Section 2

The Body's Defenses

Reading Preview

Key Concepts

- How does the body's first line of defense guard against pathogens?
- What happens during the inflammatory response?
- How does the immune system respond to pathogens?
- How does HIV affect the immune system and how does it spread?

Key Terms

- inflammatory response
- phagocyte • immune response
- lymphocyte • T cell
- antigen • B cell • antibody
- AIDS • HIV

Target Reading Skill

Building Vocabulary After you read this section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

Which Pieces Fit Together?

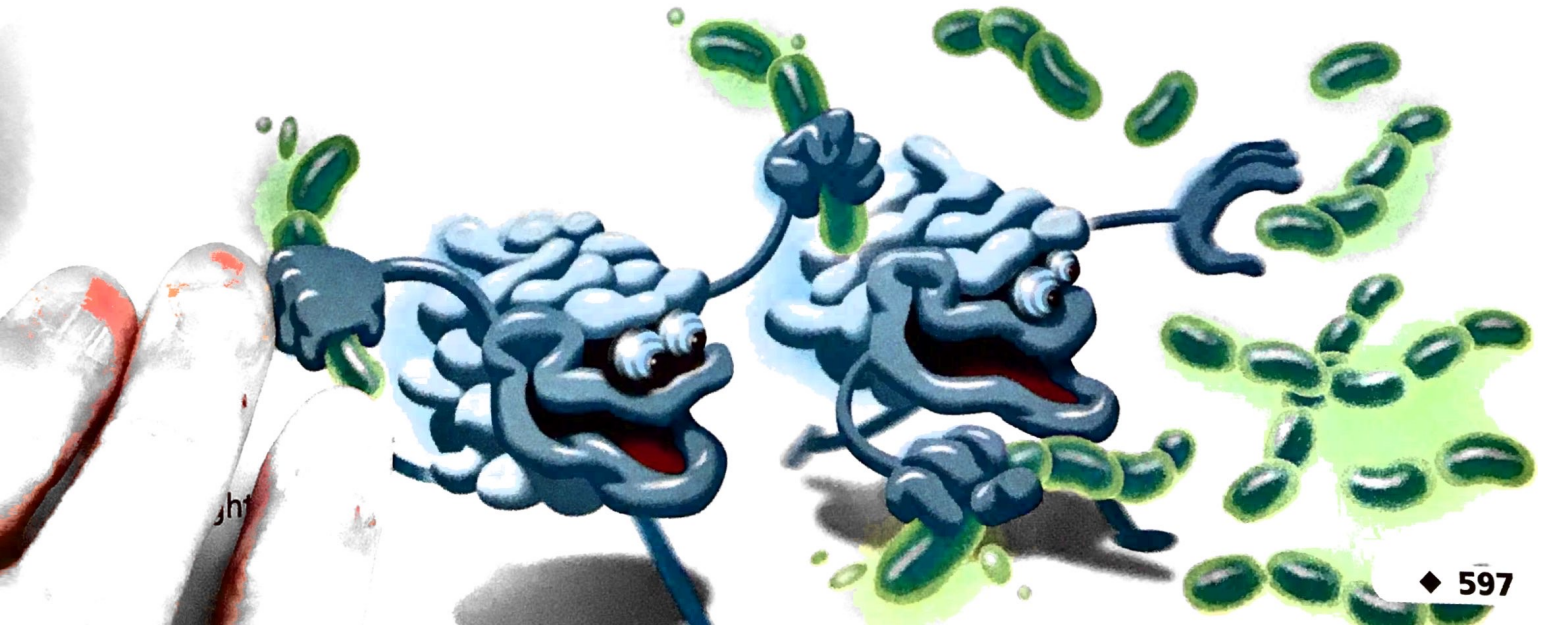
1. Your teacher will give you a piece of paper with one jagged edge.
2. One student in the class has a piece of paper with a jagged edge that matches yours, like two pieces of a jigsaw puzzle. Find the student whose paper matches yours and fit the two edges together.

Think It Over

Inferring Imagine that one piece of paper in each matching pair is a pathogen. The other is a cell in your body that defends your body against the invading pathogen. How many kinds of invaders can each defender cell recognize?

Your eyes are glued to the video screen. Enemy troops have gotten through an opening in the wall. Your soldiers have held back most of the invaders. However, some enemy soldiers are breaking through the defense lines. You need your backup defenders. They can zap invaders with their more powerful weapons. If your soldiers can fight off the enemy until the backup team arrives, you can save your fortress.

Video games create fantasy wars, but in your body, real battles happen all the time. In your body, the "enemies" are invading pathogens. You are hardly ever aware of these battles. The body's disease-fighting system is so effective that most people get sick only occasionally. By eliminating pathogens that can harm your cells, your body maintains homeostasis.



Barriers That Keep Pathogens Out

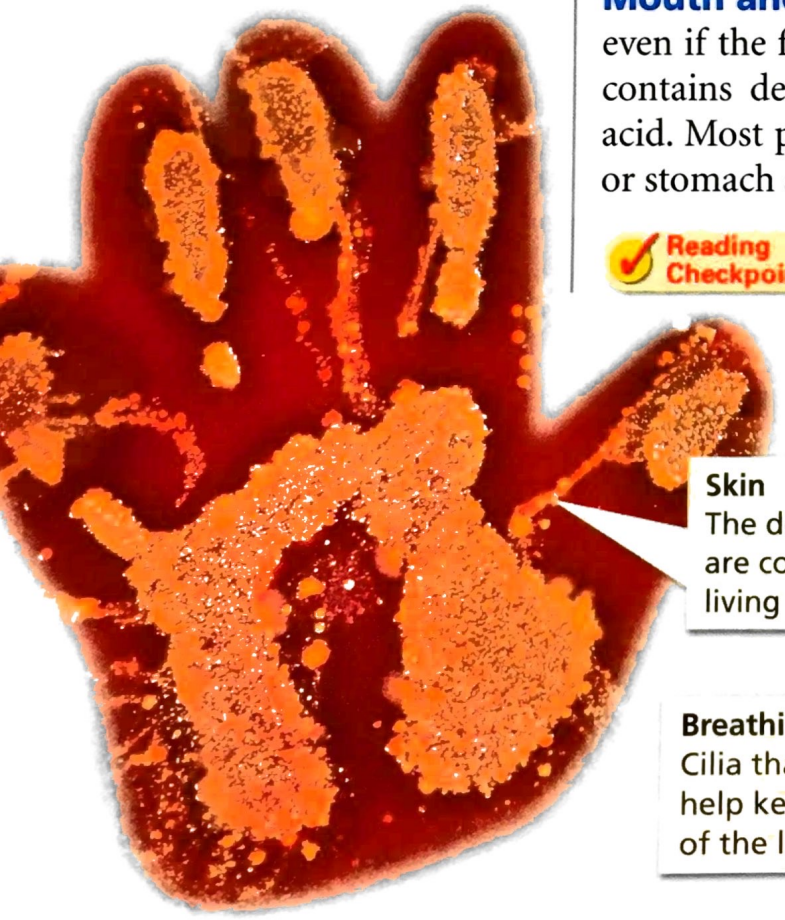
Your body has three lines of defense against pathogens. The first line consists of barriers that keep most pathogens from getting into the body. You do not wear a sign that says "Pathogens Keep Out," but that doesn't matter. **In the first line of defense, the surfaces of the skin, breathing passages, mouth, and stomach function as barriers to pathogens. These barriers trap and kill most pathogens with which you come into contact.**

Skin When pathogens land on the skin, they are exposed to destructive chemicals in oil and sweat. Even if these chemicals don't kill them, the pathogens may fall off with dead skin cells. If the pathogens manage to stay on the skin, they must get through the tightly packed dead cells that form a barrier on top of living skin cells. Most pathogens get through the skin only when it is cut. Scabs form over cuts so rapidly that the period in which pathogens can enter the body in this way is very short.

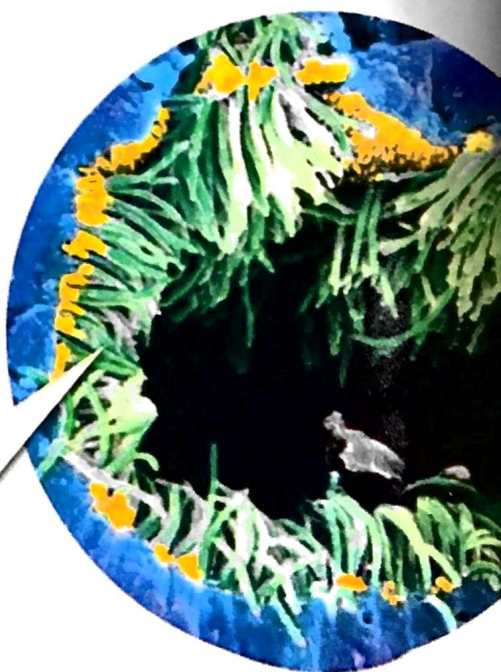
Breathing Passages Pathogens can also enter the body when you inhale. The nose, pharynx, trachea, and bronchi, however, contain mucus and cilia. Together, the mucus and cilia trap and remove most of the pathogens that enter the respiratory system. In addition, irritation by pathogens may make you sneeze or cough. Both actions force the pathogens out of your body.

Mouth and Stomach Some pathogens are found in foods, even if the foods are handled safely. The saliva in your mouth contains destructive chemicals, and your stomach produces acid. Most pathogens that you swallow are destroyed by saliva or stomach acid.

Reading Checkpoint **How do your breathing passages help keep pathogens out of your body?**



Skin
The dots in this photo are colonies of bacteria living on a person's hand.



Breathing Passages
Cilia that line the trachea help keep pathogens out of the lungs.

FIGURE 5
Barriers to Pathogens
The surfaces of your skin and breathing passages are the first line of defense for keeping pathogens out of your body.
Relating Cause and Effect *How can washing your hands help prevent infection?*

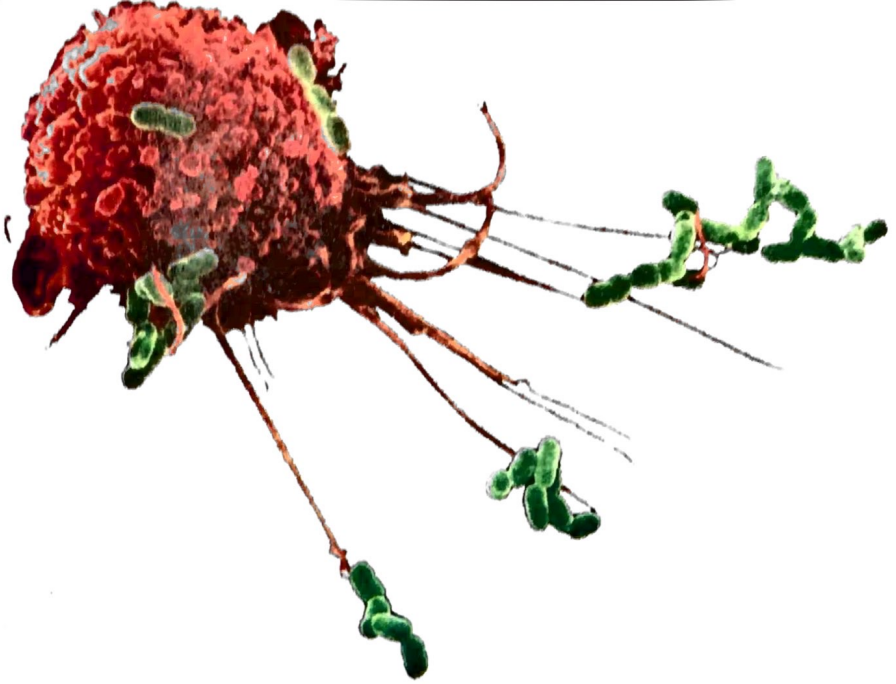


FIGURE 6
Phagocytes Destroy Pathogens Caught! A phagocyte (shown in red) is a white blood cell that engulfs and destroys bacteria (shown in green). As phagocytes do their job, the body shows visible signs of inflammation, which include redness and swelling.

The Inflammatory Response

In spite of barriers, pathogens sometimes get into your body and begin to damage cells. When body cells are damaged, they release chemicals that trigger the **inflammatory response,** which is the body's second line of defense. **In the inflammatory response, fluid and white blood cells leak from blood vessels into nearby tissues. The white blood cells then fight the pathogens.** Because the inflammatory response is the same regardless of the pathogen, it is called the body's general defense.

White Blood Cells All white blood cells are disease fighters. However, there are different types of white blood cells, each with its own particular function. The type involved in the inflammatory response are the phagocytes. A **phagocyte** (FAG uh syt) is a white blood cell that engulfs pathogens and destroys them by breaking them down.

Inflammation During the inflammatory response, blood vessels widen in the area affected by the pathogens. This enlargement increases blood flow to the area. As a result, more disease-fighting white blood cells are delivered to the area. The enlarged blood vessels, and the fluid that leaks out of them, make the affected area red and swollen. If you touch the swollen area, it will feel slightly warmer than normal.

Fever In some cases, chemicals produced during the inflammatory response cause a fever. Although fever makes you feel bad, it actually helps your body fight the infection. Some pathogens do not grow and reproduce well at higher temperatures.

Reading Checkpoint **What role do white blood cells play in the inflammatory response?**

The Immune System

If a pathogen infection is severe enough to cause a fever, it triggers the body's third line of defense—the **immune response.** The immune response is controlled by the immune system, the body's disease-fighting system. **The cells of the immune system can distinguish between different kinds of pathogens. The immune system cells react to each kind of pathogen with a defense targeted specifically at that pathogen.**

The white blood cells that distinguish between different kinds of pathogens are called **lymphocytes** (LIM fuh syts). There are two major kinds of lymphocytes—T lymphocytes and B lymphocytes, which are also called T cells and B cells. In Figure 7, you can see how T cells and B cells work together to destroy flu viruses.

T Cells A major function of **T cells** is to identify pathogens and distinguish one kind of pathogen from another. You have tens of millions of T cells circulating in your blood. Each kind of T cell recognizes a different kind of pathogen. What T cells actually recognize are marker molecules, called antigens, found on each pathogen. **Antigens** are molecules that the immune system recognizes either as part of your body or as coming from outside your body.

You can think of antigens as something like the uniforms that athletes wear. When you watch a track meet, you can look at the runners' uniforms to tell which school each runner comes from. Like athletes from different schools, each different pathogen has its own kind of antigen. Antigens differ from one another because each kind of antigen has a different chemical structure. T cells distinguish one chemical structure from another.

B Cells The lymphocytes called **B cells** produce proteins that help destroy pathogens. These proteins are called **antibodies.** Each kind of B cell produces only one kind of antibody, and each kind of antibody has a different structure. Antigen and antibody molecules fit together like pieces of a puzzle. An antigen on a flu virus will only bind to one kind of antibody—the antibody that acts against that flu virus.

When antibodies bind to the antigens on a pathogen, they mark the pathogen for destruction. Some antibodies make pathogens clump together. Others keep pathogens from attaching to the body cells that they might damage. Still other antibodies make it easier for phagocytes to destroy the pathogens.

Reading Checkpoint **What is the function of an antibody?**

Lab zone Try This Activity

Stuck Together

In this activity, you will model one way in which an antibody prevents a pathogen from infecting a body cell.

1. Use a large ball to represent a body cell, and a smaller ball to represent a pathogen.
2. Press a lump of modeling clay onto the small ball. Then use the clay to stick the two balls together. This model shows how a pathogen attaches itself to a body cell.
3. Pull the two balls apart, keeping the clay on the small ball (the pathogen).
4. Put strips of tape over the clay, so that the clay is completely covered. The tape represents an antibody.
5. Now try to reattach the small ball to the larger one.

Making Models Use the model to explain how antibodies prevent pathogens from attaching to body cells.

FIGURE 7

The Immune Response

The immune system includes T cells and B cells. The cells of the immune system work together to combat an infection, such as one caused by flu viruses.

Interpreting Diagrams *What happens after a T cell recognizes an invading virus?*

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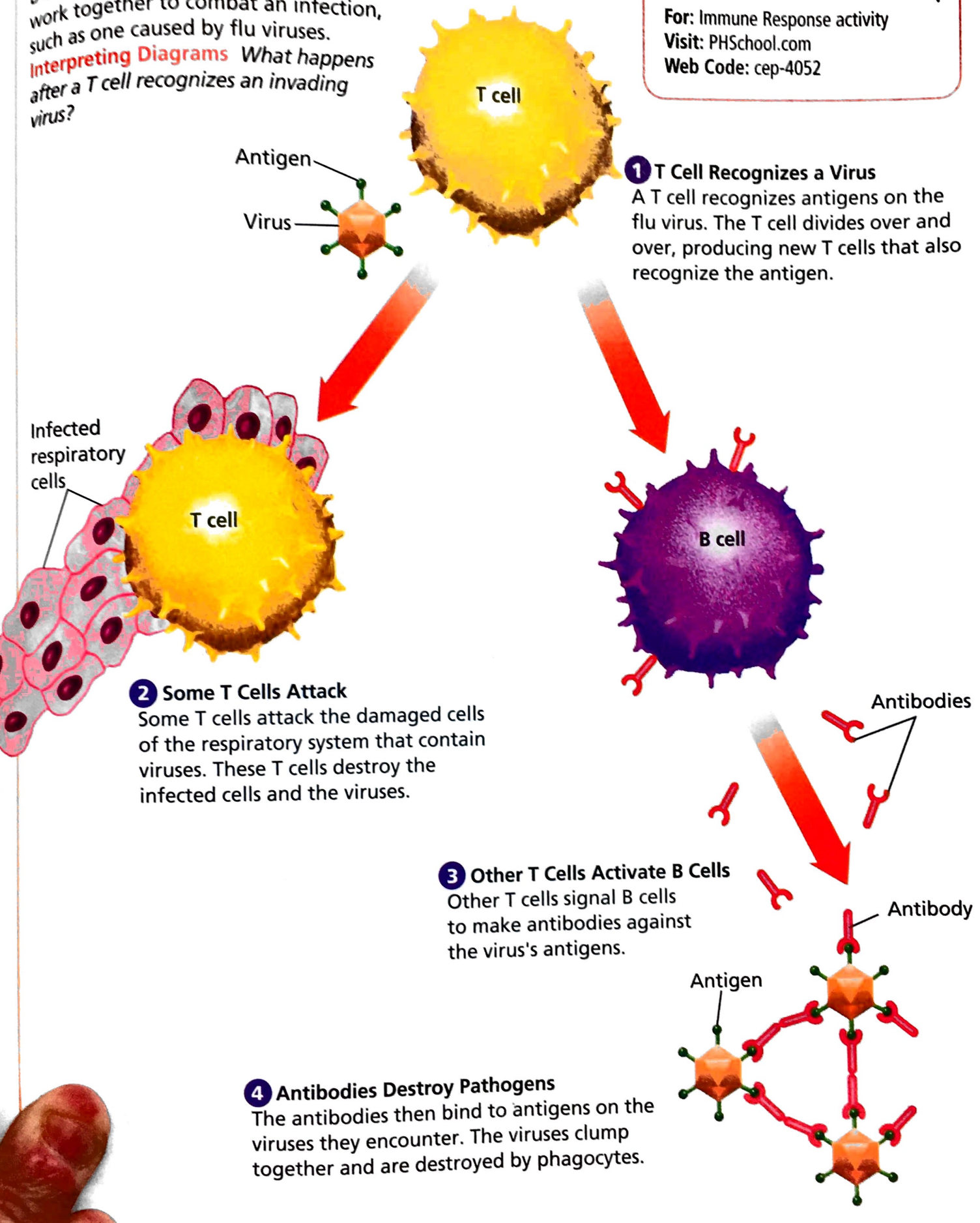

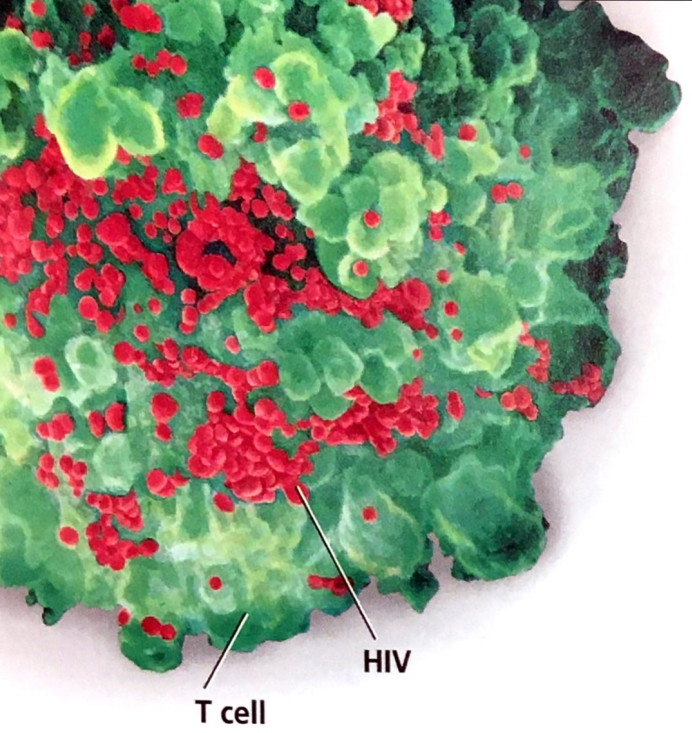

FIGURE 8
Human Immunodeficiency Virus (HIV)
The tiny red particles are HIV viruses emerging from a T cell. The viruses multiply inside the T cell and eventually cause the cell to die.
Relating Cause and Effect
Why does the destruction of T cells interfere with the body's ability to fight disease?

AIDS

Acquired immunodeficiency syndrome, or **AIDS,** is a disease caused by a virus that attacks the immune system. The virus that causes AIDS is called the human immunodeficiency virus, or **HIV.**

How HIV Affects the Body **HIV is the only kind of virus known to attack the human immune system directly and destroy T cells.** Once it invades the body, HIV enters T cells and reproduces inside them. People can be infected with HIV—that is, have the virus living in their T cells—for years before they become sick. More than 40 million people in the world, including more than 3 million children under 15, are infected with HIV.

Eventually, HIV begins to destroy the T cells it has infected. As the viruses destroy T cells, the body loses its ability to fight disease. Most persons infected with HIV eventually develop the symptoms of AIDS.

Because their immune systems no longer function properly, people with AIDS become sick with diseases not normally found in people with healthy immune systems. Many people survive attack after attack of such diseases. But eventually their immune systems fail, ending in death. At this time, there is no cure for AIDS. However, new drug treatments allow many people with AIDS to survive much longer than those in the past.

How HIV Is Spread Like all other viruses, HIV can only reproduce inside cells. However, the virus can survive for a short time outside the human body in body fluids, such as blood and the fluids produced by the male and female reproductive systems.

HIV can spread from one person to another only if body fluids from an infected person come in contact with those of an uninfected person. Sexual contact is one way in which this can happen. HIV may also pass from an infected woman to her baby during pregnancy or childbirth or through breast milk. In addition, infected blood can spread HIV. For example, if an infected drug user shares a needle, the next person who uses the needle may also become infected. Before 1985, HIV was sometimes transmitted through blood transfusions. Since 1985, however, all donated blood in the United States has been tested for signs of HIV. If blood is identified as infected, it is not used in transfusions.

FIGURE 9
How HIV Is Not Spread
You cannot get HIV, the virus that causes AIDS, by hugging someone infected with the virus.

How HIV Is Not Spread It is important to know the many ways in which HIV is *not* spread. HIV does not live on skin, so you cannot be infected by hugging or shaking hands with an infected person. You can't get infected by using a toilet seat after it has been used by someone with HIV. HIV is also not spread when you bump into someone while playing sports.

Reading Checkpoint **What disease is caused by HIV?**