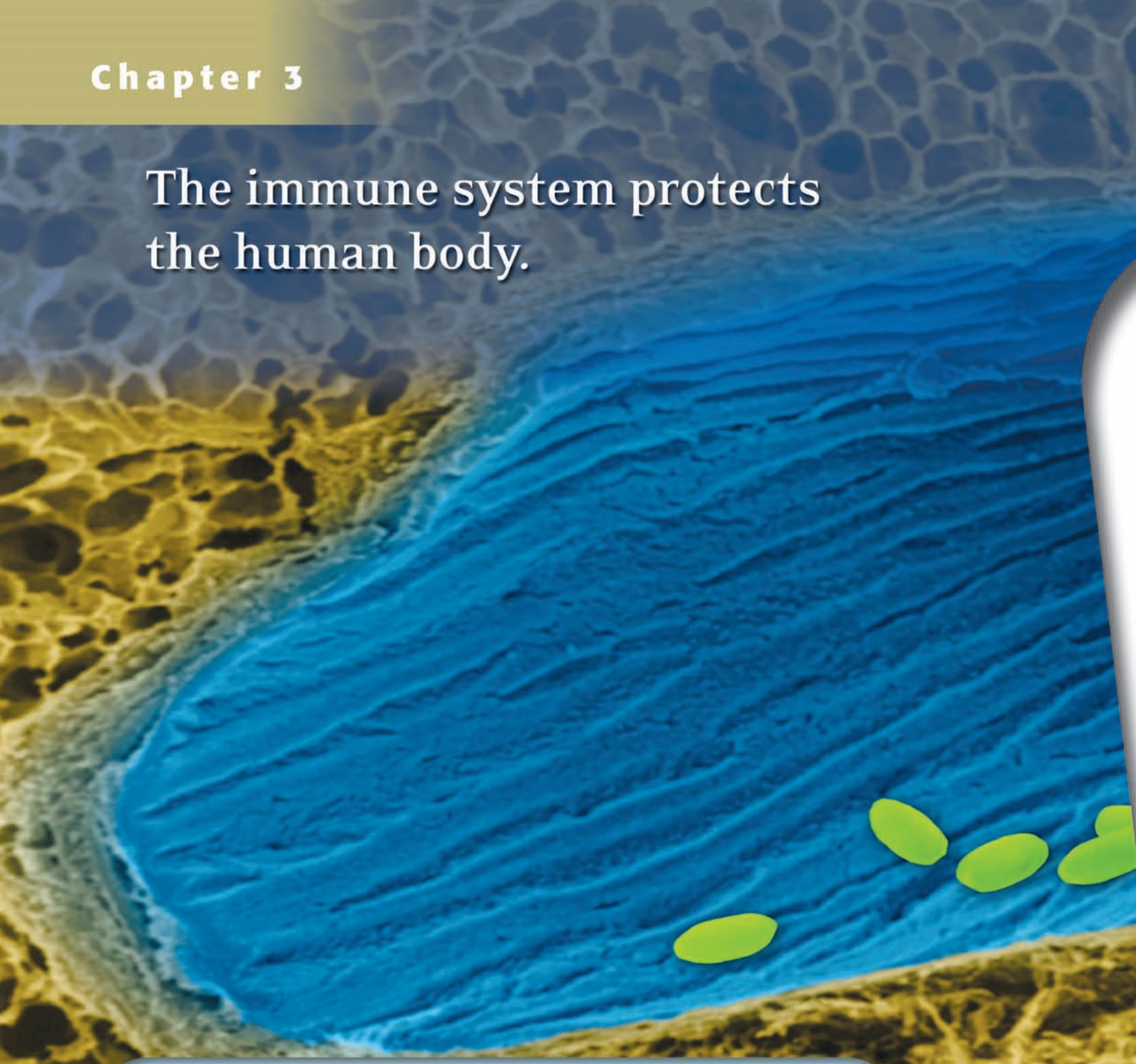
Chapter 3

The immune system protects the human body.



Every day your body is constantly under attack by disease-causing invaders, such as the common cold virus and bacteria in your surroundings. What keeps you from always getting sick? Your immune system does. The immune system is a powerful defender against disease-causing invaders. It would launch a fierce attack against the bacteria anthrax shown here invading a bronchiole. Anthrax bacteria occur naturally in soil and water and can cause serious illness or death in animals or humans unless they can be overcome by the immune system, usually with the aid of antibiotics.

What You Will Learn

In this chapter, you will

- **explain** how the immune system functions, including the roles of the primary and secondary defence systems
- **describe** factors that can have a negative effect on the immune system
- **describe** factors that can have a positive effect on the immune system

Why It Is Important

Understanding the immune system will help you appreciate how your body fights pathogens to protect your health and how you can keep your immune system healthy throughout your life.

Skills You Will Use

In this chapter, you will

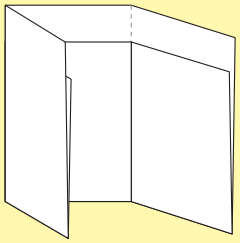
- **communicate** how the immune system functions
- **evaluate** information about various immune system disorders

FOLDABLES™
Reading & Study Skills

Make the following Foldable to take notes on the immune system.

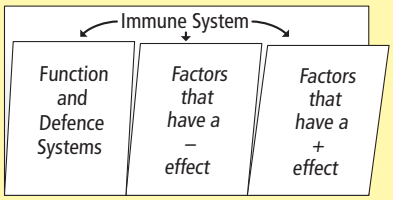
STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 3 cm longer than the front edge.

STEP 2 **Turn** the paper so the fold is on the bottom. Then, **fold** it into thirds.



STEP 3 **Unfold** and cut only the top layer along both folds to make three tabs.

STEP 4 **Label** the Foldable as shown.



Read and Write As you read this chapter, organize your notes on the immune system under the appropriate tabs.

3.1 The Immune System

Infectious diseases are caused by pathogens. The immune system attacks and destroys invaders such as pathogens and antigens that enter the body. There are two lines of defence. The first line of defence is the skin and the linings of the body's internal systems. The second line of defence has two parts: innate and acquired. An innate, or built-in, response is quick and general; an acquired response is slower and specific. In the acquired response, the immune system makes specific antibodies that attach to antigens and destroy them. The acquired response involves B cells, helper T cells, killer T cells, and memory B cells.

Key Terms

antibodies
antigen
immune system
pathogens
white blood cells

One hundred and fifty years ago, having surgery was a very dangerous experience (Figure 3.1). Even if a patient survived the operation, she or he had a 50 percent chance of dying soon after. And no one knew why.

Around this time, a British surgeon named Joseph Lister began to look for an explanation of the high death rate. He came across some interesting research suggesting that invisible organisms in the air might be the cause. What if these "germs," or disease-causing invaders called **pathogens**, were being passed to wounds from doctors' hands and from medical equipment such as scalpels and clamps? He developed a hypothesis: If medical equipment is sterilized to kill the pathogens, then the death rate after surgery will be reduced.

Today, this idea is common knowledge, but then it seemed very strange. Lister decided to test his hypothesis. He asked surgeons to wash their hands and equipment in a strong antiseptic before surgery. Many doctors found this suggestion ridiculous, but they agreed to go along with it for "scientific research purposes." To their surprise, the death rate at Lister's hospital fell significantly. Clearly, his ideas were correct. Disease-causing organisms and substances are everywhere and can infect people with a range of **infectious diseases**. Today, we still follow Lister's general guidelines to reduce infection in hospitals and in our homes. Table 3.1 on the next page shows the four general categories of transmission for infectious diseases.

Did You Know?

In the mid-1300s, 25 million people in Europe died of plague. The plague was caused by a bacterial pathogen carried by rats and the fleas found on rats.

Figure 3.1 Surgery around 1850 was performed with unsterilized instruments, and surgeons rarely washed their hands before operating.

Table 3.1 Four Ways to Transmit Infectious Diseases

Transmission Method	Example
Direct contact	Shaking hands or sharing drinking containers or bodily fluids with an infected person (Figure 3.2).
Indirect contact	Being near an infected person who sneezes without covering his or her mouth. Some pathogens can travel up to 5 m and infect people within that range.
Water and food	Eating foods, such as eggs and some meats, that are infected with *Salmonella* bacteria. Drinking water infected with *E. coli* bacteria can also result in serious illness.
Animal bites	Being bitten by an animal carrying the rabies virus.

Figure 3.2 Sharing a water bottle with someone can transmit pathogens, such as viruses.

3-1 Pass It On

Find Out ACTIVITY

In this activity, you will conduct a simulation to show how a pathogen can be transmitted. Your fictional pathogen causes coughing and other flu-like symptoms, and can be transferred by a handshake. When you have finished "shaking hands," your teacher will test your samples to identify who the pathogen was transmitted to.

Safety

- Use care when handling glassware.

Materials

- class set of glasses half filled with clear liquid
- medicine dropper
- pathogen tester (phenolphthalein indicator)

What to Do

1. Collect one glass of clear liquid and one medicine dropper from your teacher. Only one glass in the class set will contain the "pathogen."
2. Find a classmate and "shake hands." This means you take one dropper full of liquid from your glass and place it in the other person's glass. Your classmate does the same. Record the name of the person you interacted with.
3. Repeat this process with 10 different classmates and record their names.
4. Your teacher will test each of your samples for presence of the pathogen.

What Did You Find Out?

1. Record how many students in your class were infected with the pathogen. Are you surprised by this result? Explain why.
2. Your teacher will tell you who was the only person who was infected at the start of this activity. Review the list of people you shook hands with. Did you shake hands with this person? If not, how did you get infected?
3. Explain how this activity demonstrates how an infectious disease is transmitted.

Did You Know?

About one third of all colds are caused by the rhinovirus. This virus grows best at a temperature of 33°C, which is the approximate temperature inside your nose.

First Line of Defence

Pathogens are constantly attacking your body. But your **immune system** has powerful defences to fight them. The first line of defence against infectious diseases is the skin and the linings of all internal body systems. The skin is a physical barrier that stops most pathogens from entering the body. The sweat and oil on your skin, which are slightly acidic, also prevent some pathogens from growing on the surface of your body.

Inside the body, other defences include the acidic gastric juice secreted by the lining of the stomach. Gastric juice can destroy pathogens, such as bacteria, that enter the stomach. The mucus and cilia that line your nose prevent pathogens from entering your respiratory system (Figure 3.3).

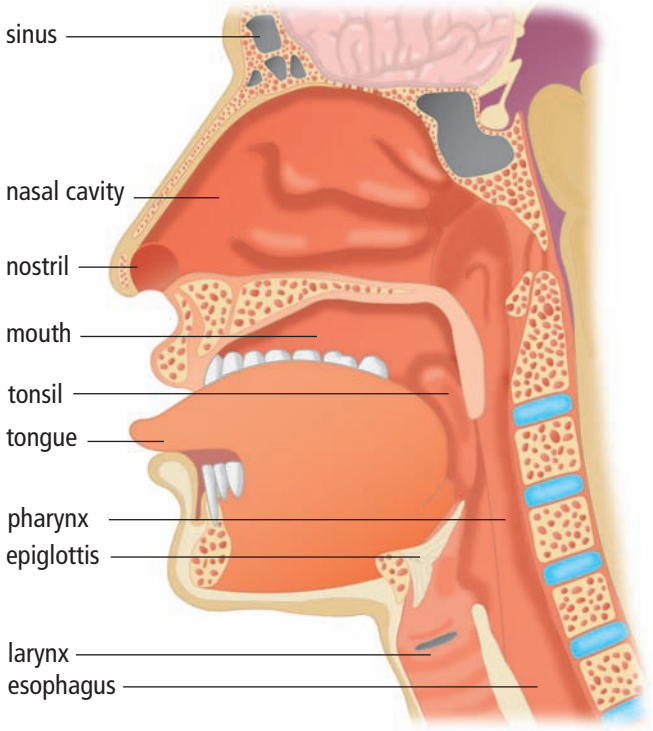


Figure 3.3 The nasal cavity of the nose is lined with mucus and microscopic cilia.

Second Line of Defence

If a pathogen makes it past the first line of defence, your body can mount an immune response to the attack and destroy the invader. This is the immune system's second line of defence. Whether or not the response succeeds depends very much on your body's ability to distinguish between cells that belong to it and cells that do not. Imagine that each of the cells of your body wears a uniform (Figure 3.4). Your immune system recognizes the uniforms of cells that belong to your body. It also recognizes the uniforms of unknown cells that do not belong. These unknown cells are invaders, and the immune system usually attacks them.

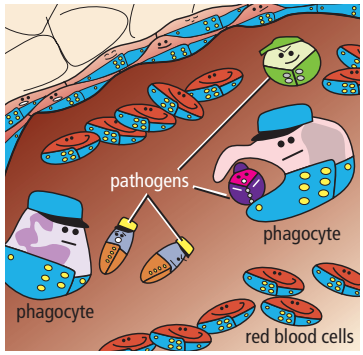


Figure 3.4 Immune response

The second line of defence includes two types of immune response. All living things can mount an **innate immune response**, a response they were born with. Animals with backbones, called vertebrates, can also mount an **acquired immune response**.

Innate Immune Response

The innate immune response to invading pathogens is quick and general, or non-specific. This means the response is the same for anything the body recognizes as an invader. Innate responses are usually mounted against invading bacteria and some viruses, such as the common cold virus.

The first action in the innate immune response is a flow of fluid, cells, and dissolved substances from the blood to the site of infection. This action causes a fever, swelling, and redness in the area. The swelling and redness is called **inflammation** (see Figure 3.5).

Did You Know?

In the 1960s, many children had their tonsils removed because physicians thought this was the best way to treat chronic tonsillitis (constantly inflamed tonsils). Today, physicians think the tonsils are an important part of the immune system and prescribe antibiotics that were not available 40 years ago to treat tonsillitis.

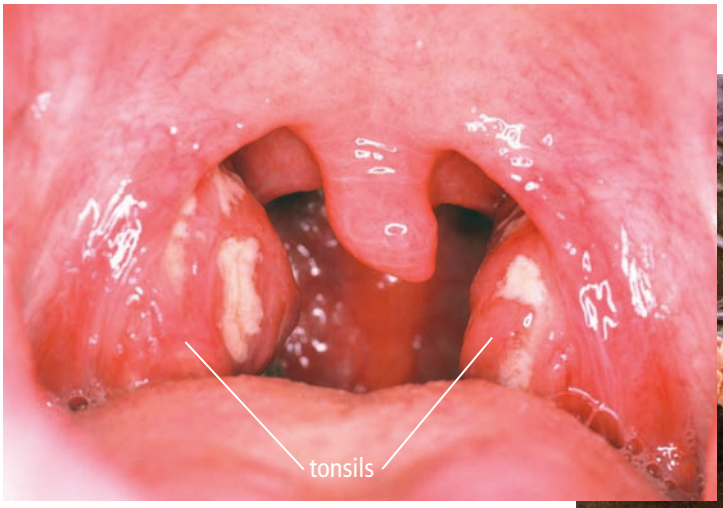


Figure 3.5 If you have ever had inflamed tonsils, they probably became infected by a bacterium or virus.

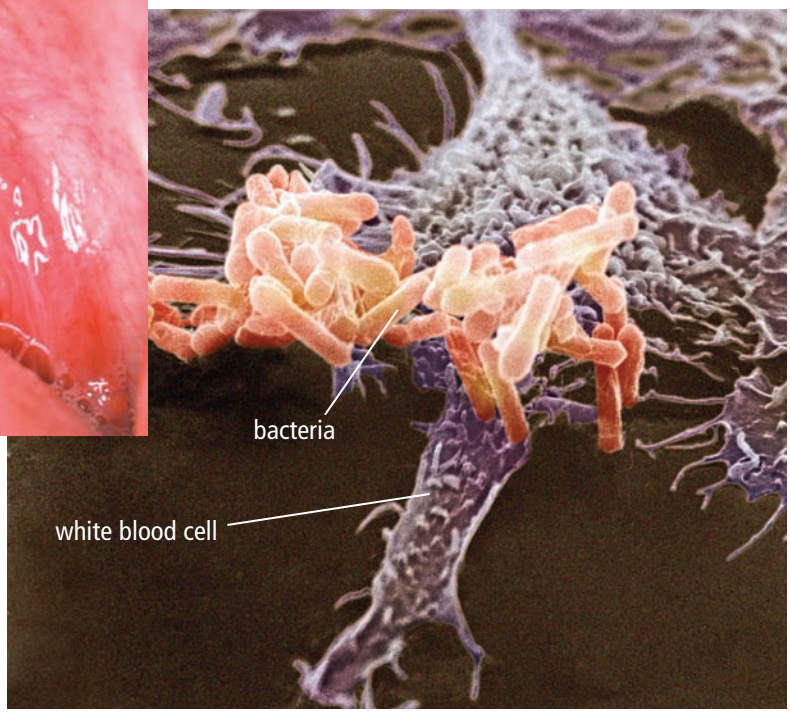


Figure 3.6 White blood cell attacking bacteria

Along with inflammation, there is an increase in types of **white blood cells** called **phagocytes**. Their role is to fight infection (see Figure 3.6). Phagocytes roam the body searching for invader cells and swallowing them. Increasing the number of phagocytes in an area of infection is one way the immune system destroys pathogens.

Word Connect

In Greek, *phago* means to eat, and *cyte* means cell.

Acquired Immune Response

The acquired immune response is a highly specific attack on a particular pathogen, or **antigen**. An antigen is any substance the body cannot recognize, from a virus to a splinter. An antigen is different from a pathogen. A pathogen is a disease-causing organism or substance. An antigen is a non-living particle or substance. Your immune system can mount an acquired immune response in two ways. Both ways involve types of white blood cells called B cells and T cells. This response can take up to a week to develop, because your body needs time to develop the exact response needed to defeat the particular invader.

B cells in action

In the first process in an acquired immune response, **B cells** recognize antigens present in the body. Then they produce specific particles, called **antibodies**, to fight them. Antibodies can attach to and destroy both antigens and pathogens carrying antigens. Figure 3.7 shows this process. In this example, a pathogen is carrying an antigen molecule. The B cell recognizes the antigen and produces antibodies that completely cover the pathogen. The antibodies either prevent the pathogen from infecting body cells or mark it for destruction by other white blood cells. At the same time, the body produces large numbers of similar B cells to fight other antigens in the body.

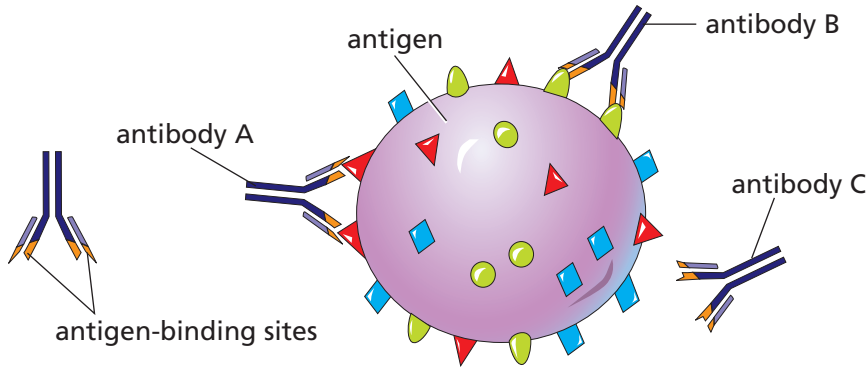


Figure 3.7 Antibodies attach to specific spots on the antigen. Several types of antibodies may attach to one antigen.

T cells in action

The second process in an acquired immune response begins when an antigen or pathogen is inside a body cell. In this case, a white blood cell recognizes the antigen or pathogen and signals for new cells called **T cells**. One type of T cell is called the helper T cell. This type of cell recognizes the presence of an antigen or pathogen and activates B cells (see Figure 3.8 on the next page). The B cells produce the antibodies. The antibodies then destroy the antigen or pathogen. Once the attack is over, some antibodies remain in the body to protect against future infections. This protection is often called immunity.

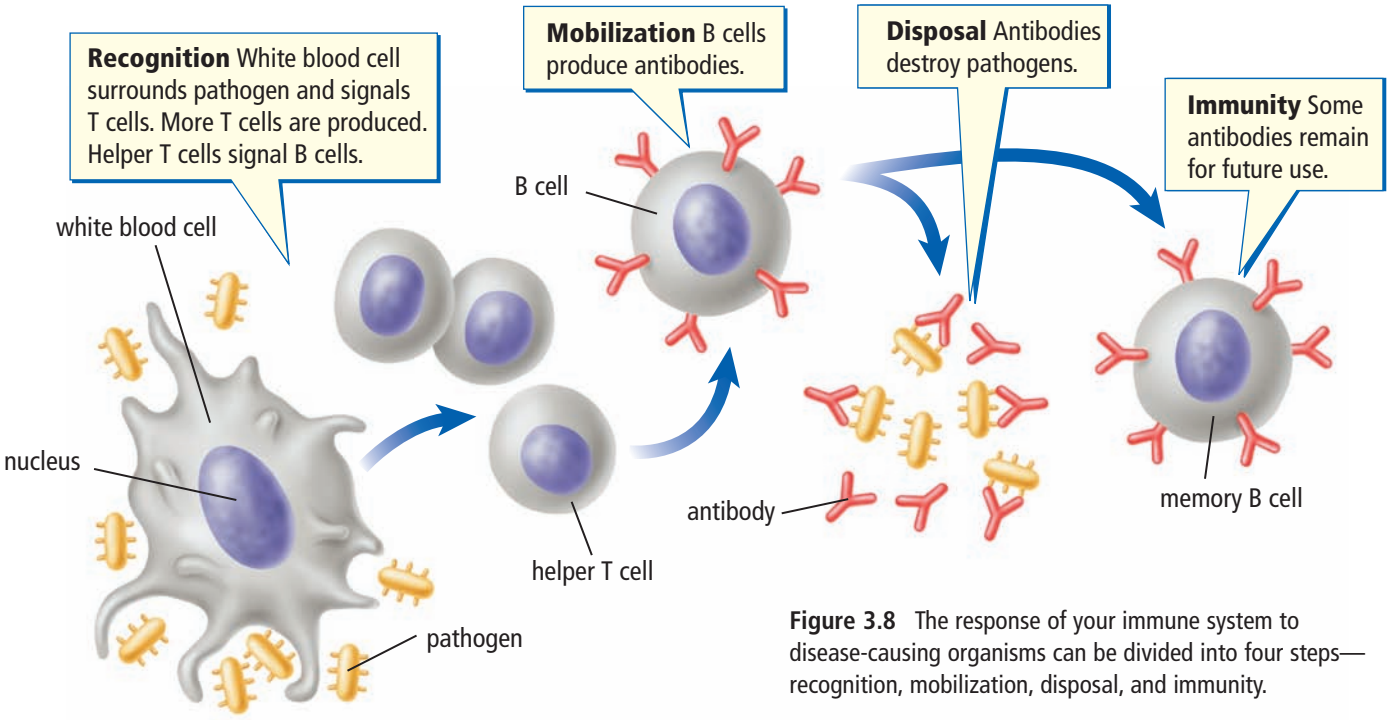


Figure 3.8 The response of your immune system to disease-causing organisms can be divided into four steps—recognition, mobilization, disposal, and immunity.

A second type of T cell is called the killer T cell. Killer T cells can work independently and directly destroy antigens or pathogens as shown in Figure 3.9.

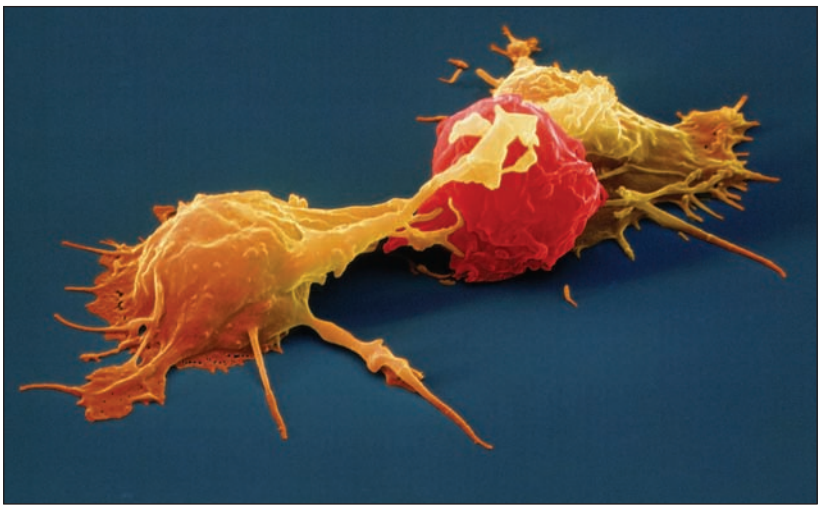


Figure 3.9 Two killer T cells (yellowish in colour) attack a cancer cell.

All acquired immune responses help give you **active immunity**. This means your body remembers which antibodies should be used to attack a pathogen that has infected it before. This is why people get diseases such as chicken pox only once. After the first infection, your body stores some of the newly produced antibodies on B cells. These important B cells are called memory B cells and can be reactivated if the antigen or pathogen reappears.

Explore More

Four hundred years ago, scientists and doctors had a completely different understanding of diseases. Find out about the ancient theory of the four body humours. Begin your research at **www.bcscience8.ca.**

internet connect

Research continues to improve our understanding of the immune system. Check out **www.bcscience8.ca** for an update on current research in this area.

Reading Check

1. What did Lister want doctors to do to help reduce the number of patient deaths after surgery?
2. What is the first line of defence in the immune system?
3. What are the two types of immune response in the second line of defence?
4. What is inflammation?
5. B cells produce antibodies. What is the role of antibodies?
6. What is the function of a killer T cell?

3-2 Visualizing the Immune System

Find Out ACTIVITY

In this activity, you will practise using a graphic organizer to help you visualize what you know about the immune system.

What to Do

1. Read the following seven statements, which briefly summarize the role of the immune system.
   - The immune system fights off invaders such as pathogens and antigens.
   - The skin and the lining of internal body systems stop many pathogens.
   - White blood cells defend the body.
   - Phagocytes eat invader cells.
   - Helper T cells control T and B cells.
   - Killer T cells destroy infected cells.
   - B cells make antibodies.
2. Choose a graphic organizer to represent your understanding of these statements and how they fit together.
3. Before starting, decide as a class what criteria you will use to assign a mark to a graphic organizer.

Science Skills

Go to Science Skill 10 for information about how to organize and communicate scientific information using graphic organizers.

What Did You Find Out?

1. When you have completed the activity, look at a classmate's graphic organizer.
2. Choose one idea you learned from your classmate's work and add it to your own graphic organizer. Use a different colour marker to indicate that this is a new idea.
3. Using the criteria you decided on as a class, assign a mark to your own graphic organizer.
4. Exchange your graphic organizer with another classmate. Assign a mark to this classmate's graphic organizer using the criteria. Return the graphic organizer to your classmate.
5. Review both marks given to your graphic organizer. If they are different, what might you do the next time to improve your mark?

3-3 Demonstrating the Immune System

Find Out ACTIVITY

In this activity, you will choose a way to demonstrate your understanding of the immune system.

What to Do

1. Review the tasks listed below. Select one that you think will be the best way for you to demonstrate what you know about the immune system. If you can think of a different task, discuss it with your teacher. You must include this information for the task you choose:
   - all words that appear in bold in this section
   - the first and second lines of defence in the immune system
   - the innate immune response
   - the acquired immune response

1 Visual Focus

Task: Create a display of the immune system.

Method: Paint, draw, sculpt, design a computer presentation, or create a comic strip.

2 Verbal Focus

Task: Write a story or news report that describes the immune system.

Method: Create an audio or video recording of your work or perform it for the class.

3 Musical Focus

Task: Compose a song that describes the immune system.

Method: Perform your song for the class or record it in audio or video format.

4 Logical Focus

Task: Invent a game that shows how the immune system works.

Method: Develop a puzzle, card game, or board game.

5 Individual Work Focus

Task: Imagine you are a reporter following a pathogen as it travels through the body. Describe the encounters the pathogen has with different parts of the immune system.

Method: Write a journal that includes pictures.

6 Small Group Focus

Task: Create a group presentation showing how the immune cells interact with and depend on each other.

Method: Each person writes five questions about the immune system and asks the group the questions. Group members discuss any incorrect answers and then develop a presentation. You may use diagrams, pictures, or verbal explanations in your presentation.

7 Body Motion Focus

Task: Perform a skit that demonstrates how the immune system functions.

Method: Write a script, practise your skit, and perform it for the class.

What Did You Find Out?

1. Present your work and watch your classmates' presentations. For each presentation, develop a short, written summary to give to the presenter or presenters. Complete the following sentences in your summary.
   (a) What I will remember most about your presentation is:
   (b) What I learned from your presentation is:
   (c) One question I have about your presentation is:

NATIONAL GEOGRAPHIC

VISUALIZING KOCH'S RULES

In the 1880s, German doctor Robert Koch developed a series of methods for identifying which organism was the cause of a particular disease. Koch's Rules are still in use today. Developed mainly for determining the cause of particular diseases in humans and other animals, these rules have been used for identifying diseases in plants as well.

A In every case of a particular disease, the organism thought to cause the disease—the pathogen—must be present.

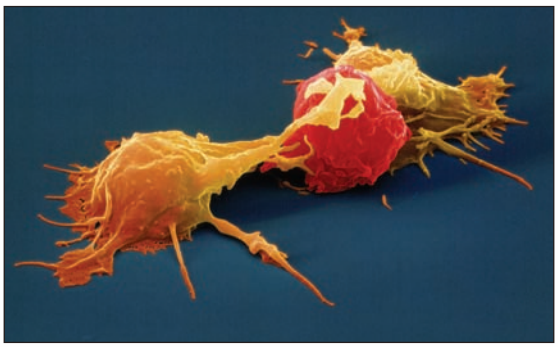
B The suspected pathogen must be separated from all other organisms and grown on agar gel with no other organisms present.

C When inoculated with the suspected pathogen, a healthy host must come down with the original illness.

D Finally, when the suspected pathogen is removed from the host and grown on agar gel again, it must be compared with the original organism. Only when they match can that organism be identified as the pathogen that causes the disease.

Checking Concepts

1. What are the four methods of transmitting diseases?
2. For each of the descriptions below describe the type of transmission method that could have led to contracting an infectious disease.
   (a) You are at a barbeque party and become ill from eating undercooked meat.
   (b) While on a hiking trip your friend is bitten by a small animal. The next day he becomes ill.
   (c) At a movie, the person behind you seems to be sneezing every five minutes. A couple of days later you develop a cold.
   (d) At the end of a soccer game, you shake hands with the other team. A few days later you become ill.
3. The red cell in the middle of the photograph below is a cancer cell. Describe the function of the two yellowish cells attacking the cancer cell.



4. Review the feature on page 108. What are Koch's four rules for identifying organisms that can cause a particular disease?
5. How is sweat part of the immune system?
6. What is the difference between a pathogen and a phagocyte?
7. Describe the process of inflammation.
8. Explain the difference between an innate response and an acquired response.
9. What is an antibody?
10. What is an antigen?
11. Summarize the function of a B cell.
12. Compare a helper T cell with a killer T cell.
13. What is active immunity?

Understanding Key Ideas

14. What is the difference between the first and second lines of defence in the immune system?
15. How does a B cell tell the difference between an invader cell and a body cell?
16. When you are sick, why does the number of white blood cells in your body increase?
17. What is the importance of the body keeping memory B cells if the antigen the cells remember is no longer present?
18. You go to the doctor feeling very tired and run down. The doctor takes a blood sample for tests and checks your vital signs such as blood pressure, breathing, and pulse. Later, you receive a call from your doctor and she says you have an infection. What did the blood tests reveal about the number of white blood cells present in your blood?
19. Using your understanding of how infectious diseases can be transmitted, explain why schools can have a large number of students absent due to illness at the same time.
20. Where in your body are there bacteria that the immune system does not attack?

Pause and Reflect

Various diseases can affect the immune system and cause it not to function properly. A weakened immune system can make a person more likely to become ill. How could you live if your immune system did not function?