40–3 Immune System Disorders

Although the immune system defends the body from a wide range of pathogens, sometimes disorders occur in the immune system itself. There are three different types of disorders. These disorders include allergies, autoimmune diseases, and immunodeficiency diseases.

Allergies
The most common overreactions of the immune system to antigens are known as allergies. Common allergies include those to pollen, dust, mold, and bee stings. Antigens that cause allergic reactions are called allergens. Some common allergens are shown in Figure 40–12.

When allergy-causing antigens enter the body, they attach themselves to mast cells. Mast cells are specialized immune system cells that initiate the inflammatory response. The activated mast cells release chemicals known as histamines. Histamines increase the flow of blood and fluids to the surrounding area. They also increase mucous production in the respiratory system. The increased mucous production brings on the sneezing, watery eyes, runny nose, and other irritations that make a person with allergies so uncomfortable. If you have allergies, you may have taken antihistamines. Antihistamines are drugs that are used to counteract the effects of histamines.

Vocabulary Preview
Suggest that students scan the section for the highlighted, boldface Vocabulary terms and write a definition for each term based on the information in the text.

Reading Strategy
Have students read the figure captions and find the terms allergens, autoimmune disease, and retrovirus. Challenge students to define the terms based on the information in the captions.

Allergies
Build Science Skills
Using Tables and Graphs
Have students design a simple allergy questionnaire that includes questions on whether the subject has allergies and which allergens are known or thought to be responsible. Then, have each student administer the questionnaire to at least five people, such as family members and neighbors, and summarize the results in a table that shows the number of people with allergies and the number allergic to each allergen. Assign a few students to pool the results for the whole class, and use the data to create a bar graph showing the proportion of the total sample affected by the top three allergens.

Figure 40–12
Common allergens include ragweed pollen, dust, and dust mites. In the SEM of the dust ball, notice the insect parts, gray spider webbing, and other dirt. Dust mites live in furniture, mattresses, and even pillows. Inferring Why do you think it is recommended that people wash their bed coverings in hot water?

Figure 40–12

Ragweed Pollen (magnification: 770X)
Dust Ball (magnification: 760X)
Dust Mite (magnification: 900X)

Section 40–3

Objectives
40.3.1 State what happens when the immune system overreacts.
40.3.2 Explain what an autoimmune disease is.
40.3.3 Describe how HIV is transmitted and affects the immune system.

Guide for Reading

Key Concepts
• What is an autoimmune disease?
• How can AIDS be prevented?

Vocabulary
allergy
histamine
asthma

Reading Using Prior Knowledge
Do you or someone you know have allergies? As you read this section, use what you learn to explain the causes and symptoms of allergies.
Asthma

Use Community Resources

Arrange to have a nurse, physician’s assistant, or other medical professional visit the class. Ask the visitor to explain the various causes of asthma as well as the different types of medications used to treat asthma. Encourage students to ask any questions they might have.

Autoimmune Diseases

Make Connections

Health Science  Point out that there are many autoimmune diseases in addition to those listed in the text. Another relatively common example is systemic lupus erythematosus (SLE). In this disease, the immune system attacks normal connective tissue, and this leads to inflammation and pain in the joints, among other symptoms.

Autoimmune Diseases

Vocabulary: Word Analysis

Beginning  Write disease and antibiotic on the board. Then, rewrite each word as a separate prefix and base, i.e., dis- and ease, and anti- and biotic. Explain that the two prefixes, dis- and anti-, can have similar meanings; they can mean “against,” or “opposing.” Explain that ease can mean “comfort” or “wellness,” and that disease is the opposite of comfort or wellness. Similarly, biotic comes from a word meaning “life,” and an antibiotic acts against harmful living things, specifically bacteria. Discuss other words with these prefixes, such as disagree, discomfort, and antifreeze.

Intermediate  After the beginning-level activity, have the students form a collaborative writing group to write sentences using each term. Have a volunteer from the group read the sentences.

Asthma

Some allergic reactions can create a dangerous condition called asthma. Asthma is a chronic respiratory disease in which the air passages become narrower than normal. This narrowing of the air passages causes wheezing, coughing, and difficulty in breathing. Many factors, including both heredity and environment, play a role in the onset of the symptoms of asthma.

Asthma is a leading cause of serious illness among children, and can be a life-threatening disease. If treatment is not started early enough or if medications are not taken properly, asthma can lead to permanent damage or destruction of lung tissue.

Asthma attacks can be triggered by respiratory infections, exercise, emotional stress, and certain medications. Other triggers include cold air, pollen, dust, tobacco smoke, pollution, molds, and pet dander.

There is no cure for asthma; however, people who have asthma can sometimes control the condition. If the attacks are caused by an allergy, a series of tests can identify what substances cause the problem. Medications are sometimes used to relieve the symptoms of asthma. Often, these medications relax the smooth muscles around the airways, making breathing easier.

Autoimmune Diseases

The immune system could not defend your body against a host of invading pathogens unless it was able to distinguish those pathogens from the cells and tissues that are part of your body. In other words, the immune system usually has the ability to distinguish “self” from “nonself.”

When the immune system makes a mistake and attacks the body’s own cells, it produces an autoimmune disease. Multiple sclerosis is one example of an autoimmune disease in which antibodies attack connective tissues around the joints. In myasthenia gravis, antibodies attack neuromuscular junctions. Multiple sclerosis is an autoimmune disease in which antibodies destroy the functions of the neurons in the brain and spinal cord.

Some autoimmune diseases are treated with medications that alleviate specific symptoms. For example, people who have Type I diabetes can be given insulin injections. Other autoimmune diseases are treated with medications that suppress the immune response. However, these medications also affect the normal immune response against pathogens, so this type of therapy is not used often or is carefully monitored. As researchers find out more about autoimmune diseases, they hope to develop more effective treatments.
AIDS, an Immunodeficiency Disease

Another type of immune system disorder is immunodeficiency disease. In one type of immunodeficiency disease, the immune system fails to develop normally. A second type of immunodeficiency disease is AIDS. AIDS results from a viral infection that destroys helper T cells. As the number of helper T cells declines, the normal immune response breaks down.

During the late 1970s, some physicians in Europe and the United States were bewildered. Some of their patients were dying from infections produced by benign microorganisms that didn’t normally cause disease. Previously healthy people began to suffer from unusual illnesses such as Pneumocystis carinii (a kind of pneumonia), Kaposi’s sarcoma (a rare form of skin cancer), and severe fungal infections of the mouth and throat. Normally, such infections are prevented by the immune system. Individual doctors realized that the symptoms were a signal that the immune systems of their patients had been weakened.

Some doctors recognized that these illnesses were actually symptoms of a new disease. Doctors in Los Angeles suggested the name AIDS—for acquired immune deficiency syndrome. As more cases appeared, researchers realized that this “syndrome” was actually an infectious disease caused by a pathogen that was unknown to the scientific community.

The Virus That Causes AIDS

In 1983, researchers identified the cause of AIDS—a virus that they named HIV for human immunodeficiency virus. HIV is a retrovirus—a virus that carries its genetic information in RNA, rather than DNA. HIV turned out to be a deadly and efficient virus for two reasons. First, HIV evades the defenses of the immune system. Second, HIV attacks key cells in the immune system, destroying the body’s defenses and leaving the body with no protection against other pathogens.

Among HIV’s main targets are the helper T cells. When the HIV virus attacks a helper T cell, it attaches to receptor molecules on the cell membrane. This allows the virus to enter the cell, as shown in Figure 40–14. Once the viral core is inside the cell, it forces the host cell to make DNA copies of the virus’s RNA. Some of those copies insert themselves into host cell DNA and stay there permanently. Other copies remain in the cytoplasm. The viral DNA may remain inactive in the host cell for varying periods of time. When activated, it directs the production of viral RNA and proteins that are assembled into new virus particles. These viruses eventually leave the infected cell and infect new cells. The immune system produces antibodies for HIV. Unfortunately, these antibodies are not effective in stopping the progression of the disease.

Despite the production of antibodies, HIV destroys ever-increasing numbers of T cells, crippling the immune system. By counting the number of helper T cells, the progression of HIV infection can be monitored. The fewer helper T cells, the more advanced the disease.

AIDS, an Immunodeficiency Disease

Address Misconceptions

Point out that the terms HIV infection and AIDS are often used interchangeably. Explain that a person with an HIV infection may or may not have symptoms of the disease AIDS. In fact, an infected person may have no idea that he or she is even infected. Add that a person is diagnosed with AIDS only after the HIV infection has caused immune system damage leading to specific unusual infections, such as fungal infections in the mouth and rare forms of skin cancer. The clinical definition of AIDS includes a helper T cell count of 200/mm³ of blood or lower.

Build Science Skills

Applying Concepts Check students’ comprehension of the way HIV causes disease. Ask: How does HIV “trick” helper T cells into making new copies of HIV? (HIV forces host T cells to make DNA copies of viral RNA. The DNA, in turn, directs the production of new viral RNA and proteins that are assembled into new virus particles.)

Ask: How does HIV enter the central nervous system? (By hiding inside certain blood cells)

Make Connections

Health Science Emphasize the point that the symptoms of AIDS are not caused directly by HIV but rather by the damage HIV does to the immune system. Explain that similar symptoms are produced by other causes of immune system damage or dysfunction, including immunosuppressant drugs, which are given to people who have organ transplants.

Answer to . . .

Cerebrospinal smooth muscle contractions reduce the size of air passageways in the lungs and make breathing very difficult.

Figure 40–14 White blood cell
Make Connections

Health Science Explain that HIV infections can be detected with a blood test for the presence of antibodies to HIV. A positive test indicates that the antibodies are present, and a negative test indicates that the antibodies are not present. Ask: What do you think a false negative result indicates? (That antibodies are present but not detected by the test)

Use Community Resources Invite a professional who works with people with AIDS to speak to the class about the medical, emotional, and financial consequences of living with AIDS. Possible speakers might include a public-health nurse, home healthcare provider, or social worker. Urge students to ask questions at the end of the presentation.

Use Community Resources

HIV and helper T cells

Two types of HIV virus are known: HIV–1 and HIV–2. In both types, each viral particle consists of a protein core that surrounds its RNA and several copies of the enzyme reverse transcriptase. When the virus attaches to a helper T cell, the protein core becomes wrapped in a lipid envelope derived from the T cell’s plasma membrane. The virus progresses from the surface of the T cell to the cell interior. Once the virus is inside the T cell, the reverse transcriptase uses the viral RNA as a template for making DNA. This DNA is then inserted into a chromosome of the helper T cell. When the helper T cell is activated, it transcribes the HIV DNA along with portions of its own DNA, thus inadvertently producing copies of viral RNA. The viral RNA is translated into viral proteins, which assemble to form new viruses that go on to infect and destroy more helper T cells.

As the number of helper T cells decreases, the body becomes more and more susceptible to other diseases. The diseases that attack a person with a weakened immune system are called opportunistic diseases.

Transmission of HIV Although HIV is a deadly disease, it is not easily transmitted. It is not transmitted through casual contact. HIV can only be transmitted through the exchange of blood, semen, vaginal secretions, or breast milk.

There are four main ways that HIV can be transmitted:

• through any form of sexual intercourse with an infected person;
• through shared needles or syringes that are contaminated with the blood of an infected person;
• through contact with blood or blood products of an infected person; and
• from an infected mother to child, either during pregnancy, during birth, or during breast-feeding.
Preventing HIV Infection  Fortunately you can choose behaviors that will help you reduce your risk of becoming infected with HIV. The only no-risk behavior with respect to HIV and AIDS is abstinence. Within a committed sexual relationship such as marriage, sexual fidelity between two uninfected partners presents the least risk of becoming infected with HIV.

Avoiding drug use is also important for reducing the risk of HIV infection. People who share contaminated needles to inject themselves with drugs are at a high risk for contracting HIV. People who have sex with drug abusers are also at high risk.

Before 1985, HIV was transmitted to some hemophiliacs and surgical patients through transfusions of infected blood or blood products. Such cases have been nearly eliminated by screening the blood supply for HIV antibodies and by discouraging potentially infected individuals from donating blood.

Can AIDS Be Cured?  At present, there is no cure for AIDS. However, progress has been made in developing drugs that make it possible to survive HIV infection for years. Unfortunately, HIV mutates and evolves very rapidly. For this reason, the virus has been able to evolve into many different strains that are resistant to virtually all drugs used against them. Because HIV evolves so rapidly, no one has developed a vaccine that offers protection for any length of time.

At present, the only way to control the virus is to use expensive multidrug and multivitamin “cocktails” that fight the virus in several ways. Thanks to these drugs, more HIV-infected people are now living with HIV rather than dying from it.

Unfortunately, the knowledge that HIV can be treated (though not cured) has given people the idea that HIV infection is not as serious as it was a decade ago. In one year, more than 5 million people around the world became infected with HIV, including roughly 800,000 people under the age of 15. That same year, more than 3 million people around the world died of AIDS, bringing the total number of deaths worldwide to more than 20 million people.
Slowing a Worldwide Epidemic

AIDS is a threat on every continent in the world, but nowhere has its effect been more devastating than in Africa. Thirty million of the world’s 42 million people infected with HIV live in Africa. In some African countries, the HIV-infection rate is as high as one in three people. Leaders from around the world disagree on how the AIDS epidemic should be handled. Some argue that generic drugs should be made available. Others argue that the focus should be on AIDS prevention and education. Still others think that some money needs to be spent on the millions of AIDS orphans.

The Viewpoints

Make Drugs More Affordable
AIDS workers in Africa believe that more affordable drugs should be the top priority. HIV-infected people in Africa do not have access to the advanced medicines that people have in the United States. In Africa, the use of antiviral drugs is not common. Although the antiviral drugs do not cure AIDS, they help prolong life as long as they are taken on a regular basis. To increase access to these drugs, activists are looking for generic drugs, which would be lower in cost. Large pharmaceutical companies, however, don’t like this idea because they say that generic drugs violate the companies’ patents on such antiviral drugs.

Spend Money for Prevention
Many people in HIV-infected populations do not have basic knowledge about AIDS, including how HIV is spread. Thus, what is needed is an intensive program of public health education to stop the spread of the virus. If prevention programs including education and counseling were available, the incidence of new HIV infections could be reduced.

Spend Money on AIDS Orphans
More than 11 million children have lost parents to AIDS. Orphanages are overflowing with children who have no one to look after them. It is expected in Ethiopia—the country with the fastest-growing HIV-infection rate—that the number of orphans could increase about 150 percent over the next ten years. Because of this growing problem, a number of people feel that some of the money used to fight AIDS should be given to care for these orphans.

Research and Decide

1. Analyzing the Viewpoints To make an informed decision, learn more about this issue by consulting library or Internet resources. Then, list the key arguments for each of the viewpoints.

2. Forming Your Opinion Given limited resources to fight HIV, how would you decide the allocation of those resources? Would you spend all of the money on one area, or would you split it up among the different areas? What are the reasons for your decision?

BACKGROUND

No one knows why HIV appeared suddenly in the late 1970s, although most scientists believe it originated in Africa. It could have been a virus in monkeys that mutated and infected humans, but it has never been isolated from any animal source. In the United States and Europe, HIV has been transmitted most often among male homosexuals and intravenous drug users. In Africa, it has been transmitted almost solely among heterosexuals. Heterosexual transmission is also on the rise in Latin America. Besides education and treatment, a third way to possibly slow the AIDS epidemic is through vaccination. Scientists have been working for years on a vaccine to prevent HIV infection, but developing a vaccine has been difficult because HIV mutates rapidly. Nonetheless, a vaccine may be available in the near future.