\[-0.974 \times 100 = -97.4\%\]

Practice

Based on the data in Table 1, what was the percent change in the cases of polio after the vaccine was discovered?

Review

• Math Practice
• Personal Tutor
Use Vocabulary
1. Distinguish between active immunity and passive immunity.
2. The _______ response includes swelling and heat near injured tissue.
3. Define the term vaccination in your own words.

Understand Key Concepts
4. List three body systems that work with the immune system to form first-line defenses.
5. Which is a first-line defense?
   A. antibody  C. inflammation
   B. hormone  D. skin
6. Explain why antibodies are considered specific responses to pathogens.

Interpret Graphics
7. Summarize Copy and fill in the graphic organizer below to summarize the steps in the inflammatory response.

Critical Thinking
8. Predict what might happen to a person who had very few of the type of cell shown at right.

Math Skills
9. The number of diphtheria cases fell from 175,000 cases before the vaccine to one case after the vaccine was developed. What percent change does this represent?
Vaccines are helping win the war against viruses.

Until recently, having chicken pox was just a part of growing up. The disease commonly occurs in children, usually before the age of 15.

Chicken pox is highly contagious, passing easily from person to person. The chicken pox virus, varicella-zoster, produces a rash of red spots and small blisters that can appear all over the body. The fluid-filled blisters crust over and become very itchy. Within a few days, the spots and blisters disappear. It takes about one week for the disease to run its course.

Chicken pox is contagious beginning 1–2 days before the rash appears until all the blisters form scabs. During this period, the virus can be spread through direct contact with the sores or through the air. Those who have not had chicken pox can become infected easily.

In 1995, a chicken pox vaccine was introduced in the United States, and the number of cases of chicken pox reported each year has declined sharply. It is estimated that almost 80 percent of young children develop immunity after one dose of vaccine. Over 90 percent of older children and adults develop immunity after the second dose.

REPORT Identify three diseases that were common 50 years ago but are not common today due to vaccines. Write a report about the diseases, when vaccines were developed against them, and how the incidences of the diseases changed.
Why Wash?

Why do surgeons wash their hands before an operation even though they wear gloves? Can hand washing keep you healthy?
Healthful Habits

Imagine you are sitting in class, and the person next to you sneezes. Fortunately, she covers her nose and mouth with her hand. After sneezing, she picks up a pencil. Just then, you realize you need to borrow a pencil. She hands you her pencil. Will you get her cold? What could you do to make that less likely?

Pathogens passed from person to person make infectious diseases such as colds and flu very common. Personal hygiene can limit the spread of these pathogens. For example, good hygiene includes using a tissue or handkerchief when you sneeze and then washing your hands. This lessens the chance you will spread your germs to others. Good hygiene can protect you from getting an infectious disease, too.

Pathogens are less likely to get past your first-line defenses if you wash your hands before you eat and avoid putting objects, such as pencils, in your mouth. Why do you think surgeons scrub their hands, as shown in the lesson opener photo, even though they wear gloves during surgical procedures?
Healthful Choices

In addition to good personal hygiene, other everyday choices, like those shown in Figure 11, can help keep you healthy. Choices that affect environmental conditions can also protect you from many infectious and noninfectious diseases.

**Diet**  Think about the foods you ate this week. If you eat a healthful diet, your immune system can react more efficiently against pathogens. A healthful diet can even protect you against noninfectious diseases such as osteoporosis and heart disease. A healthful diet, a healthful weight, and regular exercise have been linked with overall disease prevention.

**Reading Check**  How can a healthful diet protect against disease?

**Sun Protection**  Skin cancer is a noninfectious disease. The ultraviolet (UV) rays from the Sun damage skin cells and can cause them to reproduce uncontrollably. Sunscreen blocks the UV rays and limits the damage from sunlight. Wearing a hat, long sleeves, pants, and sunglasses also helps protect you against UV damage.

**Alcohol and Tobacco**  Lung cancer is one of the most deadly cancers. Most cases of lung cancer are related to smoking or working in environments with poor air quality. Many other cancers are related to excessive drinking of alcohol and to smoking. Healthful choices include not smoking or chewing tobacco and limiting or avoiding alcoholic beverages.

**Key Concept Check**  How can healthful habits and healthful choices affect diseases?
Health and Sanitation

Improved cleanliness in schools, hospitals, and public areas has increased overall health in our communities. In the mid-1800s, hospitals were dirty, overcrowded places. Patients were rarely bathed, and linens were rarely washed. Pathogens caused infections in most patients. One nurse, Florence Nightingale, is credited with improving cleanliness in hospitals. She understood there was a connection between cleanliness and health.

Food Preparation

Improved sanitation in food preparation has also led to better health. Employees must wash their hands regularly, as indicated in Figure 12, and keep equipment clean. Inspections are performed regularly to catch problems early and protect consumers from most pathogens.

Waste Management

In the mid-1300s, there were no plumbing or sewer systems. People in European cities often dumped their personal waste and garbage in the streets. Today modern landfills and sewer systems keep our streets and households much cleaner. This cleanliness slows the spread of infectious diseases.

Key Concept Check How do sanitation practices affect human health?

How clean are your hands?

Washing your hands properly can keep you from getting sick or spreading illnesses. How clean are your hands after you wash them?

1. Read and complete a lab safety form.
2. Have your partner thoroughly cover both of your hands, including your wrists and under your fingernails, with washable paint. Let your hands dry for 2 minutes.
3. Hold your hands over a sink. Have your partner put a drop of liquid soap on one of your hands and turn on the warm water. Have your partner cover your eyes with a bandana.
4. Wash your hands for 20 seconds. Have your partner remove the bandana from your eyes. Have him or her draw your hands on a sheet of paper and record any areas that still have paint.
5. Wash any remaining paint from your hands.
6. Switch roles and repeat steps 2–5.

Analyze and Conclude

1. Describe how well you washed your hands.
2. Key Concept Explain why hand washing is important to keep from getting sick or spreading disease.
Health and Chemicals

Chemicals, like those shown in Figure 13, can be beneficial for people. Some chemicals, such as the ones in sunscreen that block UV rays, protect us from noninfectious diseases. Chemicals used to make vitamin supplements improve nutrition, which helps the immune system fight disease.

Other chemicals are used in medicines. Antibiotics are medicines that stop the growth and reproduction of bacteria. Chemicals are also used to destroy cancer cells. These medicines, used in a type of treatment called chemotherapy, kill the cells that are reproducing uncontrollably.

These and many other chemicals, such as paints and pesticides, might make lives easier. But if they are not disposed of properly, they can harm our health. Some people choose to use chemicals that are harmful to health. For instance, more than 50 of the chemicals in cigarettes have been linked to cancer.

Health and the Environment

Some chemicals that are harmful to our health, such as lead, are in our environment. Before 1978, lead was used in many paints. If the dried paint flaked, it released lead into the air. Inhalation lead-contaminated air can cause noninfectious kidney and nervous system diseases.

Some objects containing harmful chemicals are safe until the object is broken. For example, when ceiling and floor tiles containing asbestos are broken, asbestos fibers are released. People who are often exposed to such chemicals might develop cancer.

Key Concept Check  How can chemicals affect the human body?
Lesson 3 Review

Visual Summary

Developing healthy habits and making healthful choices is one of the best ways you can stay healthy.

Chemicals are used in medicines such as antibiotics. These may be used for common bacterial infections, such as strep throat or ear infections.

Life choices, such as whether or not you eat a healthful diet, can influence the development and severity of diseases.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

Use Vocabulary

1. A treatment that uses chemicals to kill cancer cells is called ________.

2. Medicines that kill bacteria are called ________.

Understand Key Concepts

3. List two healthful life choices.

4. Which chemical can be harmful to your health?
   A. antibiotic  C. sunscreen
   B. asbestos  D. vitamin

Interpret Graphics

5. Examine the photo on the right and identify the healthful practices you see.

6. Create a table like the one below. In the first column, list four chemicals or materials containing chemicals. In the second column, indicate whether the chemical is beneficial or harmful. In the third column, describe how the chemical benefits or harms people.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Beneficial or Harmful?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Critical Thinking

7. Justify Imagine you are Florence Nightingale. Justify your plan to increase cleanliness in hospitals.

8. Evaluate your personal hygiene in your daily routine. What could you do to limit your exposure to pathogens?
Can one bad apple spoil the bunch?

Just like your skin protects the tissue underneath from infection, an apple’s skin protects the inside of the apple from infection by harmful organisms.

**Question**
How is an apple’s skin like your skin?

**Procedure**

1. Read and complete a lab safety form.
2. Use aseptic techniques to prepare your work area. Wash your hands, thoroughly disinfect the entire work area, and do not recontaminate. Put on gloves.
3. Label the plastic bags 1 through 5. Take a picture of a fresh apple. Place the apple in bag 1.
4. Insert a cotton swab into the decayed tissue from the rotting apple. Spread the tissue on a fresh apple and let it dry. Take a picture of the apple. Place the apple in bag 2.
5. Use the end of a potato peeler to carefully make two holes about 2 cm in diameter in the peels of the remaining three apples. Take a picture of one apple with holes. Place the apple in bag 3.
6. Insert a cotton swab into the decayed tissue of the rotten apple and then into one hole in one of the remaining apples. Repeat for the remaining holes in the last two apples. Take a picture of one apple. Place the apple in bag 4.
7 Use a cotton swab to disinfect the holes in the last apple with rubbing alcohol. Take a picture of the disinfected apple. Place the apple in bag 5.
8 Seal all bags and put them in a dark place.
9 After 3 days, note the condition of each apple. Do not open the plastic bags. In your Science Journal, record your observations in a data table like the one shown at right. Take a picture of each apple.
10 After 7 days, repeat step 10.

**Analyze and Conclude**

11 Describe How does each apple look at the start of this activity, after 3 days, and after 7 days?
12 Explain What are the differences in the conditions of the apples?
13 The Big Idea Relate what you have learned about rotting in apples to how the immune system protects humans from infection and helps maintain homeostasis.

**Communicate Your Results**

Display your data on a poster. Include the photos of each of the apples at the beginning of the activity, after 3 days, and after 7 days.

**Lab Tips**

- Remember that hand washing is an important part of aseptic techniques.
- Use good aseptic techniques to prepare your work area prior to this lab.

**Apple Observations**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Day 3</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh, no decay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh with decay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holes, no decay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holes with decay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holes with decay and rubbing alcohol</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Extension**

There are other factors that contribute to apples rotting besides infection by microorganisms. How can you tell if the rotting in this case was caused by microorganisms or other factors? Propose a study using microscope observations that might help establish the role of microorganisms in rotting fruit.
## Chapter 16 Study Guide

### The Big Idea

The immune system protects the body against infections and diseases.

### Key Concepts Summary

#### Lesson 1: Diseases
- Diseases can result from infection by **pathogens**, heredity, or the environment.
- **Infectious diseases** are caused by pathogens and are spread from an infected organism or the environment to another organism. **Noninfectious diseases** are not caused by pathogens and are not spread from one organism to another.

#### Lesson 2: The Immune System
- The immune system protects against and defends the body from disease.
- Your body has first-line, second-line, and third-line defenses against pathogens.
- The immune system works with other body systems, including the circulatory system, the respiratory system, and the digestive system, to protect against invaders.

#### Lesson 3: Staying Healthy
- Healthful habits, such as hand washing, can help prevent the spread of disease. Life choices, such as whether or not you eat a healthful diet or wear sunscreen, can influence the development and severity of diseases.
- Sanitation practices, such as safe food preparation and waste management, limit human exposure to pathogens and toxic substances.
- Chemicals can benefit human health when used as medicines, treatments for disease, and supplements. Some chemicals are harmful to human health and might cause diseases such as cancer.

### Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>pathogen</td>
<td>The cause of disease in an infectious disease.</td>
</tr>
<tr>
<td>pasteurization</td>
<td>Process of heating food to kill disease-causing</td>
</tr>
<tr>
<td>infectious disease</td>
<td>Pathogen-caused disease.</td>
</tr>
<tr>
<td>vector</td>
<td>Agent that carries disease from one host to</td>
</tr>
<tr>
<td>noninfectious disease</td>
<td>Disease not caused by pathogens and not spread</td>
</tr>
<tr>
<td>inflammation</td>
<td>Response of the body to injury or irritation.</td>
</tr>
<tr>
<td>antigen</td>
<td>Substance that stimulates an immune response.</td>
</tr>
<tr>
<td>antibody</td>
<td>Proteins produced by the immune system in</td>
</tr>
<tr>
<td>B cell</td>
<td>A type of white blood cell.</td>
</tr>
<tr>
<td>T cell</td>
<td>Another type of white blood cell.</td>
</tr>
<tr>
<td>allergy</td>
<td>Abnormal immune response to an harmless</td>
</tr>
<tr>
<td>immunity</td>
<td>State of being protected against disease.</td>
</tr>
<tr>
<td>active immunity</td>
<td>Immune response to an infection.</td>
</tr>
<tr>
<td>vaccination</td>
<td>Exposure to a disease-causing agent to protect</td>
</tr>
<tr>
<td>passive immunity</td>
<td>Immune response to an injection of body's own</td>
</tr>
<tr>
<td>antibiotic</td>
<td>Substance used to kill or inhibit bacteria.</td>
</tr>
<tr>
<td>chemotherapy</td>
<td>Treatment using drugs or other substances to</td>
</tr>
</tbody>
</table>

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### WebQuest

[Access WebQuest](#)
Use Vocabulary

1. A disease in which cells multiply uncontrollably is called ________.
2. Use the term vector in a sentence.
3. Define pasteurization in your own words.
4. Distinguish between antibodies and antigens.
5. In your own words, define immunity.
6. An overly sensitive immune response to common antigens is a(n) ________.
7. Use the term antibiotics in a sentence.
8. Differentiate between antibiotics and chemotherapy.

Link Vocabulary and Key Concepts

Copy this concept map, and then use vocabulary terms from the previous page to complete the concept map.
Chapter 16 Review

Understand Key Concepts

1. Which part of the blood plays the most direct role in fighting pathogens?
   A. plasma
   B. platelets
   C. red blood cells
   D. white blood cells

2. What is illustrated below?
   A. Bacteria can be treated with heat.
   B. Bacteria do not infect other animals.
   C. Bacteria cause disease in healthy animals.
   D. One type of bacteria causes several different diseases.

3. Which has NOT led to improved health?
   A. cleaner hospitals
   B. lead paint
   C. better waste management
   D. cleaner food preparation tools

4. Which chemical might be helpful to the human body?
   A. asbestos
   B. antibiotic
   C. lead
   D. pesticide

5. Which is NOT part of the nonspecific, first-line defenses against pathogens?
   A. antibody
   B. cilia
   C. mucus
   D. skin

6. Inflammation is a common response to pathogens. Which would NOT be a common part of the inflammatory response at the site of an injury?
   A. bruising
   B. reddening
   C. swelling
   D. warmth

7. Why is the invention shown below considered one of the most important developments in early disease research?
   A. It showed people how to pasteurize liquids.
   B. It showed people that vaccines were effective.
   C. It showed people that microorganisms existed outside of wounds.
   D. It showed people that some diseases had a genetic component.

8. Which is NOT a healthful lifestyle choice?
   A. exercising regularly
   B. smoking cigarettes
   C. using sunscreen
   D. washing hands

9. Which is true about John Snow’s research?
   A. He developed the first vaccine.
   B. He invented the first microscope.
   C. He made surgery safer for patients.
   D. He mapped a cholera outbreak.

10. Which is caused by a virus?
    A. chicken pox
    B. malaria
    C. pneumonia
    D. ringworm
Critical Thinking

11 Compose a letter to explain the causes and symptoms of cystic fibrosis to a friend of the family who is concerned about his or her child developing cystic fibrosis.

12 Role-Play Choose the most important researcher from among John Snow, Joseph Lister, Robert Koch, and Edward Jenner. Defend your choice.

13 Evaluate the following statement, using the data in the table below to support your conclusion: Every person has not been vaccinated for common diseases, such as tetanus, polio, measles, mumps, and rubella.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Rate Before Vaccination</th>
<th>Rate After Vaccination Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetanus</td>
<td>1,300</td>
<td>34</td>
</tr>
<tr>
<td>Polio</td>
<td>18,000</td>
<td>8</td>
</tr>
<tr>
<td>Measles</td>
<td>425,000</td>
<td>90</td>
</tr>
<tr>
<td>Mumps</td>
<td>200,000</td>
<td>610</td>
</tr>
<tr>
<td>Rubella</td>
<td>48,000</td>
<td>345</td>
</tr>
</tbody>
</table>

14 Categorize these parts of the immune system as first-line, second-line, or third-line defenses: cilia, white blood cells, antibodies, skin, mucus, inflammation.

15 Plan and implement a survey to determine when and how often the students in your class wash their hands.

16 Design and create a poster to remind the students in your school to make healthful life choices.

17 Write a paragraph analyzing the differences in the causes of most childhood noninfectious diseases compared to other noninfectious diseases.

18 Explain how the immune system helps the body maintain homeostasis.

19 The photo below shows a cancer cell being attacked by T cells. How does your immune system react when it detects an invader?

Use Percentages

20 The average annual number of rubella cases before the vaccine was developed was 48,000. There were 345 cases after the vaccine was developed. What percent change does this represent?

21 The average annual number of cases before vaccines were developed was 425,000 for measles and 200,000 for mumps. After the vaccines were developed, there were 90 cases of measles and 610 cases of mumps. Which vaccine was most effective in reducing cases of the disease?
Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

**Multiple Choice**

1. Which would a doctor exclude as the cause of her patient’s noninfectious disease?
   - A. environmental conditions
   - B. inherited traits
   - C. lifestyle choices
   - D. transmitted pathogens

2. What are the Y-shaped objects in the diagram?
   - A. antibodies
   - B. antigens
   - C. bacteria
   - D. pathogens

3. Which first-line defense systems use acids to kill pathogens?
   - A. circulatory and respiratory
   - B. digestive and integumentary
   - C. nervous and circulatory
   - D. respiratory and digestive

4. Which is directly linked to increased risk of skin cancer in humans?
   - A. acid rain
   - B. asbestos insulation
   - C. sunlight exposure
   - D. water pollution

5. Which does 1 in the diagram represent?
   - A. host cell
   - B. mast cell
   - C. sheath cell
   - D. stem cell

6. In stage 2 of the inflammatory response, white blood cells and plasma leak into the area. What happens as a result?
   - A. bacteria destruction
   - B. capillary dilation
   - C. protein release
   - D. tissue swelling

7. How does sanitation improve health?
   - A. aids white blood cell production
   - B. increases vitamin absorption
   - C. reduces pathogen exposure
   - D. stimulates blood circulation

8. How do vitamin supplements contribute to health?
   - A. They block UV rays.
   - B. They improve nutrition.
   - C. They kill bacteria.
   - D. They kill cancer cells.
Use the table below to answer question 9.

| Bacteria are present in ALL organisms with the disease but NOT in healthy organisms. |
| Bacteria must reproduce in the lab. |
| Sample of bacteria must cause disease in healthy animals. |
| Lab-grown pathogen is identical to original. |

9 Which scientist developed the rules in the table above?
A Koch  
B Lister  
C Pasteur  
D Snow

10 What kills bacteria in the pasteurization process?
A antiseptic  
B heat  
C isolation  
D pressure

11 What is a disease-carrying organism that does NOT develop the disease?
A antigen  
B B cell  
C T cell  
D vector

Constructed Response
Use the diagram below to answer questions 12 and 13.

12 Based on the diagram above, why is cystic fibrosis a noninfectious disease? Use the terms allele and recessive trait to describe how someone contracts this disease.

13 Why might the parents in the diagram above be unaware that their children could contract cystic fibrosis? Suppose the parents had only one child. Will that child have cystic fibrosis? Explain.

14 List three sanitation practices. How do they promote health?

15 Explain the difference between active and passive immunity. How do vaccinations contribute to human immunity?