31.2 Immune System

KEY CONCEPT The immune system consists of organs, cells, and molecules that fight infections.

MAIN IDEAS

- Many body systems protect you from pathogens.
- Cells and proteins fight the body's infections.
- Immunity prevents a person from getting sick from a pathogen.

VOCABULARY

immune system, p. 945
phagocyte, p. 946
T cell, p. 946
B cell, p. 946
antibody, p. 947
interferon, p. 947
passive immunity, p. 948
active immunity, p. 948
Review
pathogen, lymphocyte

REVIEW AT CLASSZONE.COM

Connect Think of your body as a heavily guarded castle. When pathogens come to invade, they must first break down the outer wall or find a way around it. If the intruders get past the physical barriers, they must face your body's fighters in hand-to-hand combat. When the invaders gain the upper hand, you become sick. When the body's defenses are winning the war, you remain healthy.

MAIN IDEA

Many body systems protect you from pathogens.

The **immune system** is the body system that fights off infection and pathogens. Just as a castle has several lines of defense, so does your body's immune system. The immune system relies on physical barriers to keep pathogens out. However, when pathogens get past the physical barriers, the warrior cells of the immune system travel through the lymphatic and circulatory systems to reach the site of infection.

Your skin is your body's first line of defense. Like a castle's outer wall, the skin surrounds and protects your insides. The skin physically blocks invading pathogens. The skin also secretes oil and sweat, which make the skin hypertonic and acidic. Many pathogens cannot survive in this kind of environment.

Just as a castle's walls have doors and windows, your skin also has openings. For example, your eyes, nose, ears, mouth, and excretory organs are open to the environment, and so they need extra protection. Mucous membranes in these organs use hairlike cilia that are covered with a sticky liquid to trap pathogens before they move into the body, as shown in **FIGURE 31.5.**

Connecting CONCEPTS

Hypertonic You learned in **Chapter 3** that when the environment has more solutes than a cell, water will diffuse out of the cell and the cell could die.

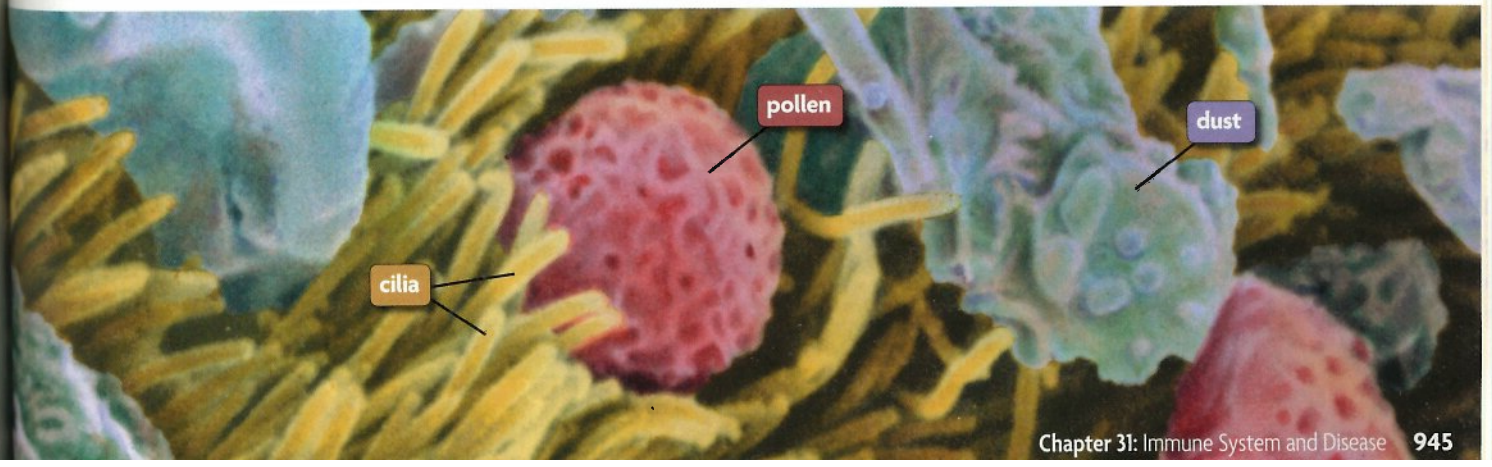


FIGURE 31.5 Cilia that line the throat (yellow) capture foreign particles. (colored SEM; magnification 7500×)

Even with skin and mucous membranes to protect you, some pathogens still get into the body. Once pathogens are inside, the immune system relies on the circulatory system to send chemical signals to coordinate an attack and to transport specialized cells to the infection.

Summarize **Name some of the tissues that help to prevent and fight infection.**

MAIN IDEA

Cells and proteins fight the body's infections.

Once pathogens get past all of your outer defenses, the cells of your immune system spring into action. Just as a castle has many fighters and weapons, your immune system has many types of white blood cells and proteins.

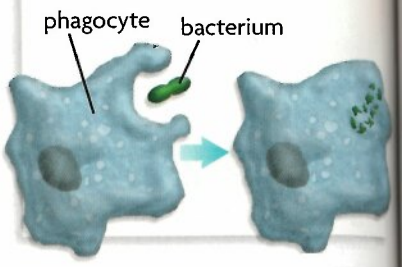
White Blood Cells

White blood cells find and kill pathogens that have gotten past the body's external barriers. The six main types of white blood cells and their roles in fighting infection are summarized in **FIGURE 31.6**.

When a pathogen enters the body, basophils in the blood stream or mast cells found in other tissues release chemical signals. These signals attract other white blood cells to the site of the infection. If the pathogen is a parasite, eosinophils come and spray the parasite with poison. If the pathogen is a virus, bacterium, or fungus, neutrophils and macrophages go to work. These cells are phagocytes. A **phagocyte** (FAG-uh-syt) is a cell that destroys pathogens by surrounding and engulfing them.

VISUAL VOCAB

A **phagocyte** is a cell that engulfs and destroys other cells. It comes from Greek words that translate to mean "cell eater."



After phagocytes, lymphocytes reach the infection. Lymphocytes are white blood cells that initiate the specific immune responses, which you will read about in Section 31.3. There are two types of lymphocytes: T-lymphocytes and B-lymphocytes, also called T cells and B cells. **T cells** destroy body cells that are infected with pathogens. **B cells** produce proteins that inactivate pathogens that have not yet infected a body cell.

Connecting CONCEPTS

Lymphocytes Recall from **Chapter 30** that lymphocytes are cells of the lymphatic system that attack disease-causing particles.

FIGURE 31.6 White Blood Cells

NAME	FUNCTION
Basophil	makes chemicals that cause inflammation in the bloodstream
Mast cell	makes chemicals that cause inflammation in other body tissues
Neutrophil	engulfs pathogens and foreign invaders; phagocyte
Macrophage	engulfs dead or damaged body cells and some bacteria; phagocyte
Lymphocyte	destroys infected body cells or produces proteins that inactivate pathogens
Eosinophil	injects poisonous packets into parasites, such as protozoa

DATA ANALYSIS

IDENTIFYING EXPERIMENTAL DESIGN FLAWS

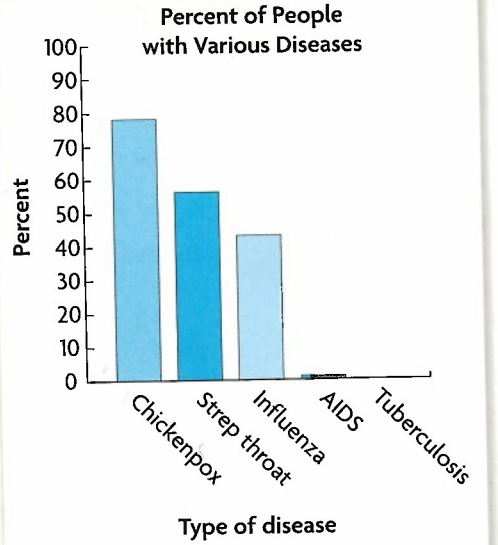
Sometimes scientific investigations can be flawed as a result of how the experiments were designed. Such design problems could include having a sample that is not representative of the population or one that is too small. This can result in the collection of invalid data, incorrect conclusions, and the release of misleading information.

To study how common certain diseases are in the United States, a student interviews 100 people as they exit a small Midwestern hospital. The student asks them if they have ever had any of five specific infectious diseases. He calculates the percent of people who responded "yes" to each question and puts the data in the graph to the right.

Based on his data, the student concludes that chickenpox is the most contagious disease of the five diseases studied. He also concludes that people in the United States no longer get tuberculosis.

1. **Evaluate** What problems exist with the sample population in this investigation?
2. **Analyze** Are the conclusions drawn from this data accurate? Why or why not?
3. **Evaluate** How could this investigation be redesigned to produce valid results?

GRAPH 1. STUDENT DATA



Proteins

The immune system uses three types of proteins to fight off invading pathogens: complement proteins, antibodies, and interferons.

- Complement proteins are made by white blood cells and by certain organs. Some complement proteins weaken a pathogen's cell membrane, allowing water to enter the cell and cause it to burst. Others attract phagocytes to the infected area. Still others cause microbes to stick to the walls of blood vessels, where they can more easily be found and destroyed by circulating phagocytes.
- **Antibodies** are proteins made by B cells. Antibodies destroy pathogens in one of three ways. Antibodies might make the pathogen ineffective by binding to the pathogen's membrane proteins. As **FIGURE 31.7** shows, antibodies might also cause pathogens to clump, making them easier for phagocytes to engulf and destroy. Other antibodies activate complement proteins that weaken the pathogen's cell membrane.
- **Interferons** (ihn-tuhr-FEER-AHNZ) are proteins produced by body cells that are infected by a virus. Cells release interferons, which stimulate uninfected body cells to produce enzymes that will prevent viruses from entering and infecting them. If viruses cannot enter healthy cells, they cannot reproduce. Other interferons stimulate an inflammation response.

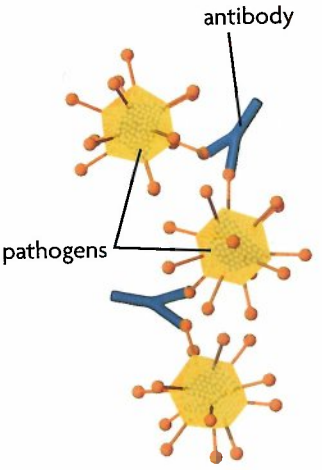


FIGURE 31.7 Antibodies help the immune system. Some types of antibodies cause pathogens to clump, making them easier to engulf and destroy.

Compare and Contrast **What are some differences between the ways white blood cells and proteins fight infections?**

MAIN IDEA

Immunity prevents a person from getting sick from a pathogen.

If you are immune to a pathogen, it means that you will not get sick when that pathogen invades your body. There are two types of immunity—passive and active.

Passive Immunity

Passive immunity is immunity that occurs without the body's undergoing an immune response. Passive immunity is transferred between generations through DNA and between mother and child.

Some viruses can be spread between different species. A pathogen that infects a bird might infect a person as well. However, some viruses only make members of a specific species sick. Genetic immunity is immunity that a species has because a pathogen is not specialized to harming that species. Infants have another type of immunity. Inherited immunity occurs when pathogen-fighting antibodies in a mother's immune system are passed to the unborn baby through the umbilical cord or the mother's milk.

Active Immunity

Active immunity is immunity that your body produces in response to a specific pathogen that has infected or is infecting your body. Acquired immunity is a type of active immunity that occurs after your immune system reacts to a pathogen invasion. Acquired immunity keeps you from becoming sick by a particular pathogen more than once. We will look more closely at how the immune system produces acquired immunity in the next section.

Sometimes people get the same colds or flus over and over again throughout their lifetimes. This occurs because the viruses that cause these sicknesses mutate very quickly. Each time a different strain of virus invades, your immune system has to start from the beginning again. On the other hand, your immune system destroys repeat invaders before you get sick.

Contrast **How do passive and active immunity differ?**

NSTA SCILINKS
scilinks.org
To find out more about the immune system, go to scilinks.org.
Keycode: MLB031

31.2 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. How does the **immune system** work with other body systems to prevent and fight disease?
2. How do **phagocytes** help to fight infections?
3. Which of the two types of immunity requires white blood cells? Explain.

CRITICAL THINKING

4. **Contrast** How do complement proteins differ from **antibodies**?
5. **Predict** If a person had a disease that prevented lymphocytes from maturing, how would the immune system's response to infection change?

Connecting CONCEPTS

6. **Protein Synthesis** How might a person's immune system be affected if a portion of the DNA that codes for **interferons** has mutated?

31.3 Immune Responses

KEY CONCEPT The immune system has many responses to pathogens and foreign cells.

MAIN IDEAS

- Many body systems work to produce nonspecific responses.
- Cells of the immune system produce specific responses.
- The immune system rejects foreign tissues.

VOCABULARY

inflammation, p. 950
antigen, p. 951
memory cell, p. 951
cellular immunity, p. 952
humoral immunity, p. 953
tissue rejection, p. 954

Review
T cell, B cell

REVIEW AT CLASSZONE.COM

Connect Your body responds to pathogens in several different ways. For example, when you get a mosquito bite, your skin might swell and itch. After you are bitten, the skin around the bite becomes swollen, and the cells of your immune system attack the pathogens that entered the skin through the bite.

MAIN IDEA

Many body systems work to produce nonspecific responses.

The body responds to pathogens and foreign particles with specific and nonspecific responses. Responses that occur on the cellular level are called specific defenses. Specific responses are slightly different for each pathogen. Nonspecific immune responses are those that happen in the same way to every pathogen. Some examples of nonspecific defenses are inflammation and fever.

Inflammation

Inflammation is a nonspecific response that is characterized by swelling, redness, pain, itching, and increased warmth at the affected site. Inflammation occurs when a pathogen enters the body or when the body's other tissues become damaged. For example, if you scrape your knee, it swells up. This occurs because the body is trying to head off pathogens that enter the body through the newly broken skin.

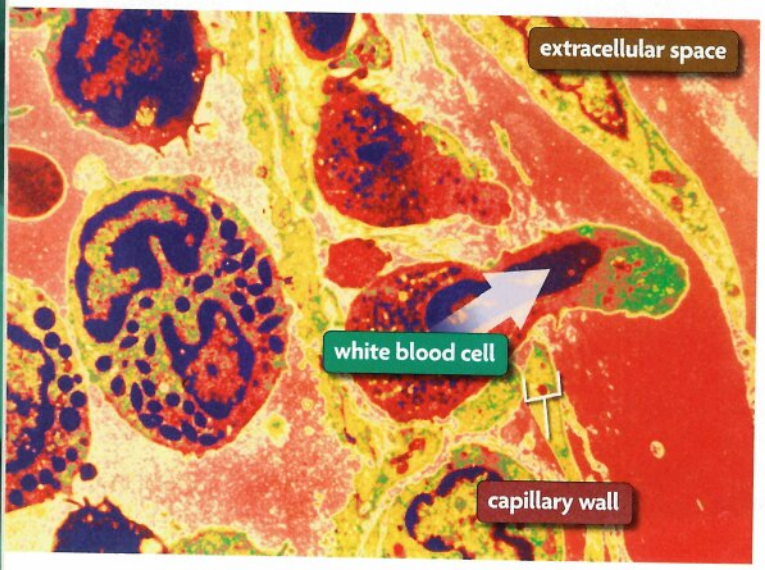


FIGURE 31.8 When pathogens invade your body, white blood cells squeeze through the capillary wall and move toward the infection. (magnification unknown)

An inflammation response begins when mast cells or basophils release chemicals called histamines in response to a pathogen invasion. Histamines cause the cells in blood vessel walls to spread out. When this happens, fluids can move out of the blood vessel and into the surrounding tissues. White blood cells squeeze out of the capillary and move toward the site of infection, as shown in **FIGURE 31.8**. Once outside of the circulatory system, the white blood cells fight off the infection. When the pathogens are defeated, swelling stops, and tissue repair begins. Inflammation is a normal body response, but sometimes it occurs in response to things other than pathogens, as you will read in Section 31.5.

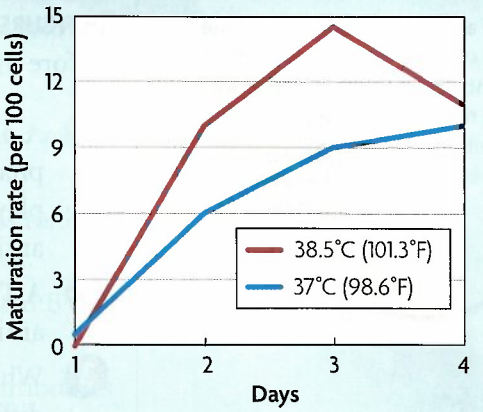
Fever

Fevers develop when mast cells or macrophages release chemicals that cause the hypothalamus to increase the body's temperature. When the infection is controlled and the mast cell's chemicals are no longer being made, the body temperature returns to normal.

Fever is a response that affects the entire body. Low fevers, around 37.7°C (100°F), stimulate the production of interferons. Recall that interferons are proteins that prevent viruses from reproducing. Low fevers also increase the activity of white blood cells by increasing the rate at which they mature, as shown in **FIGURE 31.9**. Having many mature white blood cells is important because only mature cells can destroy pathogens. The more mature white blood cells in the body, the more quickly the body can fight off an infection.

While low fevers speed up pathogen destruction, high fevers—more than 39°C, or 103°F—are dangerous. Under high fever conditions, the hypothalamus can no longer regulate body temperature. Enzymes that control chemical reactions in the body stop functioning. High fever can cause seizure, brain damage, and even death.

FIGURE 31.9 WHITE BLOOD CELL MATURATION



Scientists put immature white blood cells in a nutrient solution and found that they matured faster when the cells were heated as in a low fever (red line).

Source: Roberts, N. J. Jr. and R. T. Stergbigel. *American Society of Microbiology*

Connect **What body systems, other than the immune system, help to produce inflammation and fever?**

MAIN IDEA

Cells of the immune system produce specific responses.

Specific immune defenses lead to acquired immunity, and they occur on the cellular level. For these specific immune defenses to work, the body must be able to tell the difference between its own healthy cells and foreign or infected cells. **Antigens** (AN-tih-juhnz) are protein markers on the surfaces of cells and viruses that help the immune system identify a foreign cell or virus. If pathogens are the invading army that is waging war on the immune system, then you can think of antigens as the pathogens' uniforms.

When the immune system detects a pathogen, it triggers an immune response. There are two types of specific immune system responses: cellular and humoral immune responses. Although the two responses are different, as you will read on the next page, they both produce acquired immunity. Immunity is acquired when your body produces memory cells after fighting off an infection. **Memory cells** are specialized T and B cells that provide acquired immunity because they "remember" an antigen that has previously invaded your body. So when memory cells come across this antigen a second time, they quickly destroy the pathogen before the body has a chance to get sick. You will learn more about how memory cells work in Section 31.4, when you read about vaccines. Now, we will discuss how the immune system fights a pathogen that it is encountering for the first time.

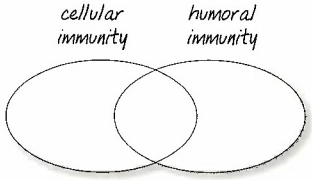
Connecting CONCEPTS

T cells and B cells Recall from the previous section that T and B cells are lymphocytes that are specialized to fight off pathogens.

- T cells destroy infected body cells.
- B cells produce proteins that inactivate pathogens.

TAKING NOTES

Use a Venn diagram to compare and contrast the cellular and humoral immune responses as you read this section.



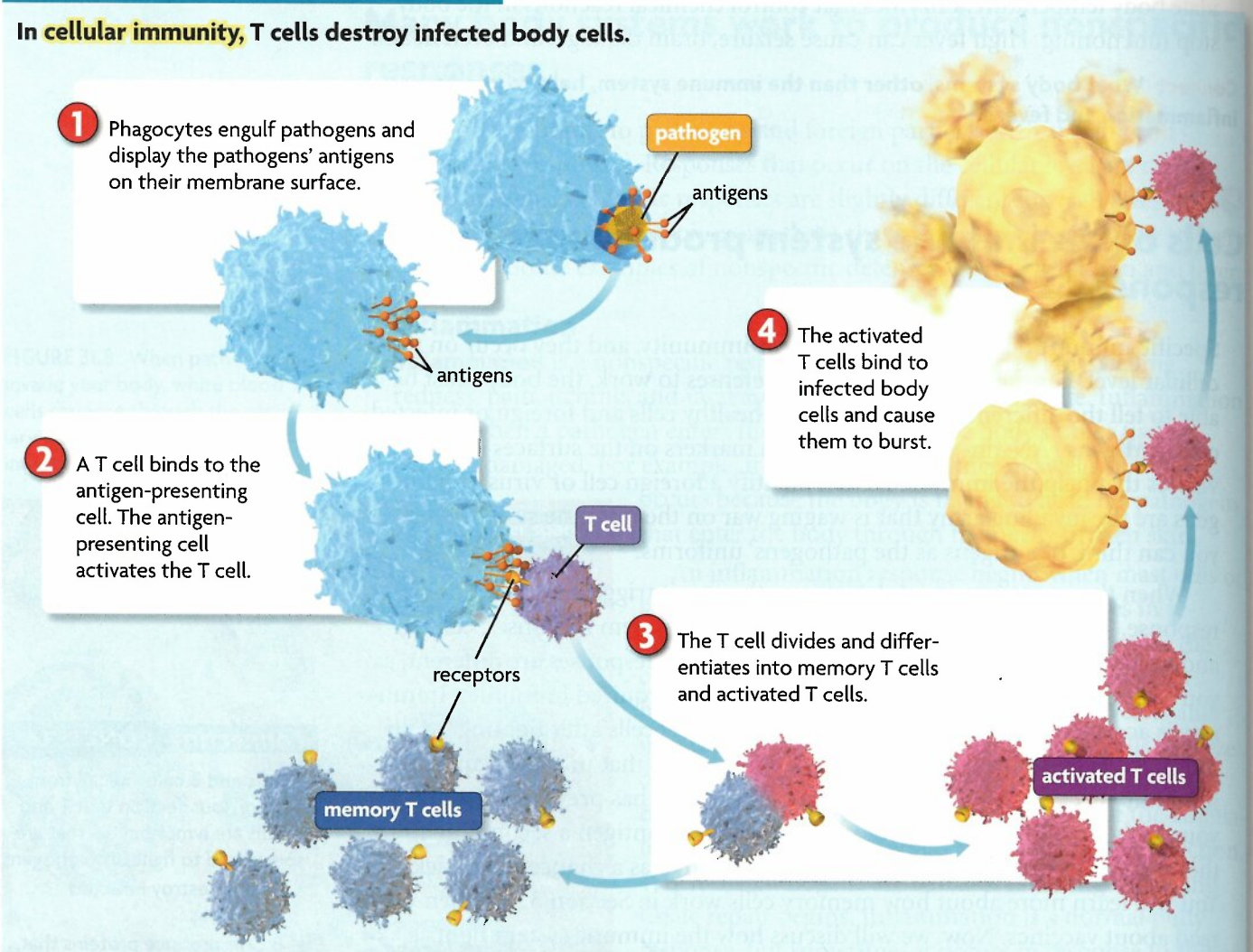
Cellular Immunity

Cellular immunity is an immune response that depends on T cells. As shown in **FIGURE 31.10**, T cells attach to infected body cells and cause them to burst. Before they can do this, however, T cells must become activated.

1. A phagocyte recognizes a foreign invader and engulfs it. Once inside the phagocyte, the invader's antigens are removed, and the phagocyte displays them on its cell membrane. A phagocyte that displays foreign antigens on its membrane is called an antigen-presenting cell.
2. A T cell encounters the antigen-presenting cell and binds to it. The antigen-presenting cell releases proteins that activate the T cell.
3. When a T cell is activated, it begins to divide and differentiate into two different types of T cells: activated and memory. The activated T cells will fight the current infection, but the memory T cells act as reserves that will wait for future invasions.
4. The activated T cells bind to and destroy infected body cells.

FIGURE 31.10 Cellular Immunity

In cellular immunity, T cells destroy infected body cells.



Analyze **What allows T cells to identify infected body cells?**

Humoral Immunity

Humoral immunity is a type of immune response that depends on antibodies. Different types of antibodies fight pathogens by either causing them to burst, inactivating them, or causing them to clump, as shown in **FIGURE 31.11.**

1. A pathogen binds to a B cell. The B cell engulfs the pathogen and puts part of the antigen onto its surface.
2. When a T cell encounters the antigen-presenting B cell, it binds to the antigens. Then the T cell releases proteins that activate the B cell.
3. Once activated, the B cell divides and differentiates into activated B cells and memory B cells.
4. Activated B cells produce as many as 2000 pathogen-specific antibodies per second. In some cases, antibodies cause pathogens to clump.
5. Phagocytes engulf and destroy the pathogen clumps.

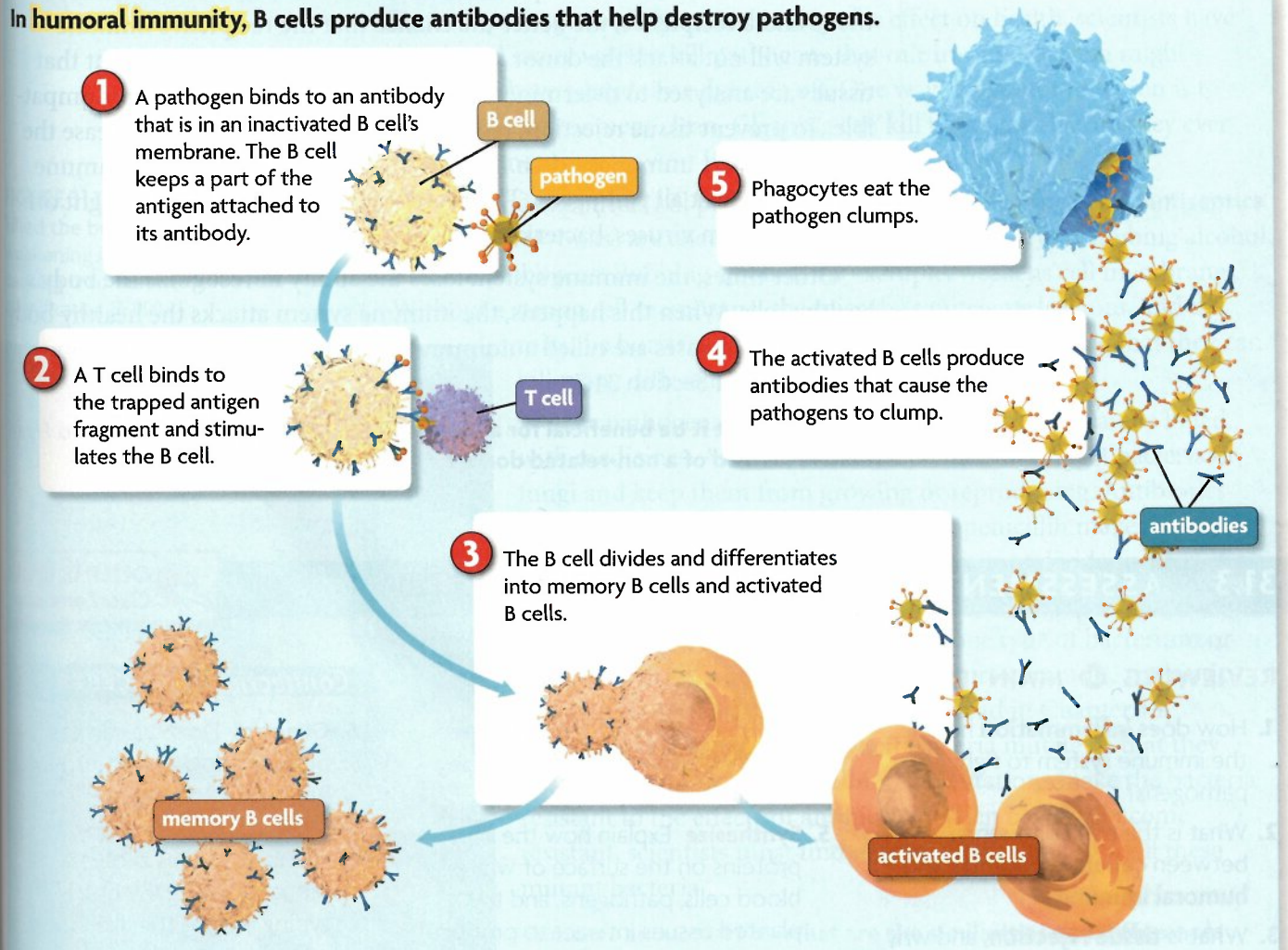
Compare **What are some similarities between the cellular and humoral responses?**

VOCABULARY

Humoral immunity comes from the Latin word *humor,* which means "fluid." *Humoral immunity* refers to the immunity given by antibodies that travel in the blood and other body fluids.

FIGURE 31.11 Humoral Immunity

In humoral immunity, B cells produce antibodies that help destroy pathogens.



Analyze **How do T cells contribute to the humoral immune response?**

MAIN IDEA

The immune system rejects foreign tissues.

Connecting CONCEPTS

Blood Typing Blood cells have different proteins, called Rh factors, on their cell walls. Review **Chapter 30** for more information on how blood types affect a person's ability to receive blood transfusions.

All cells have protein markers on their surfaces. Your body must constantly decide whether your healthy cells are, in fact, your own or foreign cells. Sometimes you do not want your body to be able to identify foreign tissues and cells. For example, when you receive a blood transfusion or an organ transplant, you want to fool your body into ignoring the foreign tissues' protein markers. If protein markers on donated tissue differ from your cells' proteins, an immune response can occur and the transplanted tissue will be attacked and rejected. **Tissue rejection** occurs when the recipient's immune system makes antibodies against the protein markers on the donor's tissue.

Antigen receptors on the surface of your white blood cells determine whether your immune system will attack or ignore a transplanted tissue. Cells with protein markers that fit into the white blood cells' receptor molecules are foreign. Cells with protein markers that do not interact with white blood cells' receptor molecules are not detected by the immune system.

People have thousands of different combinations of protein markers on their cells. The fewer of these protein markers that differ between a donor's tissue and a recipient's, the better the chance that the recipient's immune system will not attack the donor tissue. For this reason, it is important that tissues are analyzed to determine whether a donor and recipient are compatible. To prevent tissue rejection, recipients must take drugs that decrease the activity of their immune system. These drugs weaken the person's immune response against all pathogens. This leaves the recipient less able to fight off infections from viruses, bacteria, and fungi.

Other times, the immune system loses the ability to recognize the body's healthy cells. When this happens, the immune system attacks the healthy body cells. These diseases are called autoimmune diseases, and you will read more about them in Section 31.5.

Infer **Why might it be beneficial for a person to get blood or tissues donated from a relative instead of a non-related donor?**

31.3 ASSESSMENT

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REVIEWING MAIN IDEAS

1. How does **inflammation** help the immune system to fight pathogens?
2. What is the main difference between **cellular immunity** and **humoral immunity**?
3. What is **tissue rejection**, and why does it occur?

CRITICAL THINKING

4. **Contrast** What are the differences between a specific and a nonspecific immune response?
5. **Synthesize** Explain how the proteins on the surface of white blood cells, pathogens, and transplanted tissues interact to produce an immune response.

Connecting CONCEPTS

6. **Genetics** Doctors can test a person's blood to determine what types of proteins are on the surface of the person's blood cells. This is called blood typing. Why does blood typing reduce the likelihood of tissue rejection in blood transfusions?

31.5 Overreactions of the Immune System

KEY CONCEPT An overactive immune system can make the body very unhealthy.

MAIN IDEAS

- Allergies occur when the immune system responds to harmless antigens.
- In autoimmune diseases, white blood cells attack the body's healthy cells.

VOCABULARY

allergy, p. 957
allergen, p. 957
anaphylaxis, p. 958

REVIEW AT CLASSZONE.COM

Connect Eating a peanut can be deadly for a person who has an allergy. People who are allergic to peanuts can have their immune response activated by eating just one peanut or some peanut butter. An allergy is an overreaction in which the immune system produces an extreme response to a harmless protein marker. Other times, the immune system overreacts because it loses its ability to recognize the body's own healthy tissues.

MAIN IDEA

Allergies occur when the immune system responds to harmless antigens.

More than half of all Americans have an allergy. You probably know someone who is allergic to something—dogs, bee stings, or drugs, such as penicillin. An **allergy** is an oversensitivity to a normally harmless antigen. When someone has an allergy, the immune system produces antibodies in response to an allergen. **Allergens** are antigens that cause an allergic reaction.

When an allergen enters the body, mast cells or basophils release histamine, as shown in **FIGURE 31.14.** Histamine is a chemical that causes nonspecific immune responses, such as inflammation. Another type of white blood cell, eosinophils, also seems to have a role in allergic reactions. Eosinophils normally release poisonous chemicals that kill parasites that they encounter. These chemicals can also cause an inflammation response. Recall from Section 31.3 that in a normal inflammation response, cells release histamine. When histamine is released in response to a pathogen, the inflammation helps fight infection. When inflammation occurs in response to an allergen, the inflammation is unnecessary because it provides no benefit to the individual.

FIGURE 31.14 A basophil cell produces histamine, a chemical that triggers inflammation. (colored TEM; magnification 11,500×)

Scientists and doctors do not know why some individuals have allergies but others do not. Research suggests that some allergies are triggered by the overabundance of a certain type of antibody, and that a person's genetic makeup determines if a person has allergies. Other studies suggest that allergies are triggered when an allergen, such as one found in food, is given to a child at a certain stage in life.

Food Allergens

An allergic reaction can occur when a person eats a specific type of food. In the United States, one to two adults in every 100 have a severe allergy to at least one type of food, and five to eight children out of 100 have a food allergy. Although any type of food can cause an allergy, the most common food allergens are milk, eggs, peanuts and tree nuts, soy, wheat, fish, and shellfish.

If a person's allergic response is severe, he or she may experience anaphylaxis. **Anaphylaxis** (AN-uh-fuh-LAK-sihs) is a condition that occurs when the immune system releases a large amount of histamine, which causes airways to tighten and blood vessels to become porous. When the airways tighten, air cannot enter the lungs or other tissues. When blood vessels become porous, blood leaks out of the circulatory system, causing the body to shut down. If not treated immediately, anaphylaxis can cause death.

Airborne Allergens

Airborne allergens, such as the ones shown in **FIGURE 31.15,** are those that cause allergic responses when they are breathed in. You may have heard people talk about allergy season. Allergy season occurs when certain plants and molds are reproducing. Plants—such as ragweed, dandelions, and grass—release pollen into the air, and molds release spores as part of their reproductive cycle. When people breathe in pollen or spores, the histamine response may make them sneeze, get watery eyes, or become congested.

People can also be allergic to things that are indoors. Dander, which is made up of small particles in animal hair, makes some people allergic to pets, such as cats and dogs. Chemicals in animal saliva can also trigger an allergic reaction in some people. Others are allergic to the feces of dust mites, which are small arachnids that live in dust balls and cloth. In some cases, allergic reactions to airborne allergens can cause asthma. During an asthma attack the airways tighten, and breathing becomes difficult. Some people with asthma carry inhalers containing medicine that opens up the airways, reversing the effects of an asthma attack.

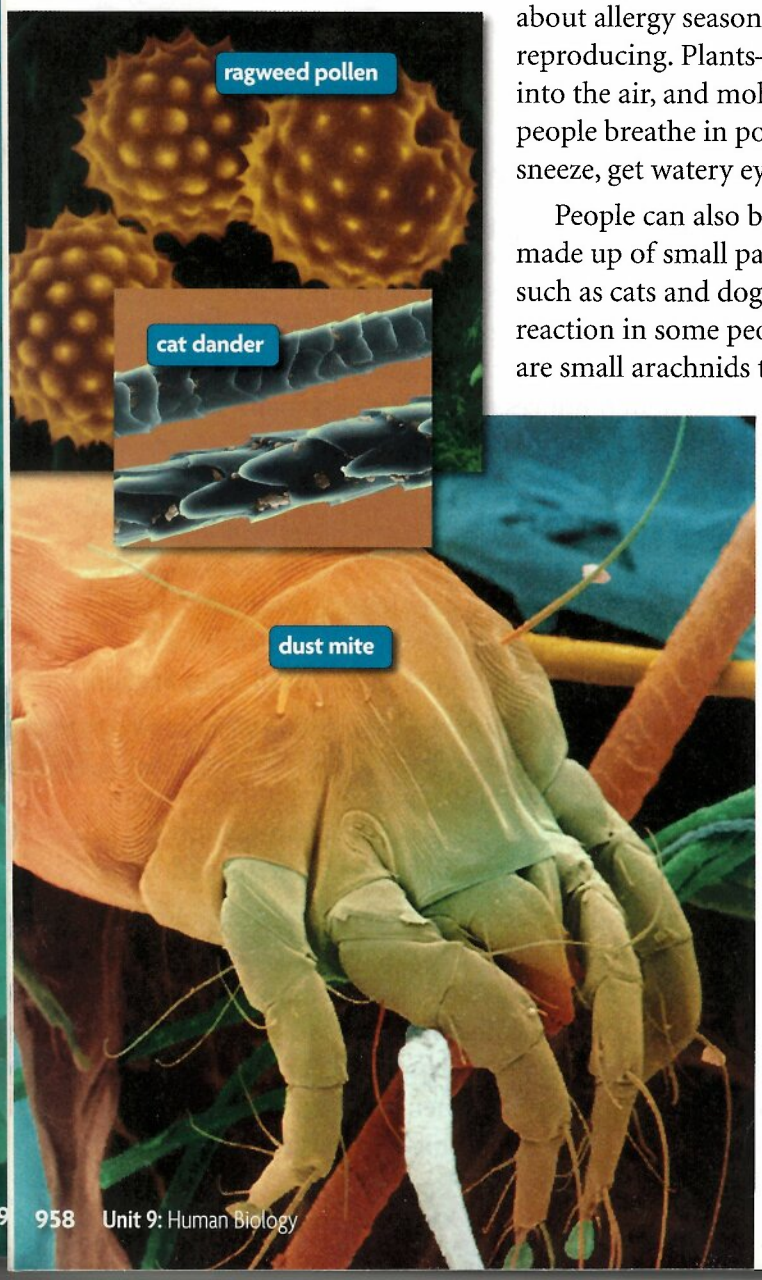

FIGURE 31.15 Common airborne allergens include pollen, animal dander, and dust mite wastes. (colored SEMs; magnifications: ragweed 1000×; cat dander about 300×; dust mite 300×)

Chemical Allergens

Chemical allergens include metals that come in contact with the skin or those that enter the blood through injection or digestion. In metal allergies, people develop rashes when certain types of metal rest on their skin for too long. Ten percent of people in the United States are allergic to nickel, a metal that is common in jewelry.

Other chemicals, such as the venom from bee stings or drugs such as penicillin, can cause allergic reactions. These chemicals can cause anaphylaxis in a person with a severe allergy.

Compare and Contrast **How is an allergic response the same as and different from a normal inflammation response?**

MAIN IDEA

In autoimmune diseases, white blood cells attack the body's healthy cells.

Autoimmune diseases are those that occur when the immune system cannot tell the difference between the body's healthy and unhealthy cells. Normally, immune system cells attack only foreign substances, such as pathogens and infected or abnormal cells. With autoimmune diseases, the body treats its own cells as though they are foreign invaders.

In Type 1 diabetes, the immune system destroys cells in the pancreas. As a result, the pancreas makes less insulin. Without insulin, the body cannot remove glucose from the blood. Type 1 diabetes can cause death if a person does not get extra insulin into the body. There are more than 60 other autoimmune diseases. Some of the most common ones are described in **FIGURE 31.16.**

FIGURE 31.16 Common Autoimmune Diseases

AUTOIMMUNE DISEASES	BODY SYSTEMS AFFECTED	THE IMMUNE SYSTEM . . .	HOW MANY AFFECTED
Rheumatoid arthritis	integumentary	breaks down tissues that line joints, making movement difficult	70 in 10,000
Type 1 diabetes mellitus	endocrine, digestive	attacks the pancreas, stopping the digestion of sugars	60 in 10,000
Hashimoto's thyroiditis	endocrine	attacks the thyroid gland, causing it to make fewer hormones	15 in 10,000
Multiple sclerosis (MS)	nervous	breaks down myelin sheaths, disrupting nerve communication	10 in 10,000
Graves' disease	endocrine	stimulates the thyroid gland, causing it to make more hormones	5 in 10,000

Scientists do not know why some people develop autoimmune diseases. Research suggests that a person's genes may make them more likely to get an autoimmune disease, but that the actual immune system attack is triggered by another factor—a virus, a drug, or an environmental toxin. Currently, doctors cannot cure autoimmune diseases, but they can provide treatments that lessen the diseases' effects.

Apply **How do autoimmune diseases disrupt other body systems?**

31.5 ASSESSMENT

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REVIEWING MAIN IDEAS

1. Under what conditions is an antigen called an **allergen**?
2. Why might an autoimmune disease be considered a failure of the immune system?

CRITICAL THINKING

3. **Infer** Some **allergies** are treated with drugs called antihistamines. How do you think antihistamines might work?
4. **Analyze** Why does someone experiencing **anaphylaxis** need to receive medicine through injection instead of swallowing a pill?

Connecting CONCEPTS

5. **Ecology** Bee stings can be deadly for people who are allergic to them, but in most people, a bee sting simply hurts and warns the person to leave the insect alone. How are stingers beneficial to the survival of bee species?