MS Diseases and the Body's Defenses

Jean Brainard, Ph.D. (JeanB)
Sarah Johnson, (SarahJ)
CK12 Editor

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AUTHORS
Jean Brainard, Ph.D. (JeanB)
Sarah Johnson, (SarahJ)
CK12 Editor

CHAPTER 1 MS Diseases and the Body's Defenses

CHAPTER OUTLINE

What does the above image look like to you? A ball with sticks coming out of it? It is actually a human immunodeficiency virus (HIV). HIV is a deadly virus that is difficult for most humans to remove from their bodies.

You have an immune system that is supposed to stop viruses from infecting your body. So how do HIV and other diseases outsmart the body's immune system? What can we do to prevent HIV and other diseases from infecting our bodies? Why can't medicines cure HIV, but they can cure other illnesses?

Just because human immune systems cannot get rid of HIV, they still help people clear viruses and bacteria every moment of every day. How does the immune system remove dangerous diseases from our bodies? How can we improve our immune system's response to disease?

Your immune system is one of the most complex and interesting systems in your body. Consider the above questions as you read about the amazing ways that immune systems respond to diseases and also how they are limited by dangerous diseases, like HIV.

1.1 Infectious Diseases

Lesson Objectives

- List common causes of infectious diseases.
- Explain how the virus known as HIV causes AIDS.
- State how infectious diseases can be prevented.

Check Your Understanding

- What are bacteria?
- What is blood made out of?

Vocabulary

AIDS Acquired immune deficiency syndrome, which is a fatal condition caused by the human immunodeficiency virus (HIV).

HIV The human immunodeficiency virus, which causes AIDS.

infectious disease A disease that spreads from person to person.

Causes of Infectious Diseases

Has this ever happened to you? A student sitting next to you in class has a cold. The other student is coughing and sneezing, but you feel fine. Two days later, you come down with a cold, too. Diseases like colds are contagious. Contagious diseases are also called infectious diseases. An **infectious disease** is a disease that spreads from person to person.

Infectious diseases are caused by pathogens. A pathogen is a living thing or virus that causes disease. Pathogens are commonly called "germs." They can travel from one person to another.

Types of Pathogens

Living things that cause human diseases include bacteria, fungi, and protozoa. Most infectious diseases caused by these organisms can be cured with medicines. For example, medicines called antibiotics can cure most diseases

caused by bacteria. Bacteria are one-celled organisms without a nucleus. Although most bacteria are harmless, some cause diseases.

Worldwide, the most common disease caused by bacteria is tuberculosis (TB). TB is a serious disease of the lungs. Another common disease caused by bacteria is strep throat. You may have had strep throat yourself. Bacteria that cause strep throat are shown in **Figure** 1.1. Some types of pneumonia and many cases of illnesses from food are also caused by bacteria.

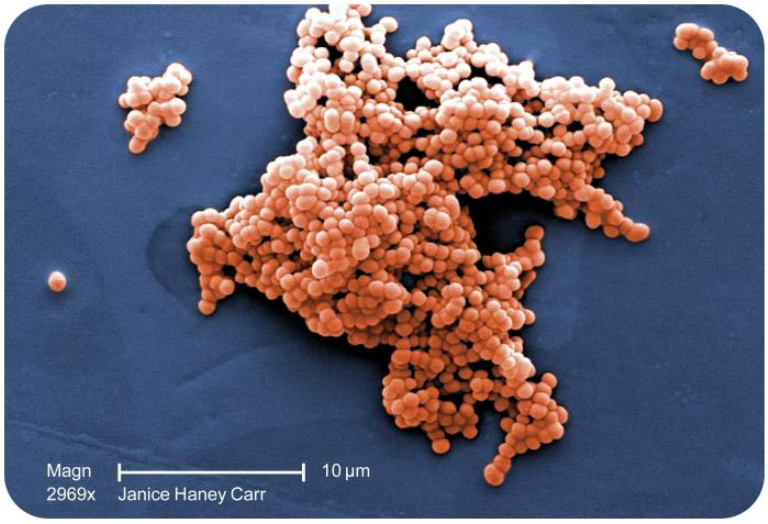

FIGURE 1.1

The structures that look like strings of beads are bacteria. They belong to the genus *Streptococcus*. Bacteria of this genus cause diseases such as strep throat and pneumonia. They are shown here 900 times bigger than their actual size.

Fungi are simple organisms that consist of one or more cells. They include mushrooms and yeasts. Human diseases caused by fungi include ringworm and athlete's foot. Both are skin diseases that are not usually serious. What a ringworm infection looks like is shown in **Figure** 1.2. A more serious fungus disease is histoplasmosis. It is a lung infection.

FIGURE 1.2

Ringworm isn't a worm at all. It's a disease caused by a fungus. The fungus causes a ring-shaped rash on the skin, like the one shown here.

Protozoa are one-celled eukaryotes. They cause diseases such as malaria. Malaria is a serious disease that is common in warm climates. The protozoa infect people when they are bit by a mosquito. More than a million people die of malaria each year. Other protozoa cause diarrhea. An example is *Giardia lamblia*, which is shown in **Figure** 1.3.

Viruses are nonliving collections of protein and DNA that must reproduce inside of living cells. Viruses cause many common diseases. For example, viruses cause colds and the flu. Cold sores are caused by the virus *Herpes simplex*. This virus is shown in **Figure** 1.4. Antibiotics do not affect viruses, because antibiotics only kill bacteria. But medicines called antiviral drugs can treat many diseases caused by viruses.

FIGURE 1.3
This picture shows a one-celled organism called *Giardia lamblia*. It is a protozoan that causes diarrhea.

FIGURE 1.4
The *Herpes simplex* virus, which is shown here, causes cold sores on the lips. Viruses are extremely small particles. This one is greatly magnified.

How Pathogens Spread

Different pathogens spread in different ways. Some pathogens spread through food. They cause food borne illnesses. These illnesses were discussed in the *Food and Digestive System* chapter. Some pathogens spread through water.

Giardia lamblia is one example.

Water can be boiled to kill *Giardia* and most other pathogens. Several pathogens spread through sexual contact. HIV is one example. It is a virus you will read about below. Other pathogens that spread through sexual contact are discussed in the *Reproductive Systems and Life Stages* chapter.

Many pathogens that cause respiratory diseases spread by droplets in the air. Droplets are released when a person sneezes or coughs. Thousands of tiny droplets are released when a person sneezes, as shown in **Figure** 1.5. Each droplet can contain thousands of pathogens. Viruses that cause colds and the flu can spread in this way. You may get sick if you breathe in the pathogens.

FIGURE 1.5

As this picture shows, thousands of tiny droplets are released into the air when a person sneezes. Each droplet may carry thousands of pathogens. You can't normally see the droplets from a sneeze because they are so small. However, you can breathe them in, along with any pathogens they carry. This is how many diseases of the respiratory system are spread.

Pathogens on Surfaces

Other pathogens spread when they get on objects or surfaces. A fungus may spread in this way. For example, you can pick up the fungus that causes athlete's foot by wearing shoes an infected person has worn. You can also pick up this fungus from the floor of a public shower. After acne, athlete's foot is the most common skin disease in the United States. Therefore, the chance of coming in contact with the fungus in one of these ways is fairly high.

Bacteria that cause the skin disease impetigo can spread when people share towels or clothes. The bacteria can also spread through direct skin contact in sports like wrestling.

Pathogens and Vectors

Still other pathogens are spread by vectors. A vector is an organism that carries pathogens from one person or animal to another. Most vectors are insects, such as ticks and mosquitoes. When an insect bites an infected person or animal, it picks up the pathogen. Then the pathogen travels to the next person or animal it bites. Ticks carry the bacteria that cause Lyme disease. Mosquitoes, like the one in **Figure** 1.6, carry West Nile virus. Both pathogens cause fever, headache, and tiredness. If the diseases are not treated, more serious symptoms may develop.

The first case of West Nile virus in North America occurred in 1999. Within just a few years, the virus had spread throughout most of the United States. Birds as well as humans can be infected with the virus. Birds often fly long distances. This is one reason why West Nile virus spread so quickly.

FIGURE 1.6

Some diseases are spread by insects. The type of mosquito shown here can spread West Nile virus. The virus doesn't make the mosquito sick. The mosquito just carries the virus from one person or animal to another.

HIV Infection and AIDS

HIV, or human immunodeficiency virus, causes AIDS. **AIDS** stands for "acquired immune deficiency syndrome." It is a condition that causes death and does not have a known cure. AIDS usually develops 10 to 15 years after a person is first infected with HIV. The development of AIDS can be delayed with proper medicines.

How HIV Spreads

HIV spreads through contact between an infected person's body fluids and another person's bloodstream or mucus membranes, which are found in the mouth, nose, and genital areas. Body fluids that may contain HIV are blood, semen, vaginal fluid, and breast milk. The virus can spread through sexual contact or shared drug needles. It can also spread from an infected mother to her baby during childbirth or breastfeeding.

Some people think they can become infected with HIV by donating blood or receiving donated blood. This is not true. The needles used to draw blood for donations are always new. Therefore, they cannot spread the virus. Donated blood is also tested to make sure it is does not contain HIV.

HIV and the Immune System

How does an HIV infection develop into AIDS? HIV destroys white blood cells called helper T cells. The cells are produced by the immune system. This is the body system that fights infections and other diseases.

You will read more about the immune system later in this chapter. HIV invades helper T cells and uses them to reproduce. This is shown in **Figure** 1.7. Then, the virus kills the helper T cells. As the number of viruses in the blood rises, the number of helper T cells falls. Without helper T cells, the immune system is unable to protect the body. The infected person cannot fight infections and other diseases because they do not have T cells. This is why people do not die from HIV. Instead, they die from another illness, like the common cold, that they cannot fight because they do not have helper T cells.

Medications can slow down the increase of viruses in the blood. But the medications cannot remove the viruses from the body. At present, there is no cure for HIV infection.

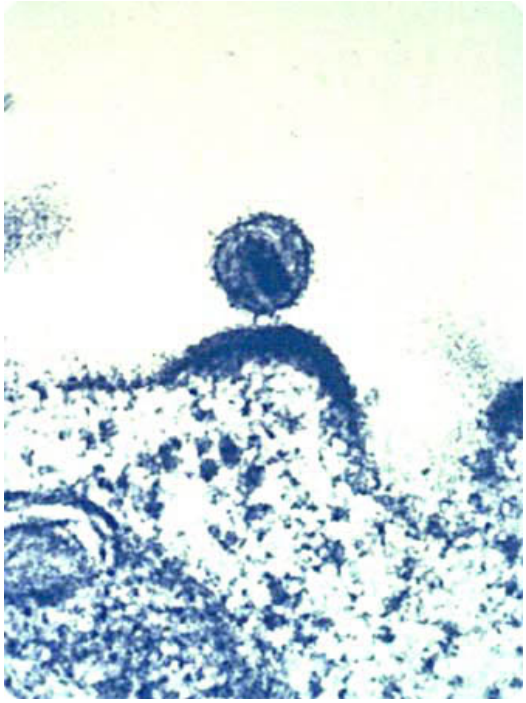

FIGURE 1.7

In this picture, the large structure on the left is a helper T cell. It is infected with HIV. The many small circles on the right are new HIV viruses being shed by the T cell.

AIDS

AIDS is not really a single disease. It is a set of symptoms and other diseases. It results from years of damage to the immune system by HIV. AIDS occurs when helper T cells fall to a very low level and the person develops infections or cancers that people with a healthy immune system can easily resist. These diseases are usually the cause of death of people with AIDS.

The first known cases of AIDS occurred in 1981. Since then, AIDS has led to the deaths of more than 25 million people worldwide. Many of them were children. The greatest number of deaths occurred in Africa. It is also where medications to control HIV are least available. There are currently more people infected with HIV in Africa than any other part of the world.

Preventing Infectious Diseases

What can you do to avoid infectious diseases? Eating right and getting plenty of sleep are a good start. These habits will help keep your immune system healthy. With a healthy immune system, you will be able to fight off many pathogens.

You can also take steps to avoid pathogens in the first place. The best way to avoid pathogens is to wash your hands often. You should wash your hands after using the bathroom or handling raw meat or fish. You should also wash your hands before eating or preparing food. In addition, you should wash your hands after being around sick people. The correct way to wash your hands is demonstrated in **Figure** 1.8. If soap and water aren't available, use a hand sanitizer. A hand sanitizer that contains at least 60 percent alcohol will kill most germs on your hands.

The best way to prevent diseases spread by vectors is to avoid contact with the vectors. For example, you can wear long sleeves and long pants to avoid tick and mosquito bites. Using insect repellent can also reduce your risk of insect bites. Many infectious diseases can be prevented with vaccinations. You will read more about vaccinations

FIGURE 1.8

This picture shows the proper way to wash your hands. Frequent hand washing helps prevent the spread of pathogens.

later in this chapter. Vaccinations can help prevent measles, mumps, chicken pox, and several other diseases.

If you do develop an infectious disease, try to avoid infecting others. Stay home from school until you are well. Also, take steps to keep your germs to yourself. Cover your mouth and nose with a tissue when you sneeze or cough, and wash your hands often to avoid spreading pathogens to other people.

Lesson Summary

- Infectious diseases are caused by living things or viruses that can travel from one person to another.
- HIV causes AIDS by destroying disease-fighting cells produced by the immune system.
- A healthy lifestyle and frequent hand washing can help reduce your risk of infectious diseases.

Review Questions

Recall

1. Name two examples of infectious diseases.

2. What is a pathogen?

3. List three ways that pathogens can spread.

4. What is HIV?
5. What is the single most important way to avoid pathogens?

Apply Concepts

6. Why do antibiotics not cure the common cold?
7. Explain why covering your mouth when you cough helps prevent the spread of germs.
8. What role do vectors play in the spread of infectious diseases?
9. How does an HIV infection develop into AIDS?

Critical Thinking

10. Explain to a friend why using insect repellent reduces your risk of developing Lyme disease.
11. Explain why HIV does not kill people, but causes other illnesses to kill people infected with HIV.

Further Reading / Supplemental Links

- Jenna Bush. *Ana's Story: A Journey of Hope*. Harper Collins, 2007.
- Scientific American. *Germ Wars: Battling Killer Bacteria and Microbes*. Rosen Publishing Group, 2008.
- http://www.cdc.gov/ncidod/dvbid/westnile/index.htm
- http://www.mayoclinic.com/health/germs/ID00002
- http://www.mayoclinic.com/health/infectious-disease/ID00004
- http://www.merck.com/mmhe/sec17/ch188/ch188a.html
- http://www.niaid.nih.gov/healthscience/healthtopics/microbes/PDF/microbesbook.pdf
- http://www.nlm.nih.gov/medlineplus/infectiousdiseases.html
- http://www.who.int/mediacentre/factsheets/fs094/en/index.html
- http://www.nlm.nih.gov/medlineplus/infectiousdiseases.html
- http://www.who.int/mediacentre/factsheets/fs094/en/index.html
- http://en.wikipedia.org/wiki/West_nile_virus

Points to Consider

- What do you think causes allergies?
- Do you know of other diseases that are not caused by pathogens?
- Do you think these diseases are contagious?

1.2 Noninfectious Diseases

Lesson Objectives

- List causes of noninfectious diseases.
- Describe causes and treatments of cancer.
- Explain why diabetes occurs.
- Describe autoimmune diseases and allergies.
- State how noninfectious diseases can be prevented.

Check Your Understanding

- What is an infectious disease?
- What are the stages of the cell cycle?

Vocabulary

allergy A condition that occurs when the immune system attacks a harmless foreign substance.

autoimmune disease A disease that occurs when the immune system attacks the body's own cells.

diabetes A disease in which the pancreas cannot make enough insulin.

noninfectious disease Disease that does not spread from person to person.

type 1 diabetes The type of diabetes that occurs when the immune system attacks normal cells of the pancreas.

type 2 diabetes Type of diabetes that occurs when body cells no longer respond to insulin.

Causes of Noninfectious Diseases

Not all diseases spread from person to person. A disease that does not spread from person to person is called a **noninfectious disease**. An examples is cancer. Certain cancers may or may not be caused by pathogens.

Most noninfectious diseases have more than one cause. The causes may include genes and an unhealthy lifestyle. Having a specific gene may increase the chances that people will have certain diseases. But other factors, like lifestyle, may determine if the diseases actually develop. For example, what people eat or whether they smoke may also play a role in whether or not a person gets cancer.

Several noninfectious diseases are discussed in other chapters. For example, heart disease is discussed in *Cardiovascular System* chapter. In this lesson, the focus is on cancer, diabetes, and diseases of the immune system.

Cancer

Cancer is a disease that causes cells to divide out of control. Normally, the body has systems that prevent cells from dividing out of control, but in the case of cancer, these systems fail.

What Causes Cancer?

Cancer is usually caused by mutations. From the *Cell Division, Reproduction, and DNA* chapter, you know that mutations are random errors in genes. Mutations that lead to cancer usually happen to genes that control the cell cycle. Because of the mutations, abnormal cells divide uncontrollably. This often leads to the development of a tumor. A tumor is a mass of abnormal tissue. As a tumor grows, it may harm normal tissues around it.

Anything that can cause cancer is called a carcinogen. Carcinogens may be pathogens, chemicals, or radiation. **Figure** 1.9, **Figure** 1.10, and **Figure** 1.11 give examples of carcinogens.

Pathogens

Pathogens that cause cancer include the human papilloma virus (HPV) and the hepatitis B virus. HPV is spread through sexual contact. It can cause cancer of the reproductive system in females (**Figure** 1.9). The hepatitis B virus is spread through sexual contact or contact with blood containing the virus. It can cause cancer of the liver.

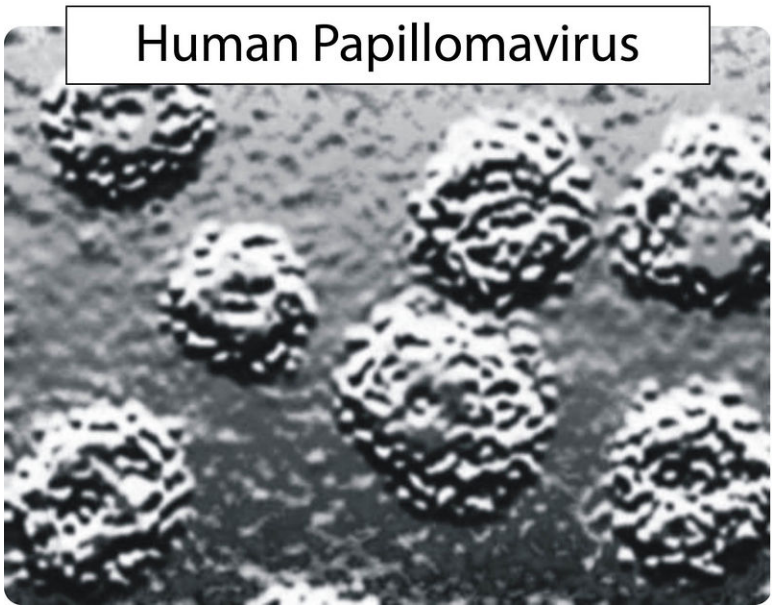

FIGURE 1.9
The mutations that cause cancer may occur when people are exposed to pathogens, such as the human papilloma virus (HPV), which is shown here.

Chemicals

Many different chemical substances cause cancer. Dozens of chemicals in tobacco smoke, including nicotine, have been shown to cause cancer. In fact, tobacco smoke is one of the main sources of chemical carcinogens. Smoking tobacco increases the risk of cancer of the lung, mouth, throat, and bladder. Using smokeless tobacco can also cause cancer.

FIGURE 1.10
The mutations that cause cancer may occur when people are exposed to chemical carcinogens, such as those in cigarettes.

Radiation

Forms of radiation that cause cancer include ultraviolet (UV) radiation and radon. UV radiation is part of sunlight. It is the leading cause of skin cancer. Radon is a natural radioactive gas that seeps into buildings from the ground. It can cause lung cancer (**Figure** 1.11).

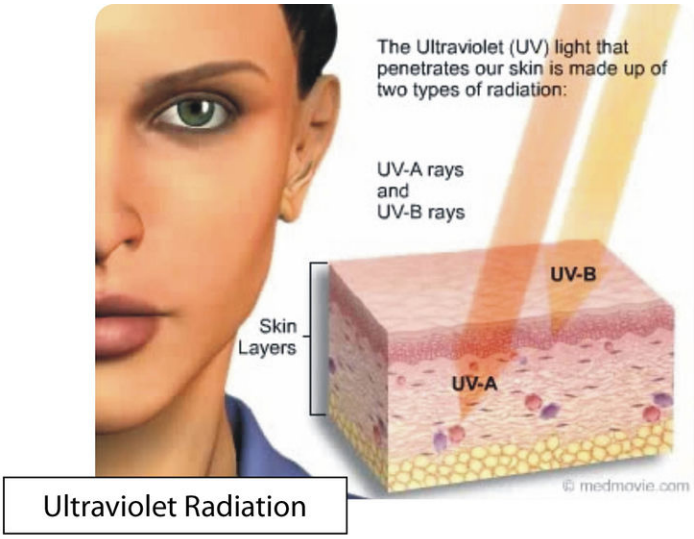

FIGURE 1.11
The mutations that cause cancer may occur when people are exposed to radiation, including the radiation from sunlight.

Sometimes cancer cells break away from a tumor. If they enter the bloodstream, they are carried throughout the body. Then, the cells may start growing in other tissues. This is usually how cancer spreads from one part of the body to another. Once this happens, cancer is very hard to stop or control.

Common Types of Cancer

Cancer is usually found in adults, especially in adults over age 50. The most common type of cancer in adult males is cancer of the prostate gland. The prostate gland is part of the male reproductive system. Prostate cancer makes up

about one third of all cancers in men. The most common type of cancer in adult females is breast cancer. It makes up about one third of all cancers in women. In both men and women, lung cancer is the second most common type of cancer. Most cases of lung cancer happen in people who smoke.

Cancer can also be found in children. But childhood cancer is rare. Leukemia is the main type of cancer in children. It makes up about one third of all childhood cancers. It happens when the body makes abnormal white blood cells.

Treating Cancer

If leukemia is treated early, it usually can be cured. In fact, many cancers can be cured if treated early. Treatment of cancer often involves removing a tumor with surgery. This may be followed by other types of treatments. These treatments may include drugs and radiation, which kill cancer cells.

The sooner cancer is treated, the greater the chances of a cure. This is why it is important to know the warning signs of cancer. Having warning signs does not mean that you have cancer. However, you should see a doctor to be sure. Everyone should know the warning signs of cancer. Detecting and treating cancer early can often lead to a cure. Some warning signs of cancer include:

- Change in bowel or bladder habits.
- Sores that do not heal.
- Unusual bleeding or discharge.
- Lump in the breast or elsewhere.
- Chronic indigestion.
- Difficulty swallowing.
- Obvious changes in a wart or mole.
- Persistent cough or hoarseness.

Diabetes

Another noninfectious disease is diabetes. **Diabetes** happens when the pancreas cannot make enough insulin. Insulin is a hormone that helps cells take up sugar from the blood. Without enough insulin, the blood contains too much sugar. This can damage blood vessels and other cells throughout the body. The kidneys work hard to filter out and remove some of the extra sugar. This leads to frequent urination and excessive thirst.

There are two main types of diabetes, type 1 diabetes and type 2 diabetes. Type 1 diabetes makes up about 5 to 10 percent of all cases of diabetes in the United States. Type 2 diabetes accounts for most of the other cases. Both types of diabetes are more likely in people that have certain genes. Having a family member with diabetes increases the risk of developing the disease.

Either type of diabetes can increase the chances of having other health problems. For example, people with diabetes are more likely to develop heart disease and kidney disease. Type 1 and type 2 diabetes are similar in these ways. However, the two types of diabetes have different causes.

Type 1 Diabetes

Type 1 diabetes happens when the immune system attacks normal cells of the pancreas. Since the cells in the pancreas are damaged, the pancreas cannot make insulin. Something in the environment causes the immune system to attack the pancreas, but it is unknown. Scientists think that the cause may be a virus. Type 1 diabetes usually develops in childhood or adolescence.

People with type 1 diabetes must frequently check the sugar in their blood. They use a meter like the one shown in

Figure 1.12. Whenever their blood sugar starts to get too high, they need a shot of insulin. The insulin brings their blood sugar back to normal. There is no cure for type 1 diabetes. Therefore, insulin shots must be taken for life. Most people with this type of diabetes learn how to give themselves insulin shots.

FIGURE 1.12

This is one type of meter used by people with diabetes to measure their blood sugar. Modern meters like this one need only a drop of blood and take less than a minute to use.

Type 2 Diabetes

Type 2 diabetes happens when body cells can no longer use insulin. The pancreas may still make insulin, but the cells of the body cannot use it. Being overweight and having high blood pressure increase the chances of developing type 2 diabetes. Type 2 diabetes usually develops in adulthood, but it is becoming more common in teens and children. This is because more young people are overweight now than ever before.

Some cases of type 2 diabetes can be cured with weight loss. However, most people with the disease need to take medicine to control their blood sugar. Regular exercise and balanced eating also help. Like people with type 1 diabetes, people with type 2 diabetes must frequently check their blood sugar.

Diseases of the Immune System

The immune system usually protects you from pathogens and other causes of disease. Later in this chapter, you will read more about how the immune system works. When the immune system is working properly, it keeps you from getting sick. But the immune system is like any other system of the body. It can break down or develop diseases.

In the last lesson you read about AIDS. AIDS is an infectious disease of the immune system caused by a virus. Some diseases of the immune system are noninfectious. They include autoimmune diseases and allergies.

Autoimmune Diseases

Does it make sense for an immune system to attack the cells it is meant to protect? No, but an immune system that does not function properly will attack its own cells. An **autoimmune disease** is a disease in which the immune system attacks the body's own cells.

One example is type 1 diabetes. In this disease, the immune system attacks cells of the pancreas. Other examples are multiple sclerosis and rheumatoid arthritis. In multiple sclerosis, the immune system attacks nerve cells. This causes weakness and pain. In rheumatoid arthritis, the immune system attacks the cells of joints. This causes joint damage and pain. These diseases cannot be cured. But they can be helped with medicines that weaken the immune system's attack on normal cells.

Allergies

An **allergy** is when the immune system attacks a harmless substance that enters the body from the outside. A substance that causes an allergy is called an allergen. It is the immune system, not the allergen, that causes the symptoms of an allergy.

Did you ever hear of hay fever? It's not really a fever at all. It's an allergy to plant pollens. People with this type of allergy have symptoms such as watery eyes, sneezing, and a runny nose. A common cause of hay fever is the pollen of ragweed. A ragweed plant is shown in **Figure** 1.13.

FIGURE 1.13
Ragweed is a common roadside weed found throughout the United States. Many people are allergic to its pollen.

Many people are allergic to poison ivy. A poison ivy plant is shown in **Figure** 1.14. Skin contact with poison ivy leads to an itchy rash in people that are allergic to the plant.

As you have read, some people are allergic to certain foods. Nuts and shellfish are common causes of food allergies. Other common causes of allergies include:

- Drugs such as penicillin.
- Mold.
- Dust.
- The dead skin cells, called dander, of dogs and cats.
- Stings of wasps and bees.

To learn more about allergies and their causes, go to http://topics.healthvideo.com/m/21404533/seasonal-and-chronic-allergies.htm#q=OR+Allergy+OR+Allergies. You can watch a video about allergies at this Web site.

Most allergies can be treated with medicines. Medicines used to treat allergies include antihistamines and corticosteroids. These medicines help control the immune system when it attacks an allergen.

FIGURE 1.14

Poison ivy plants are wild vines with leaves in groups of three. They grow in wooded areas in most of the United States. Contact with poison ivy may cause a rash in a person allergic to the plant.

Sometimes, allergies cause severe symptoms. For example, they may cause the throat to swell so it is hard to breathe. Severe allergies may be life threatening. They require emergency medical care.

Preventing Noninfectious Diseases

Most allergies can be prevented by avoiding the substances that cause them. For example, you can avoid pollens by staying indoors as much as possible. You can learn to recognize plants like poison ivy and not touch them. A good way to remember how to avoid poison ivy is "leaves of three, let it be."

Some people receive allergy shots to help prevent allergic reactions. The shots contain tiny amounts of allergens. After many months or years of shots, the immune system gets used to the allergens and no longer responds to them.

Type 1 diabetes and other autoimmune diseases cannot be prevented. But choosing a healthy lifestyle can help prevent type 2 diabetes. Getting plenty of exercise, avoiding high-fat foods, and staying at a healthy weight can reduce the risk of developing this type of diabetes. This is especially important for people that have family members with the disease.

Making these healthy lifestyle choices can also help prevent some types of cancer. In addition, you can lower the risk of cancer by avoiding carcinogens. For example, you can reduce your risk of lung cancer by not smoking. You can reduce your risk of skin cancer by using sunscreen. How to choose a sunscreen that offers the most protection is explained in **Figure** 1.15. Some people think that tanning beds are a safe way to get a tan. This is a myth. Tanning beds expose the skin to UV radiation. Any exposure to UV radiation increases in the risk of skin cancer. It doesn't matter whether the radiation comes from tanning lamps or the sun.

Lesson Summary

- Causes of noninfectious diseases may include genes and an unhealthy lifestyle.
- Cancer is caused by mutations and treated with surgery, drugs, and radiation.
- Diabetes is a disease that happens when the pancreas cannot make enough insulin or use the insulin properly.

FIGURE 1.15
When you choose a sunscreen, select one with an SPF of 30 or higher. Also, choose a sunscreen that protects against both UVB and UVA radiation.

- Autoimmune diseases occur when the immune system attacks normal body cells.
- Allergies occur when the immune system attacks harmless substances that enter the body from the outside.
- A healthy lifestyle can help reduce your risk of developing many noninfectious diseases.

Review Questions

Recall

1. What is a noninfectious disease?
2. List three carcinogens.
3. What other health problems are more likely in people with diabetes?
4. What causes rheumatoid arthritis?
5. How can you reduce your risk of developing skin cancer?

Apply Concepts

6. Explain how mutations can lead to cancer.
7. Why are frequent urination and excessive thirst symptoms of diabetes?
8. Compare and contrast type 1 and type 2 diabetes.

Critical Thinking

9. Some allergies affect people during certain seasons, while affect people year-round. Give examples of allergens that you would expect to cause each type of allergy.

10. Why is maintaining a healthy weight especially important for people that have family members with type 2 diabetes?

Further Reading / Supplemental Links

- Amy M. Mareck. *Fighting for My Life: Growing up with Cancer*. Fairview Press, 2005.
- Jillian Powell. *Allergies*. Cherrytree Books, 2008.
- Marlene Targ Birll. *Diabetes*. Twenty-First Century Books, 2007.
- http://www.cancer.gov/cancertopics/understandingcancer/immunesystem;http://www.cancerindex.org/ccw/guide2c.htm http://www.cancer.gov/cancertopics/understandingcancer/immunesystem;
- http://www.cdc.gov/cancer/az/;http://www.mayoclinic.com/health/allergy/AA99999 http://www.cdc.gov/cancer/az/;
- http://www.uihealthcare.com/topics/cancer/canc4280.html;http://www.4women.gov/FAQ/autoimmune.htm http://www.uihealthcare.com/topics/cancer/canc4280.html;
- http://en.wikipedia.org/wiki

Points to Consider

- How do you think the body fights diseases like colds?
- How do you think the immune system protects you from pathogens and other causes of disease?

1.3 First Two Lines of Defense

Lesson Objectives

- Describe your body's first line of defense against pathogens.
- Explain how inflammation helps protect you from pathogens.

Check Your Understanding

- What are some of the functions of your skin?
- What is a pathogen? Give some examples.

Vocabulary

fever Higher than normal body temperature.

inflammation Reaction causing redness, warmth, and pain that occurs at the site of an infection or injury.

mucus Sticky, moist substance that coats mucous membranes.

phagocytes A type of white blood cells that travel to sites of inflammation and destroy pathogens and debris.

phagocytosis The process by which phagocytes engulf and destroy pathogens or debris.

First Line of Defense

Your body has many ways to protect you from pathogens. Your body's defenses are like a castle of old. The outside of a castle was protected by a moat and high walls. Inside the castle, soldiers were ready to fight off any enemies that made it across the moat and over the walls. Like a castle, your body has a series of defenses. Only pathogens that get through all the defenses can harm you.

Your body's first line of defense is like a castle's moat and walls. It keeps most pathogens out of your body. The first line of defense includes different types of barriers.

Skin and Mucous Membranes

The skin is a very important barrier to pathogens. The skin is the body's largest organ. In adults, it covers an area of about 16 to 22 square feet!

The skin is also the body's most important defense against disease. It forms a physical barrier between the body and the outside world. As shown in **Figure** 1.16, the skin has several layers. The outer layer is tough and waterproof. It is very difficult for pathogens to get through this layer of skin.

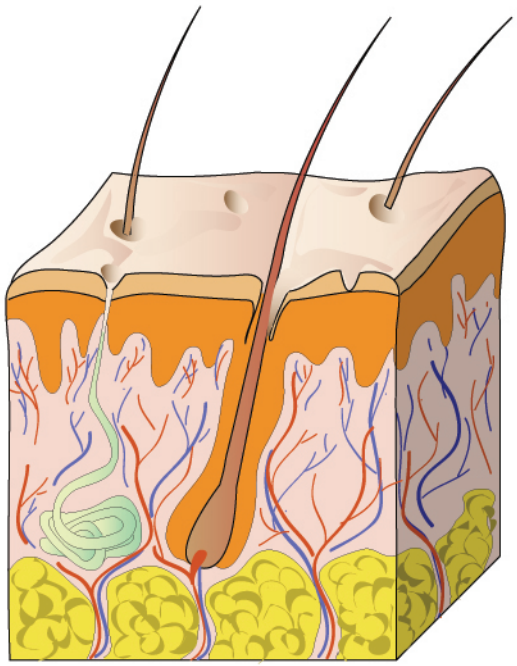

FIGURE 1.16

This drawing shows that the skin has many layers. The outer layer is so tough that it keeps out most pathogens.

The mouth and nose are not lined with skin. Instead, they are lined with mucous membranes. Other organs that are exposed to the outside world, including the lungs and stomach, are also lined with mucous membranes. Mucous membranes are not tough like skin, but they have other defenses.

One defense of mucous membranes is the mucus they release. **Mucus** is a sticky, moist substance that covers mucous membranes. Most pathogens get stuck in the mucus before they can do harm to the body. Many mucous membranes also have cilia. Cilia in the lungs are shown in **Figure** 1.17. Cilia are like tiny finger-like projections. They move in waves and sweep mucus and trapped pathogens toward body openings. When you clear your throat or blow your nose, you remove mucus and pathogens from your body.

Chemicals

Most body fluids that you release from your body contain chemicals that kill pathogens. For example, mucus, sweat, tears, and saliva contain enzymes that kill pathogens. The enzymes are called lysozymes. They break down the cell walls of bacteria to kill them.

The stomach also releases a very strong acid, called hydrochloric acid. This acid kills most pathogens that enter the stomach in food or water. Urine is also acidic, so few pathogens can grow in it.

Helpful Bacteria

You are not aware of them, but your skin is covered by millions (or more!) of bacteria. Millions more live inside your body. From the *Food and Digestive System* chapter, you know that many bacteria live inside your large intestine.

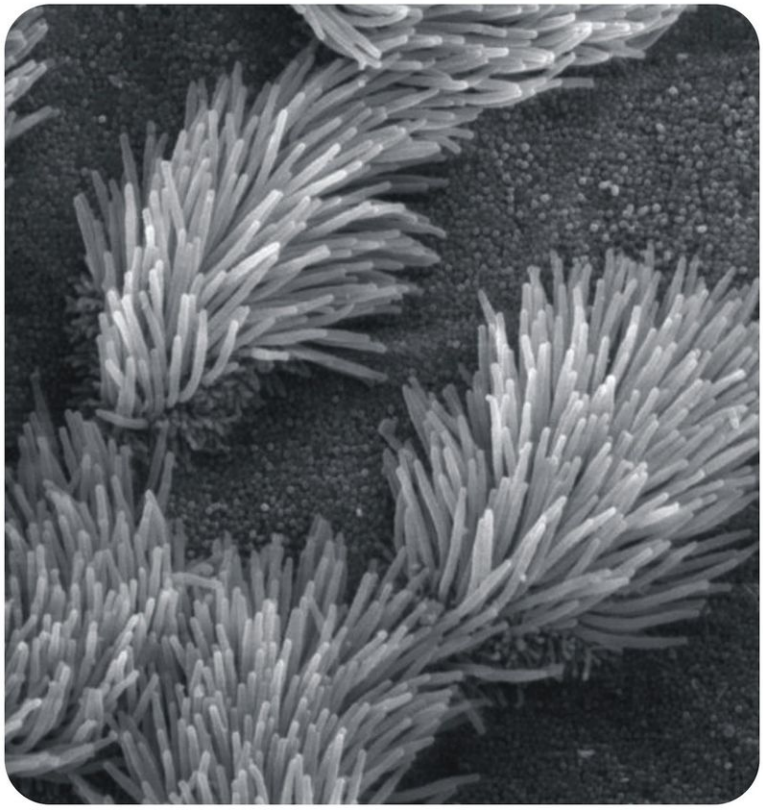

FIGURE 1.17

This is what the cilia lining the lungs look like when they are magnified. Their movements constantly sweep mucus and pathogens out of the lungs. Do they remind you of brushes?

Most of these bacteria help defend your body from pathogens. How do they do it? They compete with harmful bacteria for food and space. This prevents the harmful bacteria from multiplying and making you sick.

Second Line of Defense

The little girl in **Figure** 1.18 has a scraped knee. A scrape is a break in the skin that may let pathogens enter the body. If bacteria enter through the scrape, they could cause an infection. These bacteria would then face the body's second line of defense.

Inflammation

If bacteria enter the skin through a scrape, the area may become red, warm, and painful. These are signs of inflammation. **Inflammation** is one way the body reacts to infections or injuries. Inflammation is caused by chemicals that are released when skin or other tissues are damaged. The chemicals cause nearby blood vessels to dilate, or expand. This increases blood flow to the damaged area. The chemicals also attract white blood cells to the wound and cause them to leak out of blood vessels into the damaged tissue. You can watch a video animation of this process at http://biology-animations.blogspot.com/search/label/inflammation.

FIGURE 1.18
This little boy just got his first scraped knee. It doesn't seem to hurt, but the break in his skin could let pathogens enter his body. That's why scrapes should be kept clean and protected until they heal.

White Blood Cells

After white blood cells leave a blood vessel at the site of inflammation, they start "eating" pathogens. From the *Cardiovascular System* chapter, you know that white blood cells are one type of cell that makes up the blood.

The main role of white blood cells is to fight pathogens in the body. There are actually several different kinds of white blood cells. Some white blood cells have very specific functions. They attack only certain pathogens. You will read about these white blood cells later in this chapter.

Other white blood cells attack any pathogens they find. These white blood cells travel to areas of the body that are inflamed. They are called **phagocytes**, which means "eating cells." In addition to pathogens, phagocytes "eat" dead cells. They surround the pathogens and destroy them. This process is called **phagocytosis**. How phagocytosis occurs is shown in **Figure** 1.19. You can watch a video of a phagocyte gobbling up and destroying a pathogen at http://sciencevideos.wordpress.com/2007/09/26/defense-against-infectious-disease/.

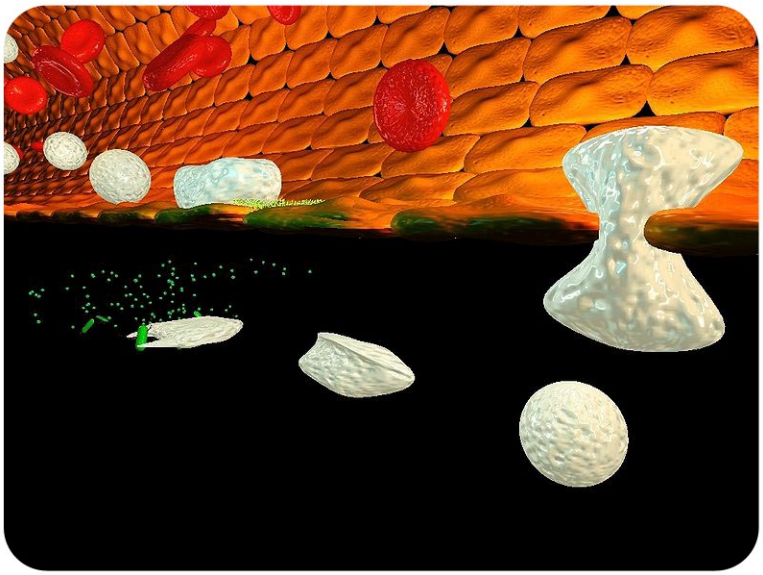

FIGURE 1.19
This drawing show phagocytosis. In this process, a phagocyte surrounds a pathogen and breaks it down as shown by the white blood cell attacking the green bacteria.

White blood cells also make chemicals that cause a fever. A **fever** is a higher-than-normal body temperature. Normal human body temperature is 98.6° F (37° C). Most bacteria and viruses that infect people reproduce fastest at this temperature.

When the temperature is higher, the pathogens cannot reproduce as fast, so the body raises the temperature to kill them. A fever also causes the immune system to make more white blood cells. In these ways, a fever helps the body fight infection.

Lesson Summary

- Your body's first line of defense includes the skin and other barriers that keep pathogens out of your body.
- If pathogens enter your body, inflammation occurs, and phagocytes come to the body's defense.

Review Questions

Recall

1. How does your skin protect you from pathogens?
2. What is mucus?
3. Define inflammation.
4. What are phagocytes?
5. What is a fever?

Apply Concepts

6. Explain how cilia help rid your body of pathogens.
7. How do helpful bacteria defend your body?
8. How does inflammation help fight pathogens?

Critical Thinking

9. Why is phagocytosis called a *general* body defense?
10. A fever is a sign of infection. Why might it be considered a good sign?

Further Reading / Supplemental Links

- Rebecca L. Johnson and Jack Desrocher. *Daring Cell Defenders*. Millbrook Press, 2007.
- Susan Heinrichs Gray. *The Skin*. Child's World, 2005.
- http://hypertextbook.com/facts/2001/IgorFridman.shtml
- http://www.biocarta.com/pathfiles/h_inflamPathway.asp
- http://www.nlm.nih.gov/medlineplus/ency/article/003090.htm
- http://en.wikipedia.org/wiki

Points to Consider

- How do you think pathogens can be recognized?
- Why do you think the body needs specific defenses as well as general ones?

1.4 Immune System Defenses

Lesson Objectives

- Describe the immune system.
- Explain how lymphocytes respond to pathogens.
- Define immunity and vaccination.

Check Your Understanding

- What are the first two lines of defense?
- Give examples of pathogens.

Vocabulary

antigen Any protein that triggers an immune response; usually a foreign protein, unlike any protein that the body makes.

immune response The specific third line of defense against pathogens; involves the immune system.

immune system System that protects the body from pathogens and other causes of disease.

immunity Ability to resist a pathogen because cells of the immune system remember the pathogen from a previous infection or vaccination.

lymph Yellowish fluid that leaks out of tiny vessels into spaces between cells in tissues.

lymph nodes Small, oval structures located along lymphatic vessels that filter pathogens from lymph.

lymphocytes Type of white blood cells involved in an immune response.

vaccination Deliberate exposure to a pathogen in order to bring about immunity without causing disease.

What Is the Immune System?

If pathogens get through the body's first two lines of defense, a third line of defense takes over. This third line of defense involves the immune system. It is called an **immune response**. The immune system has a special response for each type of pathogen.

The **immune system** is also part of the lymphatic system - named for **lymphocytes**, which are the type of white blood cells involved in an immune response. You can see the parts of the immune system in **Figure** 1.20. They include several lymph organs, lymph vessels, lymph, and lymph nodes.

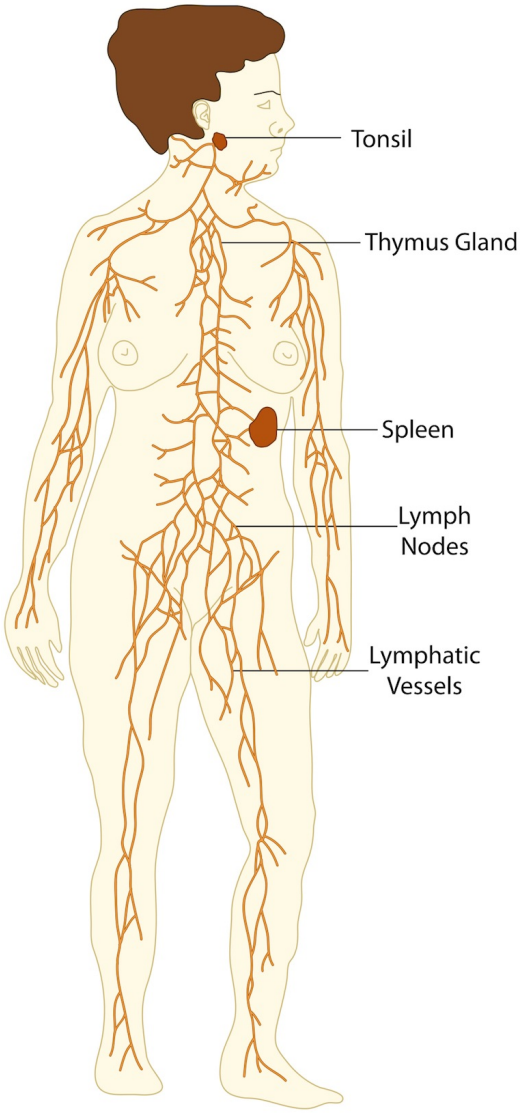

FIGURE 1.20

This diagram shows the parts of the immune system. The immune system includes several organs and a system of vessels that carry lymph. Lymph nodes are located along the lymph vessels.

Lymph Organs

The lymph organs are the red bone marrow, thymus gland, spleen, and tonsils. Each organ has a different job in the immune system. They are described in **Figure** 1.21, **Figure** 1.22, **Figure** 1.23, and **Figure** 1.24.

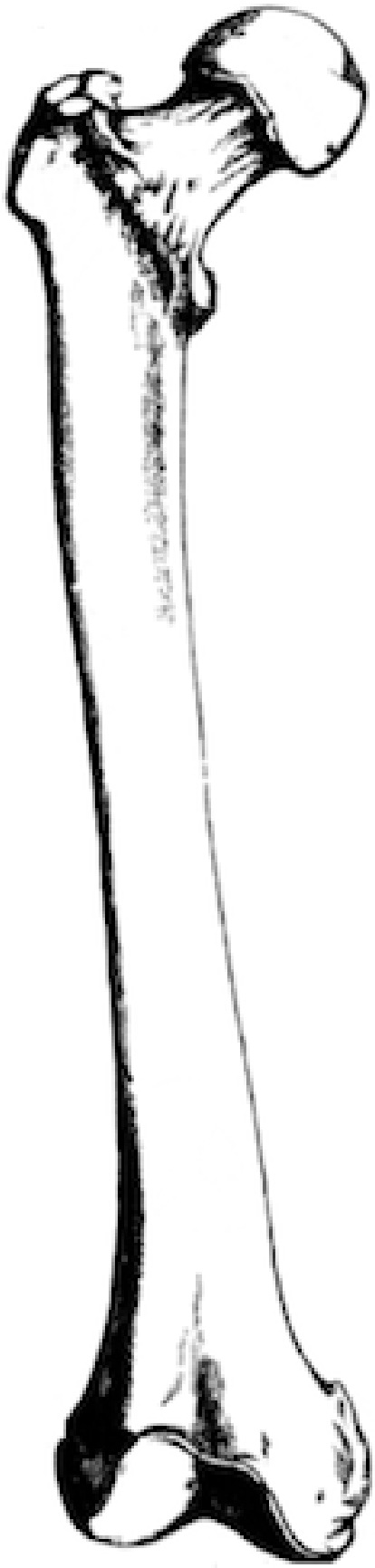

FIGURE 1.21

Red bone marrow is found inside many bones, including the femur shown here. Red bone marrow makes lymphocytes.

FIGURE 1.22
The thymus gland is in the chest behind the breast bone. It stores lymphocytes while they grow older.

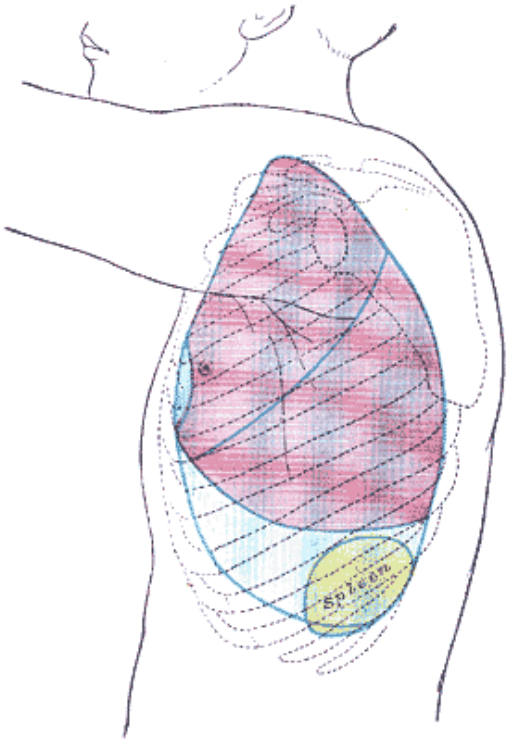

FIGURE 1.23
The spleen is in the abdomen below the lungs. Its job is to filter the toxins out of the blood. Any pathogens that are filtered out of the blood are destroyed by lymphocytes in the spleen.

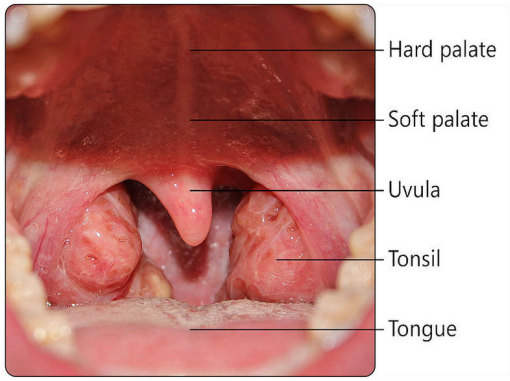

FIGURE 1.24
The tonsils are in the throat. They trap pathogens that enter the body through the mouth or nose. Lymphocytes in the tonsils destroy the trapped pathogens.

Lymph and Lymph Vessels

Lymph vessels make up a circulatory system that is similar to the cardiovascular system, which you read about in the *Cardiovascular System* chapter. Lymph vessels are like blood vessels, except they move lymph instead of blood.

Lymph is a yellowish liquid that leaks out of tiny blood vessels into spaces between cells in tissues. Where there is more inflammation, there is usually more lymph in tissues. This lymph may contain many pathogens.

The lymph that collects in tissues slowly passes into tiny lymph vessels. It then travels from smaller to larger lymph vessels. Lymph is not pumped through lymph vessels like blood is pumped through blood vessels by the heart. Instead, muscles around the lymph vessels contract and squeeze the lymph through the vessels. The lymph vessels also contract to help move the lymph along. The lymph finally reaches the main lymph vessels in the chest. Here, the lymph drains into two large veins. This is how the lymph returns to the bloodstream.

Before lymph reaches the bloodstream, pathogens are removed from it at lymph nodes. **Lymph nodes** are small, oval structures located along the lymph vessels. They act like filters. Any pathogens filtered out of the lymph at lymph nodes are destroyed by lymphocytes in the nodes.

Lymphocytes

Lymphocytes (white blood cells) are the key cells of an immune response. A photograph of a lymphocyte is shown in **Figure** 1.25. There are trillions of lymphocytes in the human body. They make up about one quarter of all white blood cells. Usually, fewer than half of the body's lymphocytes are in the blood. The rest are in the lymph, lymph nodes, and lymph organs.

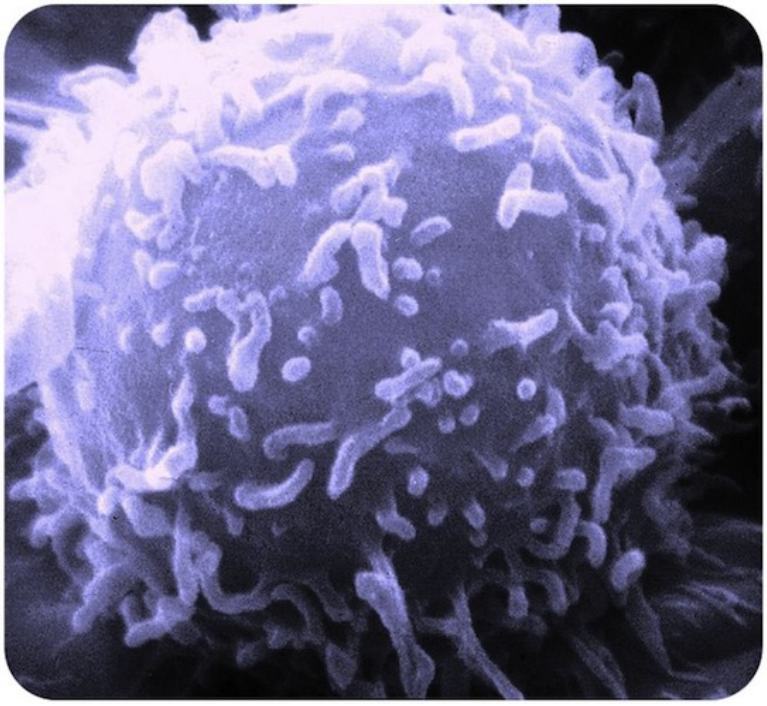

FIGURE 1.25

This image of a lymphocyte was made with an electron microscope. The lymphocyte is shown 10,000 times its actual size.

There are two main types of lymphocytes:

a. B cells.
b. T cells.

Both types of lymphocytes are produced in the red bone marrow. They are named for the sites where they grow larger. The "B" in B cells stands for “bone.” B cells grow larger in red bone marrow.

The "T" in T cells stands for “thymus.” T cells mature in the thymus gland. B and T cells must be “switched on” in order to fight a specific pathogen. Once this happens, they produce an army of cells ready to fight that particular pathogen.

How can B and T cells recognize specific pathogens? Pathogens have proteins, often located on their cell surface. These proteins are called antigens. An **antigen** is any protein that causes an immune response, because it is unlike any protein that the body makes. Antigens are found on bacteria, viruses, and other pathogens. They are also found on other cells, like allergens, that enter the body and on cancer cells.

Immune Responses

There are two different types of immune responses. One type involves B cells. The other type involves T cells. You can watch a video of both types of immune responses at http://www.dnatube.com/view_video2.php?viewkey=5ff68e3e25b9114205d4.

B Cell Response

B cells respond to pathogens and other cells from outside the body in the blood and lymph.

Most B cells fight infections by making antibodies. An antibody is a large, Y-shaped protein that binds to an antigen. Each antibody can bind with just one specific type of antigen. They fit together like a lock and key. Once an antigen and antibody bind together, they signal for a phagocyte to destroy them. A diagram of an antibody binding with an antigen is shown in **Figure** 1.26.

T Cell Response

There are different types of T cells, including killer T cells and helper T cells. Killer T cells destroy infected, damaged, or cancerous body cells. How a killer T cell destroys an infected cell is shown in **Figure** 1.27. When the killer T cell comes into contact with the infected cell, it releases poisons. The poisons make tiny holes in the cell membrane of the infected cell. This causes the cell to burst open. Both the infected cell and the viruses inside it are destroyed.

Helper T cells do not destroy infected or damaged body cells. But they are still necessary for an immune response. They help by releasing chemicals that control other lymphocytes. The chemicals released by helper T cells “switch on” both B cells and killer T cells so they can recognize and fight specific pathogens.

Immunity and Vaccination

Most B and T cells die after an infection has been brought under control. But some of them survive for many years. They may even survive for a person’s lifetime.

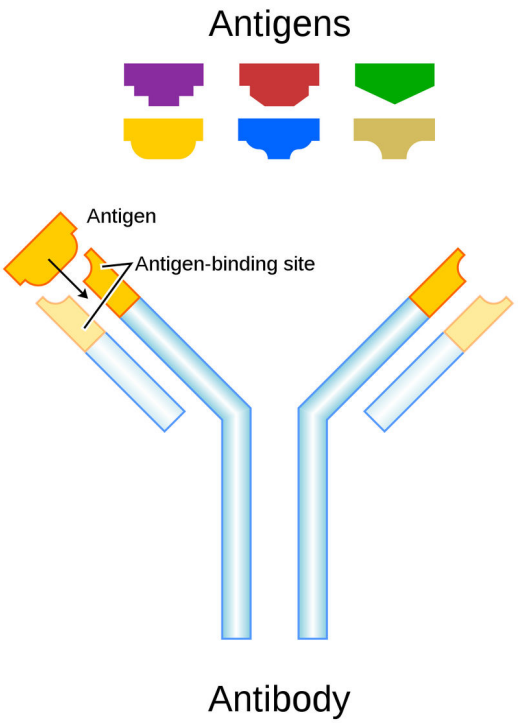

FIGURE 1.26

This diagram shows how an antibody binds with an antigen. The antibody was produced by a B cell. It binds with just one type of antigen. Antibodies produced by different B cells bind with other types of antigens.

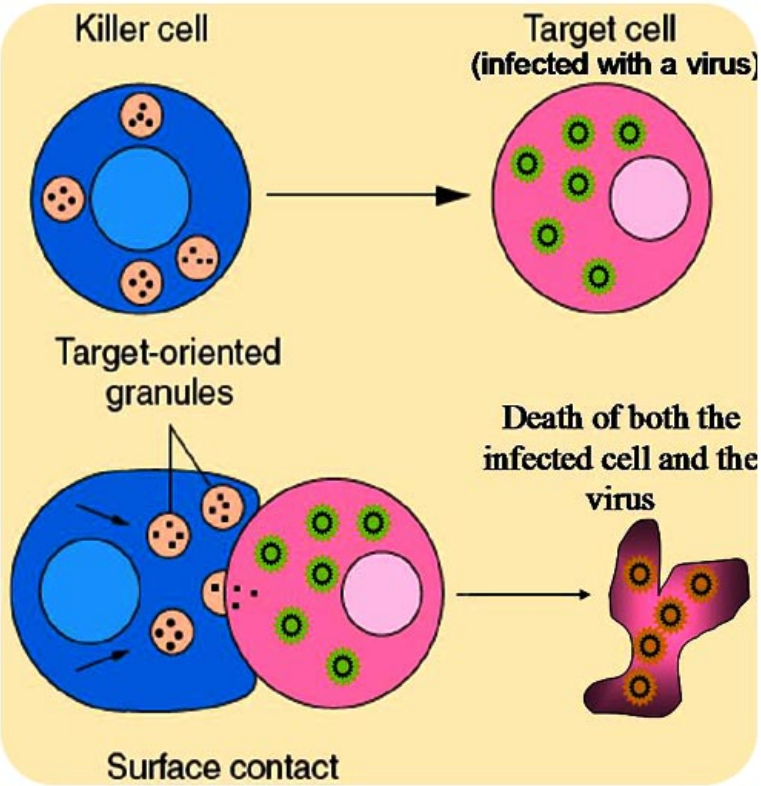

FIGURE 1.27

In this diagram, a killer T cell recognizes a body cell infected with a virus. After the killer T cell makes contact with the infected cell, it releases poisons that cause the infected cell to burst. This kills both the infected cell and the viruses inside it.

These long-lasting B and T cells are called memory cells. They allow the immune system to "remember" the pathogen after the infection is over. If the pathogen invades the body again, the memory cells will start dividing in order to fight on the disease.

They will quickly produce a new army of B or T cells to fight the pathogen. They will begin a faster, stronger attack than the first time the pathogen invaded the body. As a result, the immune system will be able to destroy the pathogen before it can cause an infection. Being able to attack the pathogen in this way is called **immunity**.

Immunity can also be caused by vaccination. **Vaccination** is the process of exposing a person to a pathogen on purpose in order to develop immunity. In vaccination, the pathogen is usually injected under the skin by a shot. Only part of the pathogen is injected, or a weak or dead pathogen is used. It sounds dangerous, but the shot causes an immune response without causing the actual illness. Diseases you have probably been vaccinated against include measles, mumps, and chicken pox.

Lesson Summary

- The immune system includes lymph organs, lymph vessels, lymph, and lymph nodes.
- B cells produce antibodies against pathogens in the blood and lymph.
- Killer T cells destroy body cells infected with pathogens.
- Immunity is the ability to resist a particular pathogen.
- Vaccination is deliberate exposure to a pathogen in order to bring about immunity.

Review Questions

Recall

1. What are lymphocytes?
2. What is lymph?
3. What is an antigen?
4. What organ produces B cells and T cells?
5. Define immunity.

Apply Concepts

6. How are an antigen and antibody like a lock and key?
7. Explain how killer T cells fight pathogens.
8. Helper T cells do not produce antibodies or destroy infected cells. Why are they necessary for immune responses?
9. If you have been vaccinated against measles, you are unlikely to ever have the disease, even if you are exposed to the measles virus. Why?

Critical Thinking

10. Some children with frequent sore throats have an operation to remove their tonsils. Why might removing the tonsils lead to fewer sore throats?

Further Reading / Supplemental Links

- Ana Maria Rodriguez. *Edward Jenner: Conqueror of Smallpox* (Great Minds of Science). Enslow Publishers, 2006.
- Lorrie Klosterman. *Immune System* (The Amazing Human Body). Benchmark Books, 2008.
- Steve Parker. *Defend Yourself: The Immune System*. Raintree, 2006.
- http://www.acm.uiuc.edu/sigbio/project/lymphatic/index.html;http://www.niaid.nih.gov/final/immun/immun.htm http://www.acm.uiuc.edu/sigbio/project/lymphatic/index.html;
- http://www.niaid.nih.gov/publications/immune/the_immune_system.pdf
- http://en.wikipedia.org/wiki

Points to Consider

- What do you think is the role of the reproductive system?
- Do you know what organs and other structures make up the reproductive system?
- Do you know how they differ between males and females?

1.5 References

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