31.6 Diseases That Weaken the Immune System

VOCABULARY

- leukemia
- opportunistic infection
- human immunodeficiency virus (HIV)
- acquired immune deficiency syndrome (AIDS)

KEY CONCEPT **When the immune system is weakened, the body cannot fight off diseases.**

MAIN IDEAS

- Leukemia is characterized by abnormal white blood cells.
- HIV targets the immune system.

Connect to Your World

There is no cure for AIDS. But people who are infected with HIV do not die directly from it—some people don't know that they're infected for more than ten years. Instead, as HIV weakens the immune system, they become sick with other diseases. Illnesses that weaken the immune system, such as an AIDS infection, make it easy for other pathogens to infect the body and take over.

MAIN IDEA

Leukemia is characterized by abnormal white blood cells.

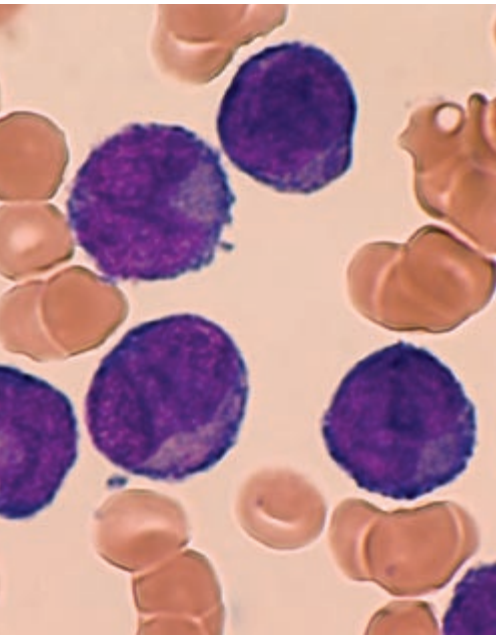


FIGURE 6.1 The blood of a person with leukemia contains an abnormally high number of immature white blood cells, dyed purple in this micrograph.
(LM; magnification 1400x)

Bone marrow is a tissue found within bones. Red bone marrow makes red and white blood cells and platelets. In healthy marrow, new blood cells replace mature ones that die. Sometimes, blood cells do not mature properly.

Leukemia is cancer of the bone marrow. Unlike other cancers, leukemia does not form tumors. Instead, it prevents the bone marrow from functioning properly. In one type of leukemia, the bone marrow produces white blood cells that do not develop properly. Because the cells are immature, they cannot fight infections. Here is how leukemia weakens the immune system.

- Bone marrow produces white blood cells that don't mature. These cells are shown in **FIGURE 6.1.**
- In effort to replace the defective white blood cells, the bone marrow produces more and more white blood cells. However, none of these new cells mature into effective white blood cells.
- Eventually, the bone marrow spends all of its time making white blood cells. As a result, it makes fewer red blood cells and platelets than are needed to replace those that die or become damaged.

To cure leukemia, the cancerous bone marrow must be replaced with healthy marrow from a donor. Before a bone marrow transplant takes place, the recipient is given large doses of radiation and chemotherapy to kill all the abnormal bone marrow cells. Then the donor marrow is put into the body. If the transplant is successful, the donor marrow will make healthy blood cells.

However, problems can arise from bone marrow transplants. In graft-versus-host disease (GVHD), the donor marrow makes antibodies against the host's healthy tissues. Chemotherapy and radiation treatments also kill both cancerous cells and healthy cells, leaving the immune system weak and open to opportunistic infections. An **opportunistic infection** is an infection caused by a pathogen that a healthy immune system would normally be able to fight off. When the immune system is weakened, an opportunistic infection can make a person very sick.

Analyze **Shortness of breath and inability to form blood clots are common symptoms of leukemia. How does the disease lead to these symptoms?**

MAIN IDEA

HIV targets the immune system.

The World Health Organization estimates that more than 30 million people in the world have HIV/AIDS. During the 1980s, fewer than 2 million people had the virus. The **human immunodeficiency virus (HIV),** illustrated in **FIGURE 6.2,** is a retrovirus that attacks and weakens the immune system. A retrovirus is a type of virus that contains RNA instead of DNA. HIV is a retrovirus that has nine genes. HIV weakens the immune system, and the body is likely to get opportunistic infections.

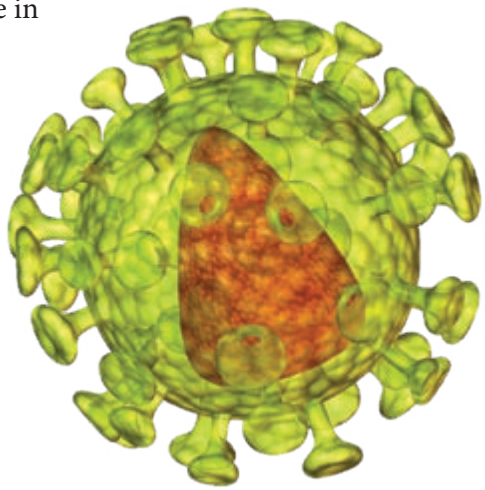


FIGURE 6.2 HIV is a small retrovirus that is covered with bumps, which are its antigens. This illustration shows an HIV about 500,000 times its actual size.

HIV Transmission

Although HIV is a very dangerous pathogen, it can only live in human blood cells and thus will not survive for long outside of the human body. For this reason, HIV is not transmitted through shaking hands with an infected individual, or swimming in a pool with an infected person. HIV cannot be transmitted through insect bites either. Insects that suck blood, such as ticks or mosquitoes, quickly digest the blood cells in their guts. Once the blood is digested, HIV dies.

A person becomes infected with HIV when the virus enters his or her bloodstream. HIV is passed from person to person through the mixing of blood and other body fluids. HIV is transmitted through sexual intercourse with an infected individual. It can also be passed from mothers to their unborn babies through the umbilical cord. A person might also get HIV if his or her skin is pierced by a needle that an infected individual recently used. Hypodermic needles used for injecting some illegal drugs and needles used for body piercing and tattooing have transmitted HIV between individuals. However, needles that your doctor uses to give shots or take blood do not transmit HIV because doctors use a new needle for every patient.

HIV Reproduces in T Cells

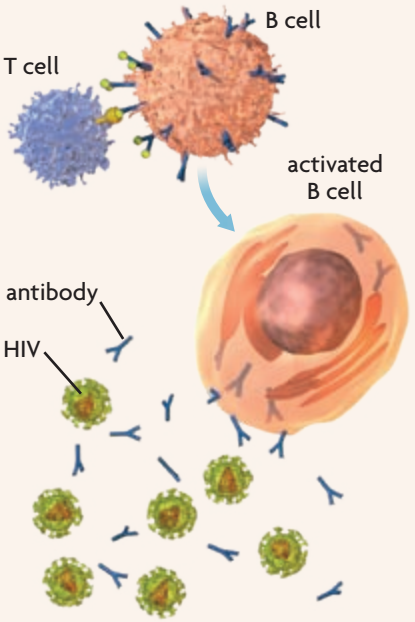
HIV infects T cells, the white blood cells that trigger the body's immune responses. When HIV enters a T cell, the T cell becomes ineffective and can no longer stimulate an immune response. While the T cell cannot function in the immune system, it remains alive as a host and produces new HIV. A single T cell can give rise to thousands of HIVs before it eventually dies.

FIGURE 6.3 HIV Destroys T cells

HIV reproduces within T cells, killing T cells and weakening the immune system.

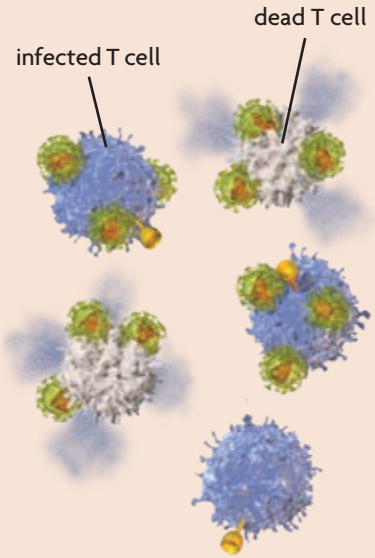
1 HIV ENTERS THE BODY

When HIV first enters the body, T cells activate B cells, and the activated B cells make antibodies against HIV.



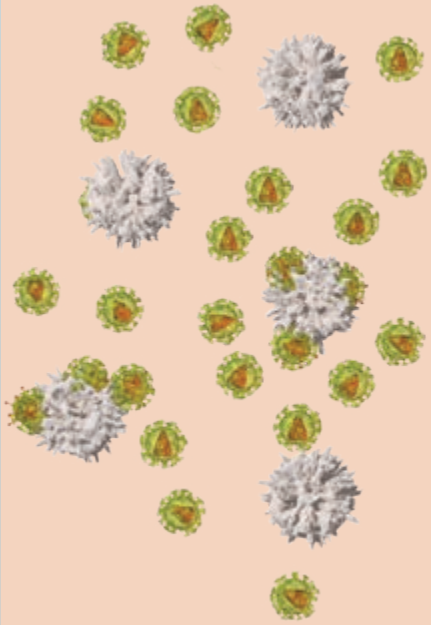
2 HIV DESTROYS T CELLS

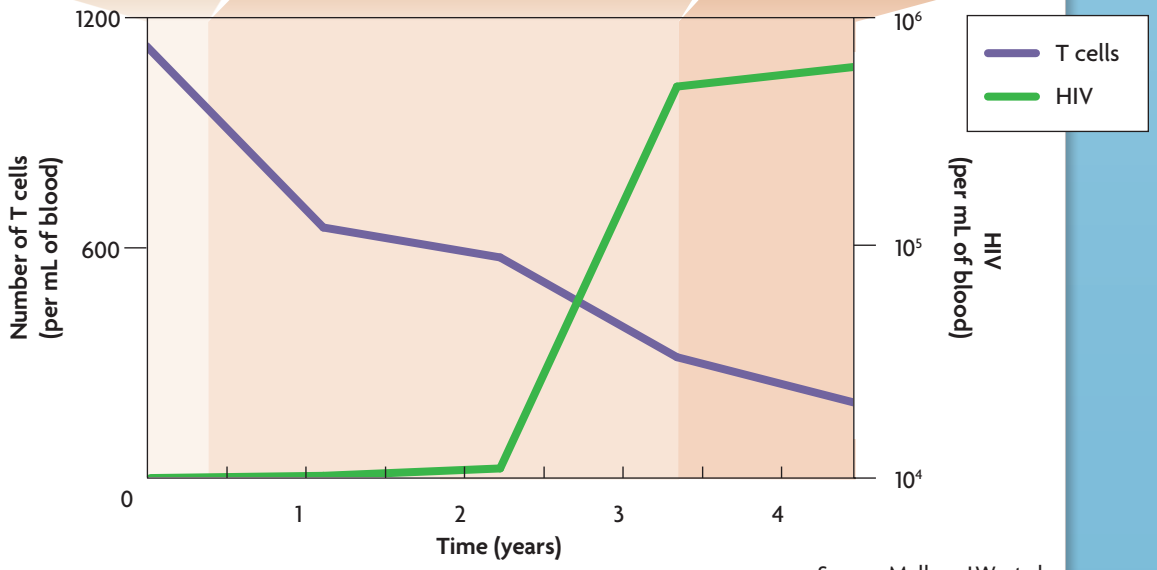
Because HIV kills T cells and reproduces more quickly than T cells, as HIV continues to reproduce, fewer and fewer T cells remain in the body.



3 HIV OVERPOWERS THE IMMUNE SYSTEM

With fewer T cells, B cells cannot be activated to make antibodies. HIV and pathogens that cause opportunistic diseases take over the body.





Source: Mellors, J.W. et al. *Annals of Internal Medicine.*

CRITICAL VIEWING **Why might a graph comparing HIV and antibodies have a similar shape to the one above, which compares HIV and T cells?**

As HIV reproduces, the body cannot make replacement T cells fast enough. As the immune system weakens, opportunistic infections begin to take over.

During the first few weeks of infection, a person usually does not feel sick. Although HIV is infecting some T cells, there are still enough healthy T cells that B cells can be activated to produce antibodies against HIV, as shown in **FIGURE 6.3.** At this stage, HIV is diagnosed by determining whether a person's blood contains antibodies against HIV.

After the initial infection, an infected person can have HIV for ten years or more without experiencing any symptoms. During this stage, more and more T cells become infected, and each cell produces thousands of HIV cells, as shown in **FIGURE 6.4.** Soon, the bone marrow cannot replace dead T cells quickly enough, and the body develops opportunistic infections and AIDS.

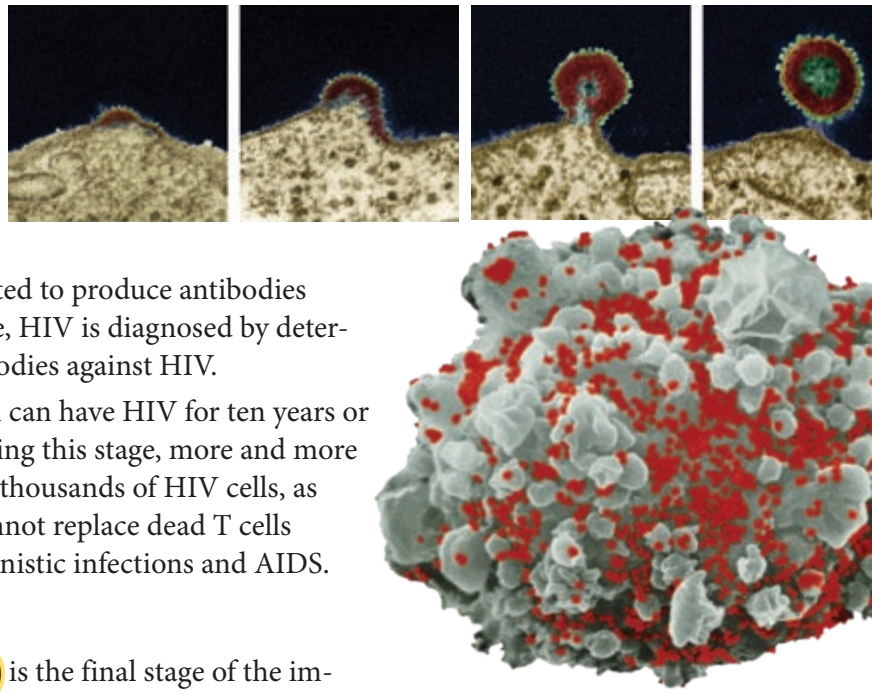


FIGURE 6.4 **Thousands of HIV, shown in red, will bud off a T cell before the T cell dies.** (top: colored TEM, magnification 105,000×; bottom: colored SEM, magnification 5000×)

HIV Leads to AIDS

Acquired immune deficiency syndrome (AIDS) is the final stage of the immune system's decline due to HIV. Whereas HIV is a virus, AIDS is the condition of having a worn-out immune system. A person with AIDS can have several opportunistic infections—such as fungal infections, tuberculosis, pneumonia, viral infections, and cancers—and very few T cells. AIDS almost always results in death because the body cannot fight many such infections.

Current treatment of an HIV infection is expensive, complicated, and only slows—but does not cure—the disease. Treatment involves a combination of three to four antiviral drugs that are taken as often as five times each day. These drugs can cause many unpleasant side effects and can be very expensive. What's more, as HIV mutates, a patient might need to use many different drug combinations to keep the infection under control. Also, HIV mutates rapidly, and so far no vaccine has provided complete protection against the constantly evolving strains of HIV. However, treatment can enable a person to live for 20 years or more after initial HIV infection.

Apply **How does destruction of T cells lead to overall immune system failure?**

31.6 Formative Assessment

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PREMIUM CONTENT

REVIEWING ▶ MAIN IDEAS

1. How does **leukemia** affect a person's entire body?
2. How do **HIV** and **AIDS** differ?

CRITICAL THINKING

3. **Analyze** Why is HIV infection difficult to cure, even with treatment with multiple medications?
4. **Compare and Contrast** Which cells of the immune system are affected by HIV and leukemia, and what parts of the immune response do these cells influence?

CONNECT TO

ANTIBIOTICS

5. You have learned that viruses cannot be treated with antibiotics. Why, then, might doctors prescribe antibiotics to patients with HIV anyway?