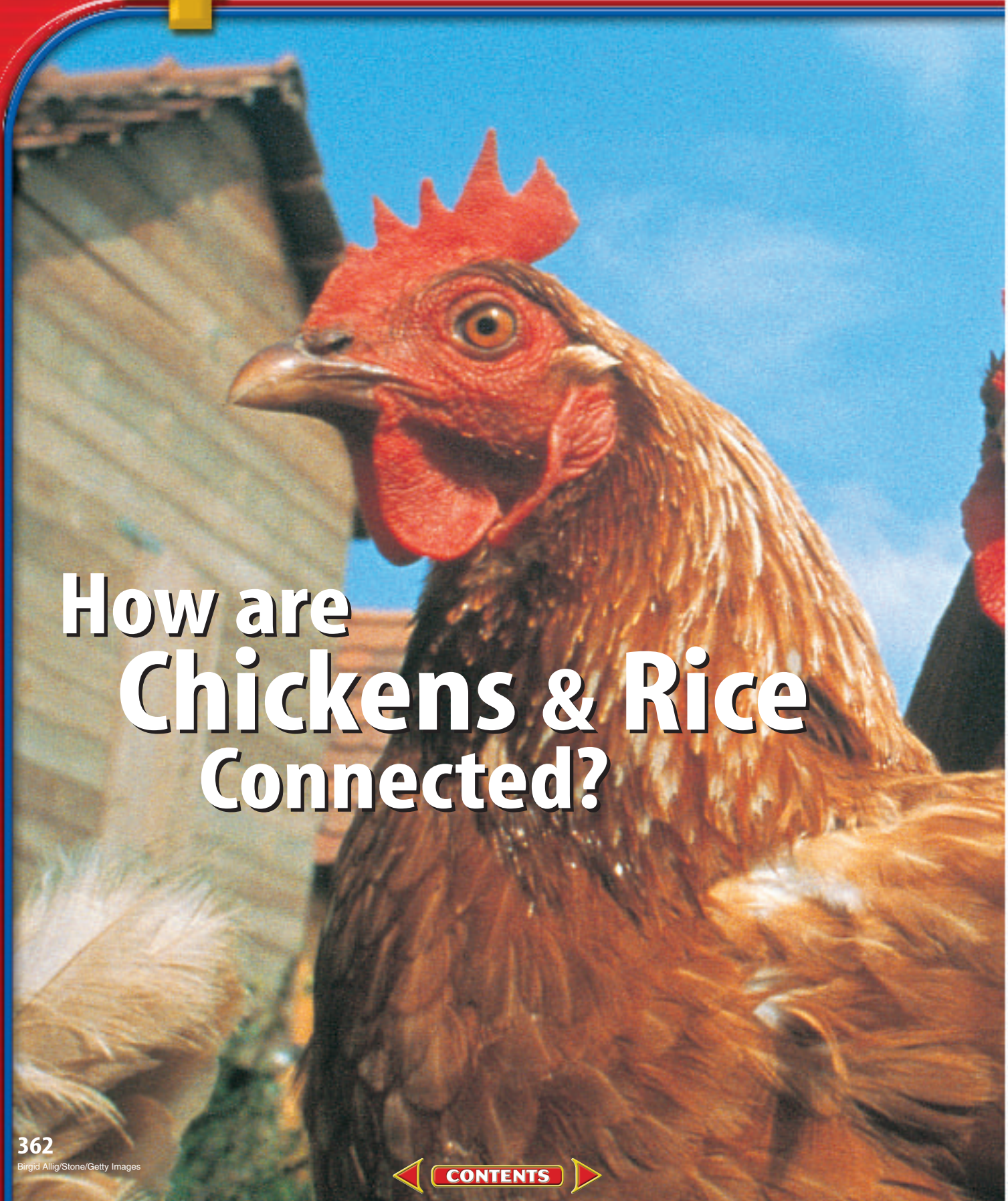
unit 4

Human Body Systems



How are Chickens & Rice Connected?

Birgid Allig/Stone/Getty Images

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NATIONAL GEOGRAPHIC

Back in the 1800s, a mysterious disease called beriberi affected people in certain parts of Asia. One day, a doctor in Indonesia noticed some chickens staggering around, a symptom often seen in people with beriberi. It turned out that the chickens had been eating white rice—the same kind of rice that was being eaten by human beriberi sufferers. White rice has had the outer layers, including the bran, removed. When the sick chickens were fed rice that still had its bran, they quickly recovered. It turned out that the same treatment worked for people with beriberi! Research eventually showed that rice bran contains a vitamin, B_1, which is essential for good health. Today, white rice usually is "vitamin-enriched" to replace B_1 and other nutrients lost in processing.

unit projects

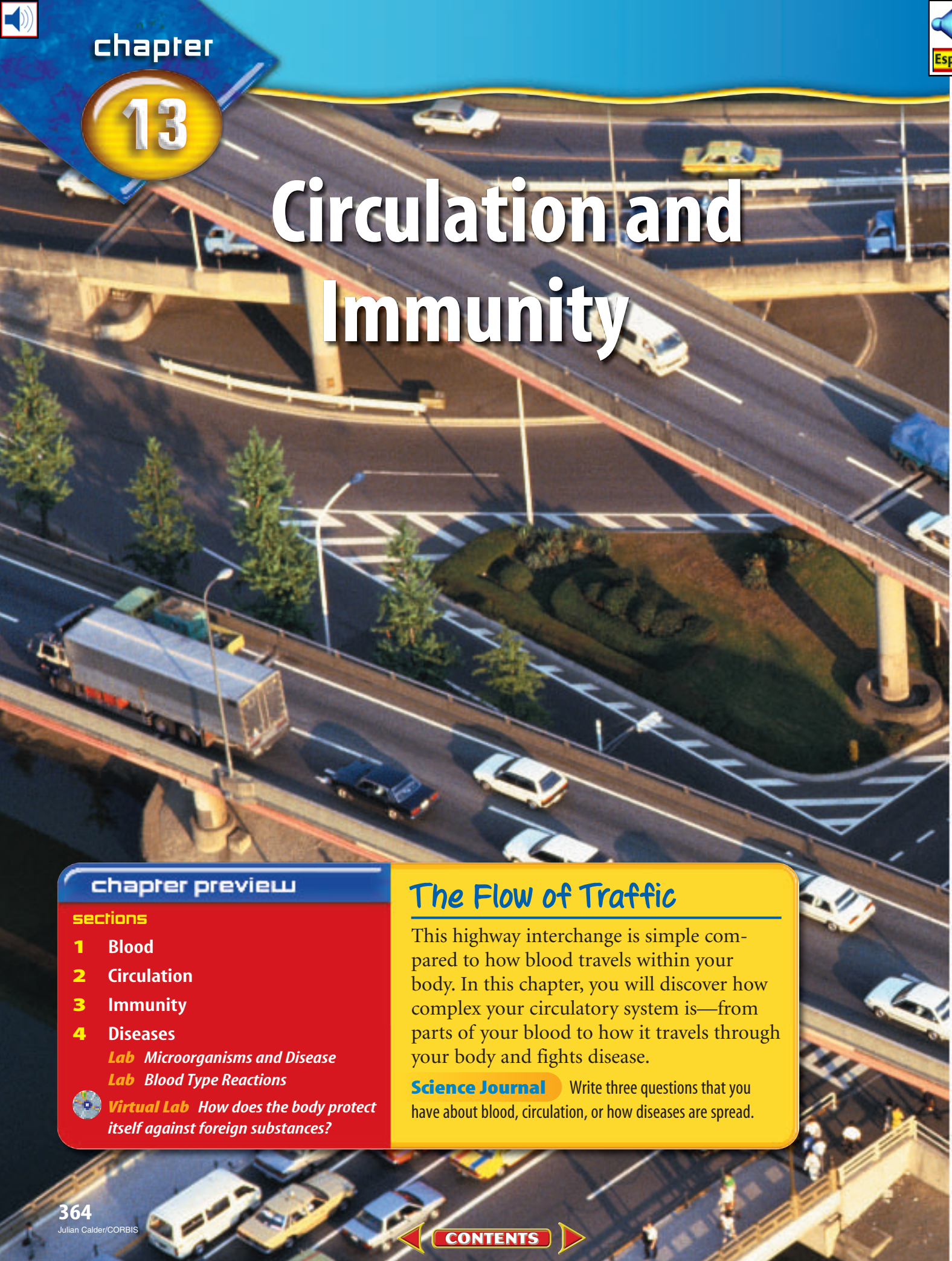
Visit **green.msscience.com/unit_project** to find project ideas and resources. Projects include:

- **History** Contribute to a class "remedy journal" with interesting, out-dated medical treatments, and how techniques have improved.
- **Technology** Investigate rare and interesting medical conditions, including their history, characteristics, and treatments. Present a colorful poster with photos and information for class display.
- **Model** Research and create a menu that includes vitamin-rich foods. Prepare a sample and a recipe card for a class food fair.

WebQuest Understand the ***History of Disease Prevention,*** and how science has progressed through history. Become acquainted with famous scientists and learn how healthy lifestyles prevent disease.

chapter 13

Circulation and Immunity



Julian Calder/CORBIS

chapter preview

sections

The Flow of Traffic

This highway interchange is simple compared to how blood travels within your body. In this chapter, you will discover how complex your circulatory system is—from parts of your blood to how it travels through your body and fights disease.

Science Journal Write three questions that you have about blood, circulation, or how diseases are spread.

Start-Up Activities

Launch Lab

Transportation by Road and Vessel

Your circulatory system is like a road system. Just as roads are used to transport goods to homes and factories, your blood vessels transport substances throughout your body. You'll find out how similar roads and blood vessels are in this lab.

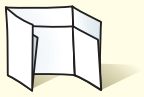
1. Observe a map of your city, county, or state.
2. Identify roads that are interstates, as well as state and county roads, using the map key.
3. Plan a route to a destination that your teacher describes. Then plan a different return trip.
4. Draw a diagram in your Science Journal showing your routes to and from the destination.
5. **Think Critically** If the destination represents your heart, what do the routes represent? In your Science Journal, draw a comparison between a blocked road on your map and a clogged artery in your body.

Foldables™ Study Organizer

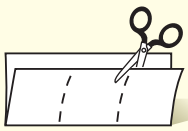
Circulation Make the following Foldable to help you organize information and diagram ideas about circulation.

STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 5 cm longer than the front edge.

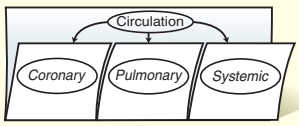
STEP 2 **Turn** the paper so the fold is on the bottom. Then **fold** it into thirds.



STEP 3 **Unfold and cut** only the top layer along both folds to make three tabs.



STEP 4 **Label** the Foldable as shown.



Read and Write As you read the chapter, write information about each circulatory system under the appropriate tab.

Science Online

Preview this chapter's content and activities at green.msscience.com

Julian Calder/CORBIS

section 1

Blood

as you read

What You'll Learn

- **Identify** the parts and functions of blood.
- **Explain** why blood types are checked before a transfusion.
- **Give** examples of diseases of blood.

Why It's Important

Blood plays a part in every major activity of your body.

Review Vocabulary

diffusion: a type of passive transport within cells in which molecules move from areas where there are more of them to areas where there are fewer of them

New Vocabulary

- plasma
- platelet
- hemoglobin

Functions of Blood

You take a last, deep, calming breath before plunging into a dark, vessel-like tube. Water is everywhere. You take a hard right turn, then left as you streak through a narrow tunnel of twists and turns. The water transports you down the slide much like the way blood carries substances to all parts of your body. Blood has four important functions.

1. Blood carries oxygen from your lungs to all your body cells. Carbon dioxide diffuses from your body cells into your blood. Your blood carries carbon dioxide to your lungs to be exhaled.
2. Blood carries waste products from your cells to your kidneys to be removed.
3. Blood transports nutrients and other substances to your body cells.
4. Cells and molecules in blood fight infections and help heal wounds.

Anything that disrupts or changes these functions affects all the tissues of your body. Can you understand why blood is sometimes called the tissue of life?

Parts of Blood

A close look at blood tells you that blood is not just a red-colored liquid. Blood is a tissue made of plasma (PLAZ muh), red and white blood cells, and platelets (PLAYT luts), shown in **Figure 1.** Blood makes up about eight percent of your body's total mass. If you weigh 45 kg, you have about 3.6 kg of blood moving through your body.

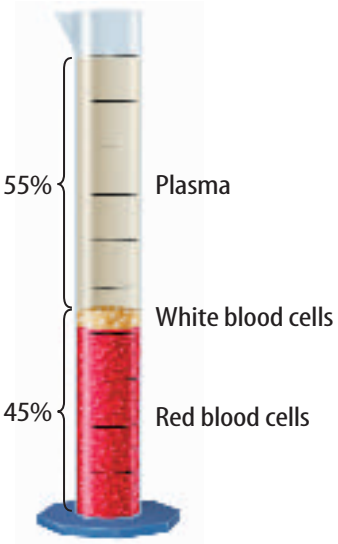


Figure 1 The blood in this graduated cylinder has separated into its parts. Each part plays a key role in body functions.

Plasma The liquid part of blood, which is made mostly of water, is called **plasma.** It makes up more than half the volume of blood. Nutrients, minerals, and oxygen are dissolved in plasma so that they can be carried to body cells. Wastes from body cells also are carried in plasma.

Blood Cells Disk-shaped red blood cells, shown in **Figure 2,** are different from other cells in your body because they have no nuclei when they mature. They contain **hemoglobin** (HEE muh gloh bun), which is a molecule that carries oxygen and carbon dioxide. Hemoglobin carries oxygen from your lungs to your body cells. Then it carries some of the carbon dioxide from your body cells back to your lungs. The rest of the carbon dioxide is carried in the cytoplasm of red blood cells and in plasma.

Red blood cells have a life span of about 120 days. They are made at a rate of 2 million to 3 million per second in the center of long bones, like the femur in your thigh. Red blood cells wear out and are destroyed at about the same rate.

A cubic millimeter of blood, about the size of a grain of rice, has about 5 million red blood cells. In contrast, a cubic millimeter of blood has about 5,000 to 10,000 white blood cells. White blood cells fight bacteria, viruses, and other invaders of your body. Your body reacts to invaders by increasing the number of white blood cells. These cells leave the blood through capillary walls and go into the tissues that have been invaded. Here, they destroy bacteria and viruses and absorb dead cells. The life span of white blood cells varies from a few days to many months.

Circulating with the red and white blood cells are platelets. **Platelets** are irregularly shaped cell fragments that help clot blood. A cubic millimeter of blood can contain as many as 400,000 platelets. Platelets have a life span of five to nine days.

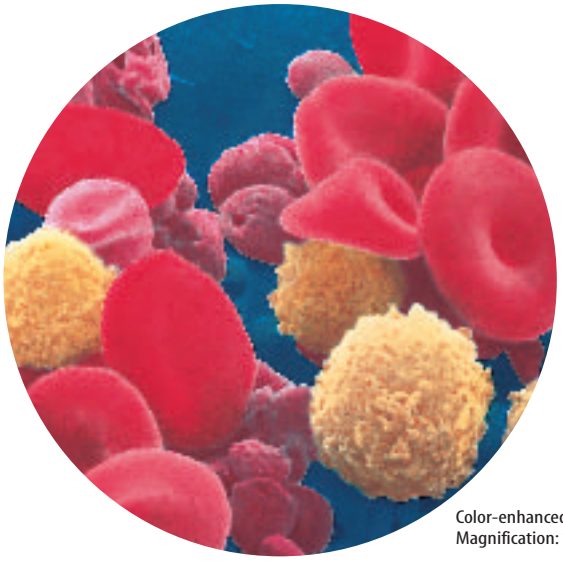
Science Online

Topic: Human White Blood Cells

Visit green.msscience.com for Web links to information about the types of human white blood cells and their functions.

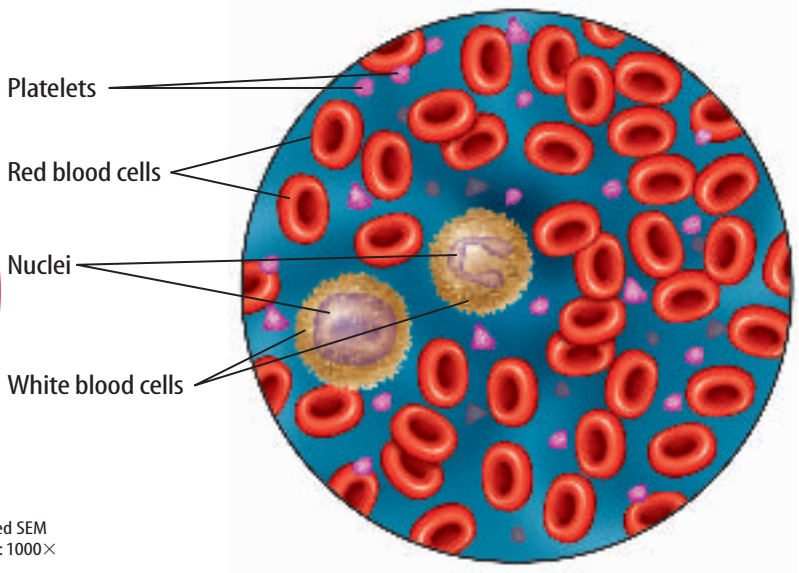
Activity Make a table showing the functions of the various types of white blood cells.

Figure 2 Red blood cells supply your body with oxygen, and white blood cells and platelets have protective roles.



Color-enhanced SEM
Magnification: 1000×

Platelets help stop bleeding. Platelets not only plug holes in small vessels, they also release chemicals that help form filaments of fibrin.



Several types, sizes, and shapes of white blood cells exist. These cells destroy bacteria, viruses, and foreign substances.

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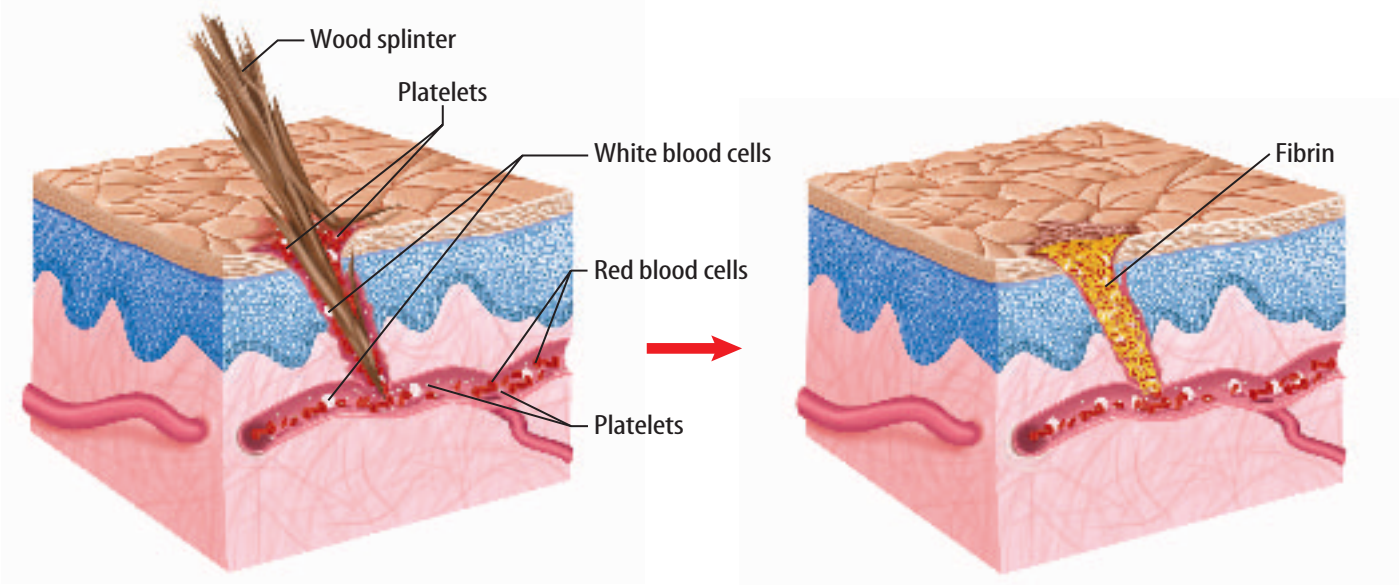
Figure 3 When the skin is damaged, a sticky blood clot seals the leaking blood vessel. Eventually, a scab forms to protect the wound from further damage and allow it to heal.



Mini LAB

Modeling Scab Formation

Procedure

1. Place a 5-cm × 5-cm square of **gauze** on a piece of **aluminum foil.**
2. Place several drops of a **liquid bandage solution** onto the gauze and let it dry. Keep the liquid bandage away from eyes and mouth.
3. Use a **dropper** to place one drop of **water** onto the area of the liquid bandage. Place another drop of water in another area of the gauze.

Analysis

1. Compare the drops of water in both areas.
2. Describe how the treated area of the gauze is like a scab.

Blood Clotting

You're running with your dog in a park, when suddenly you trip and fall down. Your knee starts to bleed, but the bleeding stops quickly. Already the wounded area has begun to heal. Bleeding stops because platelets and clotting factors in your blood make a blood clot that plugs the wounded blood vessels.

A blood clot also acts somewhat like a bandage. When you cut yourself, platelets stick to the wound and release chemicals. Then substances, called clotting factors, carry out a series of chemical reactions. These reactions cause threadlike fibers called fibrin (FI brun) to form a sticky net, as shown in **Figure 3.** This net traps escaping blood cells and plasma and forms a clot. The clot helps stop more blood from escaping. After the clot is in place and becomes hard, skin cells begin the repair process under the scab. Eventually, the scab is lifted off. Bacteria that get into the wound during the healing process usually are destroyed by white blood cells.

Reading Check *What blood components help form blood clots?*

Most people will not bleed to death from a minor wound, such as a cut or scrape. However, some people have a genetic condition called hemophilia (hee muh FIH lee uh). Their plasma lacks one of the clotting factors that begins the clotting process. A minor injury can be a life-threatening problem for a person with hemophilia.

Blood Types

Blood clots stop blood loss quickly in a minor wound, but with a serious wound a person might lose a lot of blood. A blood transfusion might be necessary. During a blood transfusion, a person receives donated blood or parts of blood. The medical provider must be sure that the right type of blood is given. If the wrong type is given, the red blood cells will clump together. Then, clots form in the blood vessels and the person could die.

The ABO Identification System People can inherit one of four types of blood: A, B, AB, or O. Types A, B, and AB have chemical identification tags called antigens (AN tih junz) on their red blood cells. Type O red blood cells have no antigens.

Each blood type also has specific antibodies in its plasma. Antibodies are proteins that destroy or neutralize substances that do not belong in or are not part of your body. Because of these antibodies, certain blood types cannot be mixed. This limits blood transfusion possibilities, as shown in **Table 1.** If type A blood is mixed with type B blood, the antibodies in type A blood determine that type B blood does not belong there. The antibodies in type A blood cause the type B red blood cells to clump. In the same way, type B blood antibodies cause type A blood to clump. Type AB blood has no antibodies, so people with this blood type can receive blood from A, B, AB, and O types. Type O blood has both A and B antibodies.

Reading Check ***Why are people with type O blood called universal donors?***

The Rh Factor Another inherited chemical identification tag in blood is the Rh factor. If the Rh factor is on red blood cells, the person has Rh-positive (Rh+) blood. If it is not present, the person has Rh-negative (Rh−) blood. If an Rh− person receives a blood transfusion from an Rh+ person, he or she will produce antibodies against the Rh factor. These antibodies can cause Rh+ cells to clump. Clots then form in the blood vessels and the person could die. In the same way, an Rh− mother can make antibodies against her Rh+ baby during pregnancy. If the antibodies pass into the baby's blood, they can destroy the baby's red blood cells. To prevent deadly results, blood groups and Rh factor are checked before transfusions and during pregnancies.

INTEGRATE History

Blood Transfusions In 1665, the first successful blood transfusion was performed between two dogs. The first successful human-to-human blood transfusion was performed in 1818. However, many failures followed. The different blood types and the problems that result when they are mixed were unknown at that time. Research the discovery of the four types of blood and write a summary in your Science Journal.

Table 1 Blood Transfusion Possibilities

Type	Can Receive	Can Donate To
A	O, A	A, AB
B	O, B	B, AB
AB	all	AB
O	O	all

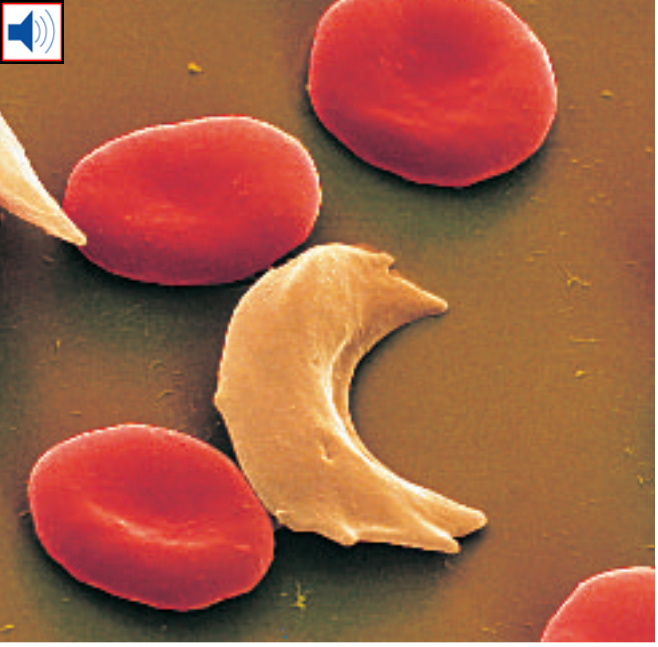


Figure 4 Persons with sickle-cell disease have misshapened red blood cells. The sickle-shaped cells clog the capillaries of a person with this disease. Oxygen cannot reach tissues served by the capillaries, and wastes cannot be removed. **Explain** *how this damages the affected tissues.*

Diseases of Blood

Because blood circulates to all parts of your body and performs so many important functions, any disease of the blood is a cause for concern. One common disease of the blood is anemia (uh NEE mee uh). In this disease of red blood cells, body tissues can't get enough oxygen and are unable to carry on their usual activities. Anemia has many causes. Sometimes, anemia is caused by the loss of large amounts of blood. A diet lacking iron or certain vitamins also might cause anemia. Still other types of anemia are inherited problems related to the structure of the red blood cells. Cells from one such type of anemia, sickle-cell disease, are shown in **Figure 4.**

Leukemia (lew KEE mee uh) is a disease in which one or more types of white blood cells are made in excessive numbers. These cells are immature and do not fight infections well. These immature cells fill the bone marrow and crowd out the normal, mature cells. Then not enough red blood cells, normal white blood cells, and platelets can be made. Some types of leukemia affect children. Other kinds are more common in adults. Medicines, blood transfusions, and bone marrow transplants are used to treat this disease. If the treatments are not successful, the person will eventually die from related complications.

section 1 review

Summary

Functions and Parts of Blood

- Blood carries oxygen, carbon dioxide, wastes, and nutrients.
- Blood contains cells that help fight infections and heal wounds.
- Blood is a tissue made of plasma, red and white blood cells, and platelets.

Blood Clotting and Blood Types

- Platelets and clotting factors form blood clots to stop bleeding from a wound.
- Blood type—A, B, AB, or O—must be identified before a person receives a transfusion.

Diseases of Blood

- Anemia affects red blood cells, while leukemia affects white blood cells.

Self Check

1. **List** the four functions of blood in the body.
2. **Compare and contrast** red blood cells, white blood cells, and platelets.
3. **Describe** how anemia and leukemia affect the blood.
4. **Explain** why blood type and Rh factor are checked before a transfusion.
5. **Think Critically** Think about the main job of your red blood cells. If red blood cells couldn't deliver oxygen to your cells, what would be the condition of your body tissues?

Applying Skills

6. **Interpret Data** Look at the data in **Table 1** about blood group interactions. To which group(s) can people with blood type AB donate blood?

Meckes/Ottawa/Photo Researchers

section 2

Circulation

The Body's Delivery System

It's time to get ready for school, but your younger sister is taking a long time in the shower. "Don't use up all the water," you shout. Water is carried throughout your house in pipes that are part of the plumbing system. The plumbing system supplies water for your needs and carries away wastes. Just as you expect water to flow when you turn on the faucet, your body needs a continuous supply of oxygen and nutrients and a way to remove wastes. In a similar way, materials are moved throughout your body by your cardiovascular (kar dee oh VAS kyuh lur) system. It includes your heart, kilometers of blood vessels, and blood. Blood vessels carry the blood to every part of your body, as shown in **Figure 5.** Recall that blood moves oxygen and nutrients to cells and carries carbon dioxide and other wastes away from the cells.

The Heart

Your heart is an organ made of cardiac muscle tissue. It is located behind your breastbone, called the sternum, and between your lungs. Your heart has four compartments called chambers. The two upper chambers are called the right and left atriums (AY tree umz). The two lower chambers are called the right and left ventricles (VEN trih kulz). A one-way valve separates each atrium from the ventricle below it. The blood flows from an atrium to a ventricle, then from a ventricle into a blood vessel. A wall between the two atriums or the two ventricles keeps blood rich in oxygen separate from blood low in oxygen.

Figure 5 The blood is pumped by the heart to all the cells of the body and then back to the heart through a network of blood vessels.

as you read

What You'll Learn

- **Compare and contrast** arteries, veins, and capillaries.
- **Explain** how blood moves through the heart.
- **Identify** the functions of the pulmonary and systemic circulation systems.
- **Describe** functions of the lymphatic system.

Why It's Important

Your body's cells depend on blood vessels to deliver nutrients and remove wastes. The lymphatic system helps protect you from infections and disease.

Review Vocabulary

tissue: group of similar cells that work together to do one job

New Vocabulary

- capillary
- artery
- vein
- lymph

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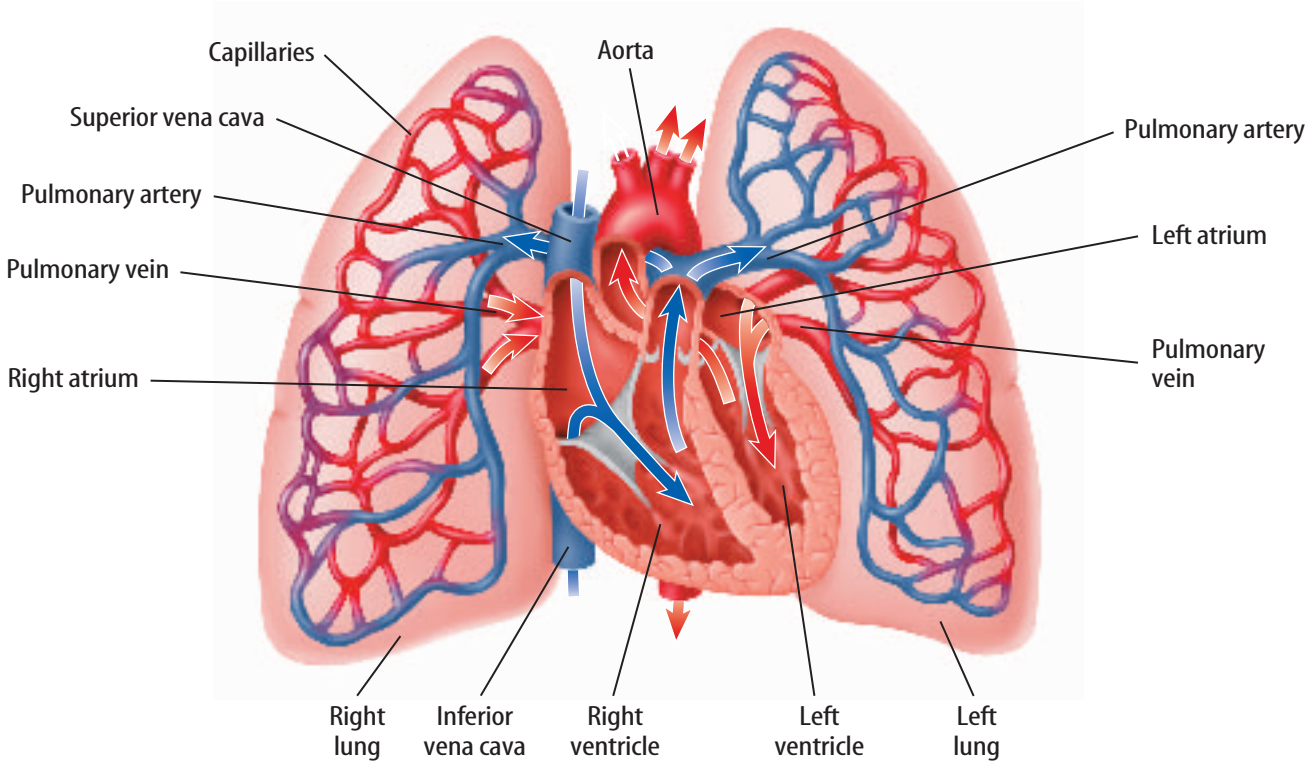

Figure 6 Pulmonary circulation moves blood between the heart and lungs.

Types of Circulation

Scientists have divided the circulatory system into three sections—coronary (KOR uh ner ee) circulation, pulmonary (PUL muh ner ee) circulation, and systemic circulation. The beating of your heart controls blood flow through each section.

Coronary Circulation Your heart has its own blood vessels that supply it with nutrients and oxygen and remove wastes. Coronary circulation is the flow of blood to and from the tissues of the heart. When the coronary circulation is blocked, oxygen and nutrients cannot reach all the cells of the heart. This can result in a heart attack.

Pulmonary Circulation The flow of blood through the heart to the lungs and back to the heart is called pulmonary circulation. Use **Figure 6** to trace the path blood takes through this part of the circulatory system. The blood returning from the body through the right side of the heart and to the lungs contains cellular wastes. The wastes include molecules of carbon dioxide and other substances. In the lungs, gaseous wastes diffuse out of the blood, and oxygen diffuses into the blood. Then the blood returns to the left side of the heart. In the final step of pulmonary circulation, the oxygen-rich blood is pumped from the left ventricle into the aorta (ay OR tuh), the largest artery in your body. From there, the oxygen-rich blood flows to all parts of your body.

Systemic Circulation Oxygen-rich blood moves to all of your organs and body tissues, except the heart and lungs, and oxygen-poor blood returns to the heart by a process called systemic circulation. Systemic circulation is the largest of the three sections of your circulatory system. Oxygen-rich blood flows from your heart in the arteries of this system. Then nutrients and oxygen are delivered by blood to your body cells and exchanged for carbon dioxide and wastes. Finally, the blood returns to your heart in the veins of the systemic circulation system.

Blood Vessels

In the middle 1600s, scientists discovered that blood moves by the pumping of the heart and flows in one direction from arteries to veins. But they couldn't explain how blood gets from arteries to veins. Using a new invention of that time, the microscope, scientists discovered **capillaries** (KA puh ler eez), the blood vessels that connect arteries and veins.

Arteries As blood is pumped out of the heart, it travels through arteries, capillaries, and then veins, shown in **Figure 7.** **Arteries** are blood vessels that carry blood away from the heart. Arteries have thick, elastic walls made of connective tissue and smooth muscle tissue.

Veins The blood vessels that carry blood back to the heart are called **veins.** Veins have one-way valves that keep blood moving toward the heart. If blood flows backward, the pressure of the blood against the valves causes them to close. Blood flow in veins also is helped by your skeletal muscles. When skeletal muscles contract, this action squeezes veins and helps blood move toward the heart.

Reading Check ***What are the similarities and differences between arteries and veins?***

Capillaries The walls of capillaries are only one cell thick. Nutrients and oxygen diffuse into body cells from capillaries. Waste materials and carbon dioxide diffuse from body cells into the capillaries.

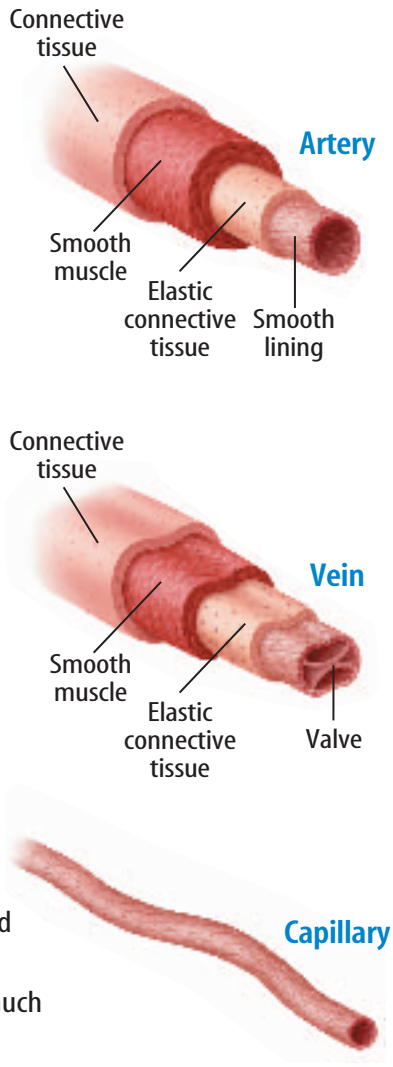

Figure 7 The structures of arteries, veins, and capillaries are different. Valves in veins prevent blood from flowing backward. Capillaries are much smaller. Capillary walls are only one cell thick.

Blood Pressure

INTEGRATE Physics

If you fill a balloon with water and then push on it, the pressure moves through the water in all directions, as shown in **Figure 8.** Your circulatory system is like the water balloon. When your heart pumps blood through the circulatory system, the pressure of the push moves through the blood. The force of the blood on the walls of the blood vessels is called blood pressure. This pressure is highest in arteries and lowest in veins. When you take your pulse, you can feel the waves of pressure. This rise and fall of pressure occurs with each heartbeat.

Controlling Blood Pressure Special nerve cells in the walls of some arteries sense changes in blood pressure. When pressure is higher or lower than normal, messages are sent to your brain. Then the brain sends messages that speed up or slow the heart rate. This helps keep blood pressure constant within your arteries so that enough blood reaches all organs and tissues in your body and delivers needed nutrients to every cell.

Cardiovascular Disease

Any disease that affects the cardiovascular system—the heart, blood vessels, and blood—can seriously affect the health of your entire body. Heart disease is the leading cause of death in humans.

Atherosclerosis One leading cause of heart disease is called atherosclerosis (ah thur oh skluh ROH sus). In this condition, fatty deposits build up on arterial walls. Atherosclerosis can occur in any artery in the body, but fatty deposits in coronary arteries are especially serious. If a coronary artery is blocked, a heart attack can occur. Open-heart surgery then may be needed to correct the problem.

Figure 8 When pressure is exerted on a fluid in a closed container, the pressure is transmitted through the liquid in all directions. Your circulatory system is like a closed container. Blood pressure is measured using a blood pressure cuff and a stethoscope.

Hypertension Another condition of the cardiovascular system is called hypertension (hi pur TEN chun), or high blood pressure. When blood pressure is higher than normal most of the time, the heart must work harder to keep blood flowing. One cause of hypertension is atherosclerosis. A clogged artery can increase pressure within the vessel, causing the walls to become stiff and hard. The artery walls no longer contract and dilate easily because they have lost their elasticity.

Preventing Cardiovascular Disease

Having a healthy lifestyle is important for the health of your cardiovascular system. The choices you make now to maintain good health may reduce your risk of future serious illness. Regular checkups, a healthful diet, and exercise are all part of a heart-healthy lifestyle.

Another way to prevent cardiovascular disease is to not smoke. Smoking causes blood vessels to contract and makes the heart beat faster and harder. Smoking also increases carbon monoxide levels in the blood. Not smoking helps prevent heart disease and a number of respiratory system problems.

Functions of the Lymphatic System

You turn on the water faucet and fill a glass with water. The excess water runs down the drain. In a similar way, your body's tissue fluid is removed by the lymphatic (lihm FA tihk) system, shown in **Figure 9.** The nutrient, water, and oxygen molecules in blood diffuse through capillary walls to nearby cells. Water and other substances become part of the tissue fluid that is found between cells. This fluid is collected and returned to the blood by the lymphatic system.

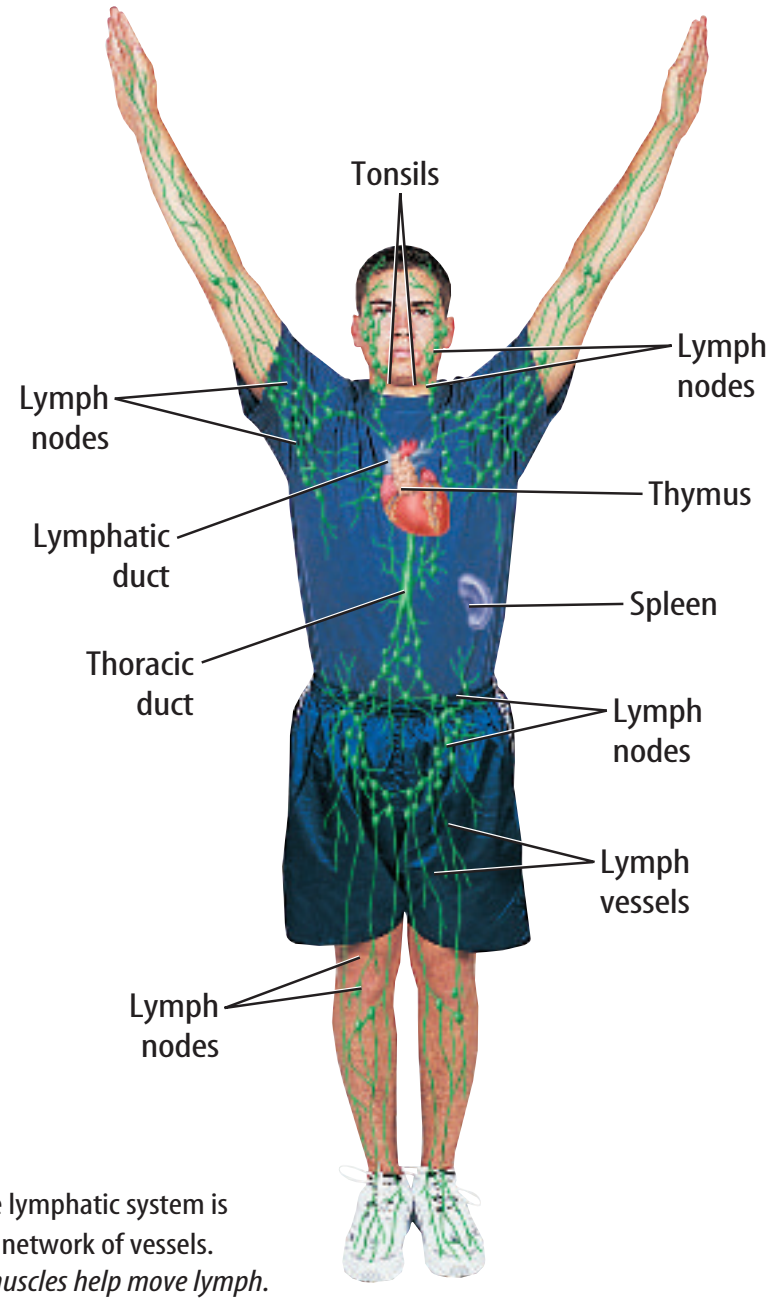

Figure 9 The lymphatic system is connected by a network of vessels. **Explain** *how muscles help move lymph.*

Aaron Haupt
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Science Online

Topic: Hodgkin's Disease

Visit green.msscience.com for Web links to information about Hodgkin's Disease.

Activity Create a brochure about Hodgkin's Disease, including what it is, its symptoms, risk factors, and treatment.

Lymph After tissue fluid diffuses into the lymphatic capillaries, it is called **lymph** (LIHMF). In addition to water and dissolved substances, lymph contains lymphocytes (LIHM fuh sites), a type of white blood cell. Lymphocytes help your body defend itself against disease-causing organisms. If the lymphatic system is not working properly, severe swelling occurs because the tissue fluid cannot get back to the blood.

Reading Check *What is lymph?*

Your lymphatic system carries lymph through a network of lymph capillaries and larger lymph vessels. Then, the lymph passes through lymph nodes, which are bean-shaped organs found throughout the body. Lymph nodes filter out microorganisms and foreign materials that have been taken up by lymphocytes. After it is filtered, lymph enters the bloodstream through large veins near the neck. No heartlike structure pumps the lymph through the lymphatic system. The movement of lymph depends on the contraction of smooth muscles in lymph vessels and skeletal muscles. Lymphatic vessels, like veins, have valves that keep lymph from flowing backward.

section 2 review

Summary

The Body's Delivery System

- Blood vessels carry blood to the body.

The Heart and Types of Circulation

- Your heart controls blood flow through the circulatory system.
- In the lungs, carbon dioxide leaves the blood and oxygen diffuses into the blood.

Blood Vessels and Blood Pressure

- The three types of blood vessels are arteries, veins, and capillaries.
- The force of the blood on the walls of the blood vessels is called blood pressure.

Cardiovascular Disease

- Heart disease is a leading cause of death.

Functions of the Lymphatic System

- Lymph is tissue fluid from cells that has entered the lymph vessels.
- Lymphocytes help fight disease.

Self Check

1. **Compare and contrast** veins, arteries, and capillaries.
2. **Identify** the vessels in the pulmonary and systemic circulation systems that carry oxygen-rich blood.
3. **Describe** the functions of the lymphatic system.
4. **Explain** how blood moves through the heart.
5. **Explain** why blood type and Rh factor are checked before a transfusion.
6. **Think Critically** What waste product builds up in blood and cells when the heart is unable to pump blood efficiently?

Applying Skills

7. **Use a Database** Research diseases of the circulatory system. Make a database showing what part of the circulatory system is affected by each disease. Categories should include the organs and vessels of the circulatory system.
8. **Concept Map** Make an events-chain concept map to show pulmonary circulation beginning at the right atrium and ending at the aorta.

section 3

Immunity

Lines of Defense

Your body has many ways to defend itself. Its first-line defenses work against harmful substances and all types of disease-causing organisms, called pathogens (PA thuh junz). Your second-line defenses are specific and work against specific pathogens. This complex group of defenses is called your immune system. Tonsils are one of the organs in the immune system that protect your body.

Reading Check *What types of defenses does your body have?*

First-Line Defenses Your skin and respiratory, digestive, and circulatory systems are first-line defenses against pathogens, like those in **Figure 10.** The skin is a barrier that prevents many pathogens from entering your body. However, pathogens can get into your body easily through a cut or through your mouth and the membranes in your nose and eyes. The conditions on the skin can affect pathogens. Perspiration contains substances that can slow the growth of some pathogens. At times, secretions from the skin's oil glands and perspiration are acidic. Some pathogens cannot grow in this acidic environment.

Internal First-Line Defenses Your respiratory system traps pathogens with hairlike structures, called cilia (SIH lee uh), and mucus. Mucus contains an enzyme that weakens the cell walls of some pathogens. When you cough or sneeze, you get rid of some of these trapped pathogens.

Your digestive system has several defenses against pathogens—saliva, enzymes, hydrochloric acid solution, and mucus. Saliva in your mouth contains substances that kill bacteria. Also, enzymes (EN zimez) in your stomach, pancreas, and liver help destroy pathogens. Hydrochloric acid solution in your stomach helps digest your food. It also kills some bacteria and stops the activity of some viruses that enter your body on the food that you eat. The mucus found on the walls of your digestive tract contains a chemical that coats bacteria and prevents them from binding to the inner lining of your digestive organs.

as you read

What You'll Learn

- **Explain** the difference between an antigen and an antibody.
- **Compare and contrast** active and passive immunity.

Why It's Important

Your body's defenses fight the pathogens that you are exposed to every day.

Review Vocabulary

enzyme: a type of protein that speeds up the rate of a chemical reaction in your body

New Vocabulary

- antigen
- antibody
- active immunity
- passive immunity

Stained LM Magnification: 1000×

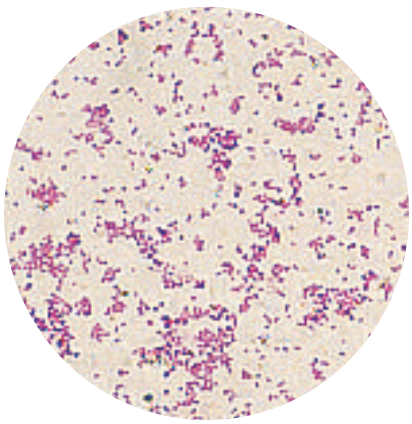


Figure 10 Most pathogens, such as the staphylococci bacteria shown below, cannot get through unbroken skin.

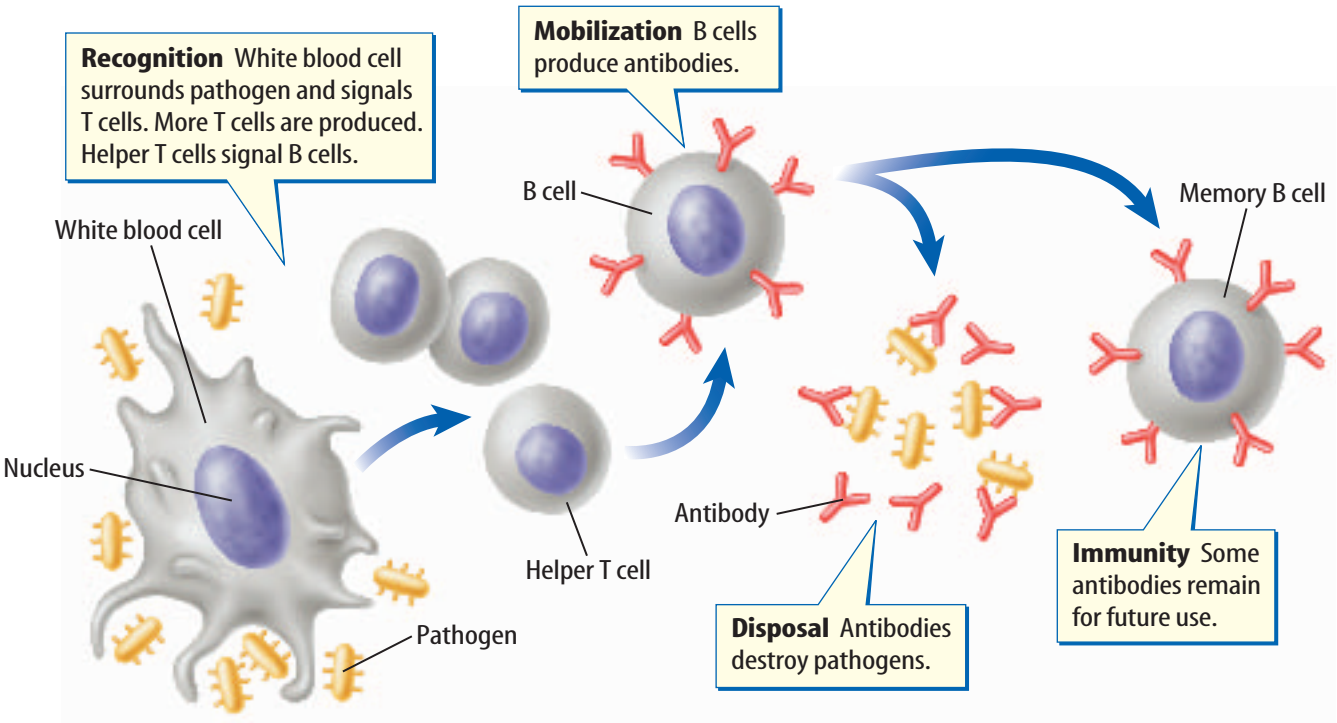


Figure 11 The response of your immune system to disease-causing organisms can be divided into four steps—recognition, mobilization, disposal, and immunity.
Describe *the function of B cells.*

White Blood Cells

Your circulatory system contains white blood cells that surround and digest foreign organisms and chemicals. These white blood cells constantly patrol your body, sweeping up and digesting bacteria that invade.

Inflammation

When tissue is damaged or infected by pathogens, it can become inflamed—becomes red, feels warm, swells, and hurts. Chemicals released by damaged cells expand capillary walls, allowing more blood to flow into the area. Other chemicals released by damaged tissue attract certain white blood cells that surround and take in pathogenic bacteria. If pathogens get past these first-line defenses, your body uses another line of defense called specific immunity.

Specific Immunity

When your body fights disease, it is battling complex molecules called **antigens** that don't belong there. Antigens can be separate molecules or they can be found on the surface of a pathogen.

When your immune system recognizes foreign molecules, as in **Figure 11,** special lymphocytes called T cells respond. One type of T cells, called killer T cells, releases enzymes that help destroy invading foreign matter. Another type of T cells, called helper T cells, turns on the immune system. They stimulate other lymphocytes, known as B cells, to form antibodies. An **antibody** is a protein made in response to a specific antigen. The antibody attaches to the antigen and makes it useless.

Memory B Cells Another type of lymphocyte, called memory B cells, also has antibodies for the specific pathogen. Memory B cells remain in the blood, ready to defend against an invasion by that same pathogen at another time.

Active Immunity Antibodies help your body build defenses in two ways—actively and passively. In **active immunity** your body makes its own antibodies in response to an antigen. **Passive immunity** results when antibodies that have been produced in another animal are introduced into your body.

When a pathogen invades your body, the pathogen quickly multiplies and you get sick. Your body immediately starts to make antibodies to attack the pathogen. After enough antibodies form, you usually get better. Some antibodies stay on duty in your blood, and more are produced rapidly if the pathogen enters your body again. Because of this defense system, you usually don't get certain diseases, such as chicken pox, more than once.

Reading Check *How does active immunity differ from passive immunity?*

Vaccination Another way to develop active immunity to a disease is to be inoculated with a vaccine, as shown in **Figure 12.** The process of giving a vaccine by injection or by mouth is called vaccination. A vaccine is a form of the antigen that gives you active immunity against a disease.

A vaccine can prevent a disease, but it is not a cure. As you grow older, you will be exposed to many more types of pathogens and will build a separate immunity to each one.

Figure 12 The Td vaccine protects against tetanus and diphtheria, an infectious disease of the respiratory system, and usually is injected into the arm.

Mini LAB

Determining Reproduction Rates

Procedure

1. Place **one penny** on a table. Imagine that the penny is a bacterium that can divide every 10 min.
2. Place **two pennies** below to form a triangle with the first penny. These indicate the two new bacteria present after a bacterium divides.
3. Repeat three more divisions, placing two pennies under each penny in the row above.
4. Calculate how many bacteria you would have after 5 h of reproduction. Graph your data.

Analysis

1. How many bacteria are present after 5 h?
2. Why is it important to take antibiotics promptly if you have an infection?

Try at Home

Table 2 Cases of Disease Before and After Vaccine Availability in the U.S.

Disease	Average Number of Cases per Year Before Vaccine Available	Cases in 1998 After Vaccine Available
Measles	503,282	89
Diphtheria	175,885	1
Tetanus	1,314	34
Mumps	152,209	606
Rubella	47,745	345
Pertussis (whooping cough)	147,271	6,279

Data from the National Immunization Program, CDC

Passive Immunity Passive immunity does not last as long as active immunity does. For example, you were born with all the antibodies that your mother had in her blood. However, these antibodies stayed with you for only a few months. Because newborn babies lose their passive immunity in a few months, they need to be vaccinated to develop their own immunity. Vaccines have helped reduce the number of cases of many childhood diseases, as shown in **Table 2.**

section 3 review

Summary

Lines of Defense

- The purpose of the immune system is to fight disease.
- Your skin and your respiratory, digestive, and circulatory systems are first-line defenses against pathogens.
- Your body's second line of defense is called specific immunity.
- In active immunity, your body makes its own antibodies in response to an antigen.
- Vaccinations can give you active immunity against a disease.
- Passive immunity results when antibodies that have been produced in another animal are introduced into your body.

Self Check

1. **Describe** how harmful bacteria can cause infections in your body.
2. **List** the natural defenses that your body has against harmful substances and disease.
3. **Explain** how an active vaccine works to protect the human body.
4. **Think Critically** Several diseases have symptoms similar to those of measles. Why doesn't the measles vaccine protect you from all of these diseases?

Applying Skills

5. **Make Models** Create models of the different types of T cells, antigens, and B cells from clay, construction paper, or other art materials. Use them to explain how T cells function in the immune system.

section 4

Diseases

Disease in History

Throughout time, the plague, smallpox, and influenza have killed millions of people worldwide. Today, the causes of these diseases are known, and treatments can prevent or cure them. But even today, some diseases cannot be cured, and outbreaks of new diseases, such as severe acute respiratory syndrome (SARS), occur.

Discovering Disease Organisms With the invention of the microscope in the latter part of the seventeenth century, bacteria, yeast, and mold spores were seen for the first time. However, scientists did not make a connection between microorganisms and disease transmission until the late 1800s and early 1900s.

The French chemist Louis Pasteur learned that microorganisms cause disease in humans. Many scientists of his time did not believe that microorganisms could harm larger organisms, such as humans. However, Pasteur discovered that microorganisms could spoil wine and milk. He then realized that microorganisms could attack the human body in the same way. Pasteur invented **pasteurization** (pas chuh ruh ZAY shun), which is the process of heating a liquid to a temperature that kills most bacteria.

Disease Organisms **Table 3** lists some of the diseases caused by various groups of pathogens. Bacteria and viruses cause many common diseases.

Table 3 Human Diseases and Their Agents

Agent	Diseases
Bacteria	Tetanus, tuberculosis, typhoid fever, strep throat, bacterial pneumonia, plague
Protists	Malaria, sleeping sickness
Fungi	Athlete's foot, ringworm
Viruses	Colds, influenza, AIDS, measles, mumps, polio, smallpox, SARS

as you read

What You'll Learn

- **Describe** the work of Pasteur, Koch, and Lister in the discovery and prevention of disease.
- **Identify** diseases caused by viruses and bacteria.
- **Explain** how HIV affects the immune system.
- **Define** noninfectious diseases and list their causes.
- **Explain** what happens during an allergic reaction.

Why It's Important

You can help prevent certain illnesses if you know what causes disease and how disease spreads.

Review Vocabulary

virus: tiny piece of genetic material surrounded by a protein coating that infects and multiplies in host cells

New Vocabulary

- pasteurization
- infectious disease
- noninfectious disease
- allergen

Antibiotics Soil contains many microorganisms—some that are harmful, such as tetanus bacteria, and some that are helpful. Some infections are treated with antibiotics made from bacteria and molds found in the soil. One such antibiotic is streptomycin. In your Science Journal, write a brief report about the drug streptomycin.

Pathogens The conditions in your body, such as temperature and available nutrients, help harmful bacteria that enter your body grow and multiply. Bacteria can slow down the normal growth and metabolic activities of body cells and tissues. Some bacteria even produce toxins that kill cells on contact.

A virus infects and multiplies in host cells. The host cells die when the viruses break out of them. These new viruses infect other cells, leading to the destruction of tissues or the interruption of vital body activities.

Reading Check ***What is the relationship between a virus and a host cell?***

Pathogenic protists, such as the organisms that cause malaria, can destroy tissues and blood cells or interfere with normal body functions. In a similar manner, fungus infections can cause athlete's foot, nonhealing wounds, chronic lung disease, or inflammation of the membranes of the brain.

Koch's Rules Many diseases caused by pathogens can be treated with medicines. In many cases, these organisms need to be identified before specific treatment can begin. Today, a method developed in the nineteenth century by Robert Koch still is used to identify organisms, as shown in **Figure 13.**

Infectious Diseases

A disease that is caused by a virus, bacterium, protist, or fungus and is spread from an infected organism or the environment to another organism is called an **infectious disease.** Infectious diseases are spread by direct contact with the infected organism, through water and air, on food, by contact with contaminated objects, and by disease-carrying organisms called biological vectors. Examples of vectors that have been sources of disease are rats, birds, cats, dogs, mosquitoes, fleas, and flies, as shown in **Figure 14.**

Figure 14 When flies land on food, they can transport pathogens from one location to another.

Human Vectors People also can be carriers of disease. Colds and many other diseases are spread through contact. Each time you turn a doorknob or use a telephone, your skin comes in contact with bacteria and viruses, which is why washing your hands frequently should be part of your daily routine.

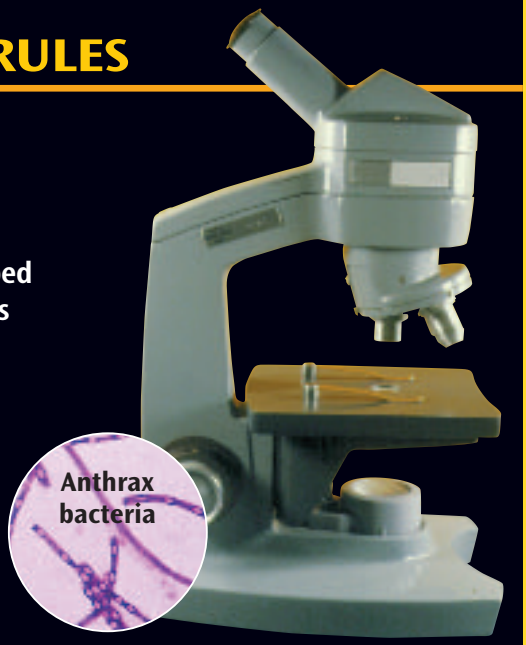
Joseph Lister, an English surgeon, recognized the relationship between infections and cleanliness. Lister dramatically reduced the number of deaths among his patients by washing their skin and his hands with carbolic (kar BAH lihk) acid, which is a liquid that kills pathogens.

NATIONAL GEOGRAPHIC

VISUALIZING KOCH'S RULES

Figure 13

In the 1880s, German doctor Robert Koch developed a series of methods for identifying which organism was the cause of a particular disease. Koch's Rules are still in use today. Developed mainly for determining the cause of particular diseases in humans and other animals, these rules have been used for identifying diseases in plants as well.



A In every case of a particular disease, the organism thought to cause the disease—the pathogen—must be present.

B The suspected pathogen must be separated from all other organisms and grown on agar gel with no other organisms present.

C When inoculated with the suspected pathogen, a healthy host must come down with the original illness.

D Finally, when the suspected pathogen is removed from the host and grown on agar gel again, it must be compared with the original organism. Only when they match can that organism be identified as the pathogen that causes the disease.

Sexually Transmitted Diseases Infectious diseases that are passed from person to person during sexual contact are called sexually transmitted diseases (STDs). STDs are caused by bacteria or viruses.

Gonorrhea (gah nuh REE uh), chlamydia (kluh MIH dee uh), and syphilis (SIH fuh lus) are STDs caused by bacteria. Antibiotics are used to treat these diseases. If they are untreated, gonorrhea and chlamydia can leave a person sterile because the reproductive organs can be damaged permanently. Untreated syphilis may infect cardiovascular and nervous systems, resulting in damage to body organs that cannot be reversed.

Genital herpes, a lifelong viral disease, causes painful blisters on the sex organs. This type of herpes can be transmitted during sexual contact or from an infected mother to her child during birth. Herpes has no cure, and no vaccine can prevent it. However, the symptoms of herpes can be treated with antiviral medicines.

Reading Check *Why should STDs be treated in the early stages?*

Applying Science

Has the annual percentage of deaths from major diseases changed?

Each year, many people die from diseases. Medical science has found numerous ways to treat and cure disease. Have new medicines, improved surgery techniques, and healthier lifestyles helped decrease the number of deaths from disease? By using your ability to interpret data tables, you can find out.

Percentage of Deaths Due to Major Diseases

Disease	Year			
	1950	1980	1990	2000
Heart	37.1	38.3	33.5	29.6
Cancer	14.6	20.9	23.5	23.0
Stroke	10.8	8.6	6.7	7.0
Diabetes	1.7	1.8	2.2	2.9
Pneumonia and flu	3.3	2.7	3.7	2.7

Identifying the Problem

The table above shows the percentage of total deaths due to six major diseases for a 50-year time period. Study the data for each disease. Can you see any trends in the percentage of deaths?

Solving the Problem

1. Has the percentage increased for any disease that is listed?
2. What factors could have contributed to this increase?

HIV and Your Immune System

Human immunodeficiency virus (HIV) can exist in blood and body fluids. This virus can hide in body cells, sometimes for years. You can become infected with HIV by having sex with an HIV-infected person or by reusing an HIV-contaminated hypodermic needle for an injection. However, a freshly unwrapped sterile needle cannot transmit infection. The risk of getting HIV through blood transfusion is small because all donated blood is tested for the presence of HIV. A pregnant woman with HIV can infect her child when the virus passes through the placenta. The child also may become infected from contacts with blood during the birth process or when nursing after birth.

HIV cannot multiply outside the body, and it does not survive long in the environment. The virus cannot be transmitted by touching an infected person, by handling objects used by the person unless they are contaminated with body fluids, or from contact with a toilet seat.

AIDS An HIV infection can lead to Acquired Immune Deficiency Syndrome (AIDS), which is a disease that attacks the body's immune system. HIV, as shown in **Figure 15,** is different from other viruses. It attacks the helper T cells in the immune system. The virus enters the T cell and multiplies. When the infected cell bursts open, it releases more HIV. These infect other T cells. Soon, so many T cells are destroyed that not enough B cells are stimulated to produce antibodies. The body no longer has an effective way to fight invading antigens. The immune system then is unable to fight HIV or any other pathogen.

In December 2003, it was estimated that nearly 40 million people worldwide have HIV/AIDS. At this time the disease has no known cure. However, several medications help treat AIDS in some patients.

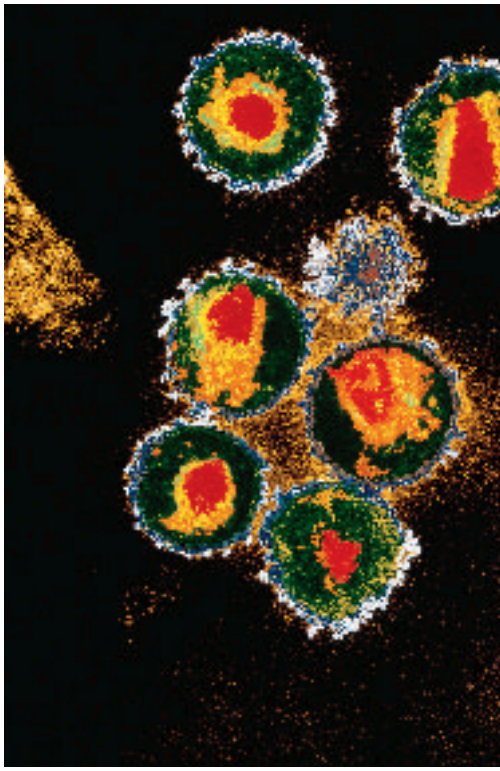


Figure 15 A person can be infected with HIV and not show any symptoms of the infection for several years.
Explain *why this characteristic makes the spread of AIDS more likely.*

Fighting Disease

Washing a small wound with soap and water is the first step in preventing an infection. Cleaning the wound with an antiseptic and covering it with a bandage are other steps. Is it necessary to wash your body to help prevent diseases? Yes! In addition to reducing body odor, washing your body removes and destroys some surface microorganisms.

In your mouth, microorganisms are responsible for mouth odor and tooth decay. Using dental floss and routine tooth brushing keep these organisms under control.

CONTENTS

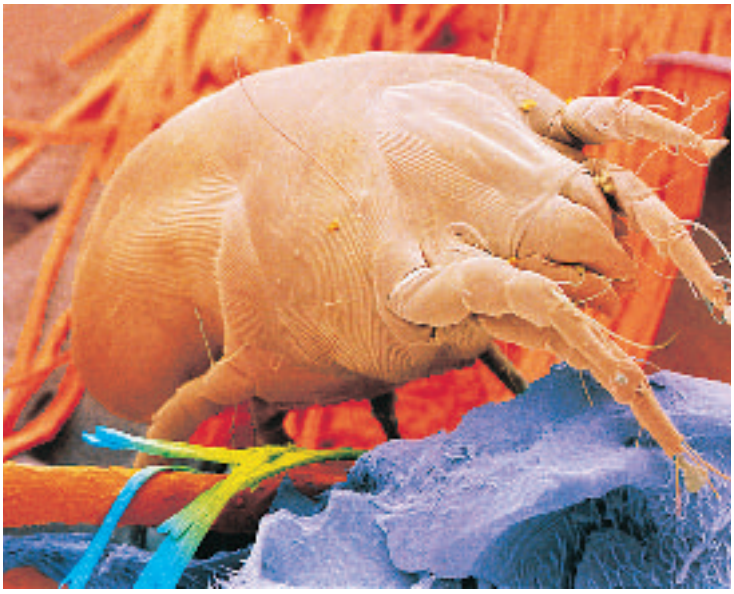


Figure 16 Dust mites are smaller than a period at the end of a sentence. They can live in pillows, mattresses, carpets, furniture, and other places.

Healthy Choices Exercise and good nutrition help the circulatory and respiratory systems work more effectively. Good health habits, including getting enough rest and eating well-balanced meals, can make you less susceptible to the actions of disease organisms such as those that cause colds and flu. Keeping up with recommended immunizations and having annual health checkups also can help you stay healthy.

Chronic Disease

Not all diseases are caused by pathogens. Diseases and disorders such as diabetes, allergies, asthma, cancer, and heart disease are **noninfectious diseases.** They are not spread from one person to another. Many are chronic (KRAH nihk). This means that they can last for a long time. Although some chronic diseases can be cured, others cannot.

Some infectious diseases can be chronic too. For example, deer ticks carry a bacterium that causes Lyme disease. This bacterium can affect the nervous system, heart, and joints for weeks to years. It can become chronic if not treated. Antibiotics will kill the bacteria, but some damage cannot be reversed.

Allergies Many people have allergies. Some people react to cosmetics, shellfish, strawberries, peanuts, or insect stings. An allergy is an overly strong reaction of the immune system to a foreign substance. Most allergic reactions are minor. However, severe allergic reactions can occur, causing shock and even death if they aren't treated promptly.

Substances that cause an allergic response are called **allergens.** Some chemicals, certain foods, pollen, molds, some antibiotics, and dust are allergens for some people. Dust can contain cat and dog dander and dust mites, shown in **Figure 16.**

When you come in contact with an allergen, your immune system usually forms antibodies. Your body reacts by releasing chemicals called histamines (HIHS tuh meenz) that promote red, swollen tissues. Antihistamines are medications that can be used to treat allergic reactions and asthma, a lung disorder associated with reactions to allergens. Some severe allergies are treated with repeated injections of small doses of the allergen. This allows your body to become less sensitive to the allergen.

Diabetes A chronic disease associated with the levels of insulin produced by the pancreas is diabetes. Insulin is a hormone that enables glucose to pass from the bloodstream into your cells. Doctors recognize two types of diabetes—Type 1 and Type 2. Type 1 diabetes is the result of too little or no insulin production. In Type 2 diabetes, your body cannot properly process insulin. Symptoms of diabetes include fatigue, excessive thirst, frequent urination, and tingling sensations in the hands and feet.

If glucose levels in the blood remain high for a long time, other health problems can develop. These problems can include blurred vision, kidney failure, heart attack, stroke, loss of feeling in the feet, and the loss of consciousness (diabetic coma).

Cancer

Cancer is the name given to a group of closely related diseases that result from uncontrolled cell growth. It is a complicated disease, and no one fully understands how cancers form. Characteristics of cancer cells are shown in **Table 4.** Tumors can occur anywhere in your body. Cancerous cells can leave a tumor, spread throughout the body via blood and lymph vessels, and then invade other tissues.

Reading Check *How do cancers spread?*

Causes In the latter part of the eighteenth century, a British physician recognized the association of soot to cancer in chimney sweeps. Since that time, scientists have learned more about causes of cancer. Research done in the 1940s and 1950s first related genes to cancer.

Although not all the causes of cancer are known, many causes have been identified. Smoking has been linked to lung cancer—the leading cause of cancer deaths for males in the United States. Exposure to certain chemicals also can increase your chances of developing cancer. These substances, called carcinogens (kar SIH nuh junz), include asbestos, various solvents, heavy metals, alcohol, and home and garden chemicals. Exposure to X rays, nuclear radiation, and ultraviolet radiation of the Sun also increases your risk of cancer.

Table 4 Characteristics of Cancer Cells

Cell growth is uncontrolled.
These cells do not function as part of your body.
The cells take up space and interfere with normal body functions.
The cells travel throughout the body.
The cells produce tumors and abnormal growths anywhere in your body.

Table 5 Early Warning Signs of Cancer
Changes in bowel or bladder habits
A sore that does not heal
Unusual bleeding or discharge
Thickening or lump in the breast or elsewhere
Indigestion or difficulty swallowing
Obvious change in a wart or mole
Nagging cough or hoarseness

from the National Cancer Institute

Prevention Knowing some causes of cancer might help you prevent it. The first step is to know the early warning signs, shown in **Table 5.** Medical attention and treatments such as chemotherapy or surgery in the early stages of some cancers can cure or keep them inactive.

A second step in cancer prevention concerns lifestyle choices. Choosing not to use tobacco and alcohol products can help prevent mouth and lung cancers and the other associated respiratory and circulatory system diseases. Selecting a healthy diet without many foods that are high in fats, salt, and sugar also might reduce your chances of developing cancer. Using sunscreen and limiting the amount of time that you expose your skin to direct sunlight are good preventive measures against skin cancer. Careful handling of harmful home and garden chemicals will help you avoid the dangers connected with these substances.

section 4 review

Summary

Disease in History

- Pasteur, Koch, and Lister made important discoveries about the causes and how to prevent the spread of diseases.

Infectious Diseases and HIV

- Bacteria, fungi, protists, and viruses can cause infectious disease.
- STDs are passed during sexual contact and are caused by bacteria or viruses.
- HIV infection can lead to AIDS, a disease that attacks the immune system.

Fighting Disease

- Good health habits can help prevent the spread of disease.

Chronic Disease and Cancer

- Allergies, diabetes, and cancer are chronic noninfectious diseases.
- Early detection and lifestyle choices can help treat or prevent some cancers.

Self Check

1. **Name** an infectious disease caused by each of the following: a virus, a bacterium, a protist, and a fungus.
2. **Compare and contrast** how HIV and other viruses affect the immune system.
3. **Explain** why diabetes is classified as a noninfectious disease.
4. **Recognize** how poor hygiene is related to the spread of disease.
5. **Describe** how your body might respond to an allergen.
6. **Think Critically** In what ways does Koch's procedure demonstrate the use of scientific methods?

Applying Math

7. **Make and Use Graphs** Make a bar graph using the following data about the number of deaths from AIDS-related diseases for children younger than 13 years old: 1995, 536; 1996, 420; 1997, 209; 1998, 115; and 1999, 76.

LAB

Microorganisms and Disease

Microorganisms are everywhere. Washing your hands and disinfecting items you use helps remove some of these organisms.

Real-World Question

How do microorganisms cause infection?

Goals

- **Observe** the transmission of microorganisms.
- **Relate** microorganisms to infections.

Materials

fresh apples (6)
rotting apple
rubbing alcohol (5 mL)
self-sealing plastic bags (6)
labels and pencil
gloves
paper towels
sandpaper
cotton ball
soap and water
newspaper

Safety Precautions

WARNING: *Do not eat the apples. Do not remove goggles until the lab and cleanup are completed.* When you complete the experiment, give all bags to your teacher for disposal.

Procedure

1. **Label** the plastic bags 1 through 6. Put on gloves. Place a fresh apple in bag 1.
2. Rub the rotting apple over the other five apples. This is your source of microorganisms. **WARNING:** *Don't touch your face.*
3. Put one apple in bag 2.
4. Hold one apple 1.5 m above the floor and drop it on a newspaper. Put it in bag 3.
5. Rub one apple with sandpaper. Place this apple in bag 4.
6. Wash one apple with soap and water. Dry it well. Put this apple in bag 5.
7. Use a cotton ball to spread alcohol over the last apple. Let it air-dry. Place it in bag 6.
8. Seal all bags and put them in a dark place.
9. On day 3 and day 7, compare all of the apples without removing them from the bags. Record your observations in a data table.

Apple Observations

Condition	Day 3	Day 7
1. Fresh		
2. Untreated		
3. Dropped		
4. Rubbed with sandpaper		
5. Washed with soap and water		
6. Covered with alcohol		

Conclude and Apply

1. **Infer** How does this experiment relate to infections on your skin?
2. **Explain** why it is important to clean a wound.

Communicating Your Data

Prepare a poster illustrating the advantages of washing hands to avoid the spread of disease. Get permission to put the poster near a school rest room. **For more help, refer to the Science Skill Handbook.**

LAB

Design Your Own

Blood Type Reactions

Goals

- **Design** an experiment that simulates the reactions between different blood types.
- **Identify** which blood types can donate to which other blood types.

Possible Materials

simulated blood (10 mL low-fat milk and 10 mL water plus red food coloring)
lemon juice as antigen A (for blood types B and O)
water as antigen A (for blood types A and AB)
droppers
small paper cups
marking pen
10-mL graduated cylinder

Safety Precautions

WARNING: *Do not taste, eat, or drink any materials used in the lab.*

Real-World Question

Human blood can be classified into four main blood types—A, B, AB, and O. These types are determined by the presence or absence of antigens on the red blood cells. After blood is collected into a transfusion bag, it is tested to determine the blood type. The type is labeled clearly on the bag. Blood is refrigerated to keep it fresh and available for transfusion. What happens when two different blood types are mixed?

Form a Hypothesis

Based on your reading and observations, form a hypothesis to explain how different blood types will react to each other.

Test Your Hypothesis

Make a Plan

1. As a group, agree upon a hypothesis and decide how you will test it. Identify the results that will confirm the hypothesis.
2. **List** the steps you must take and the materials you will need to test your hypothesis. Be specific. Describe exactly what you will do in each step.
3. **Prepare** a data table like the one at the right in your Science Journal to record your observations.

Blood Type Reactions

Blood Type	Clumping (Yes or No)
A	
B	Do not write in this book.
AB	
O	

CONTENTS

4. Reread the entire experiment to make sure all steps are in logical order.
5. **Identify** constants and variables. Blood type O will be the control.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment according to the approved plan.
3. While doing the experiment, record your observations and complete the data table in your Science Journal.

Analyze Your Data

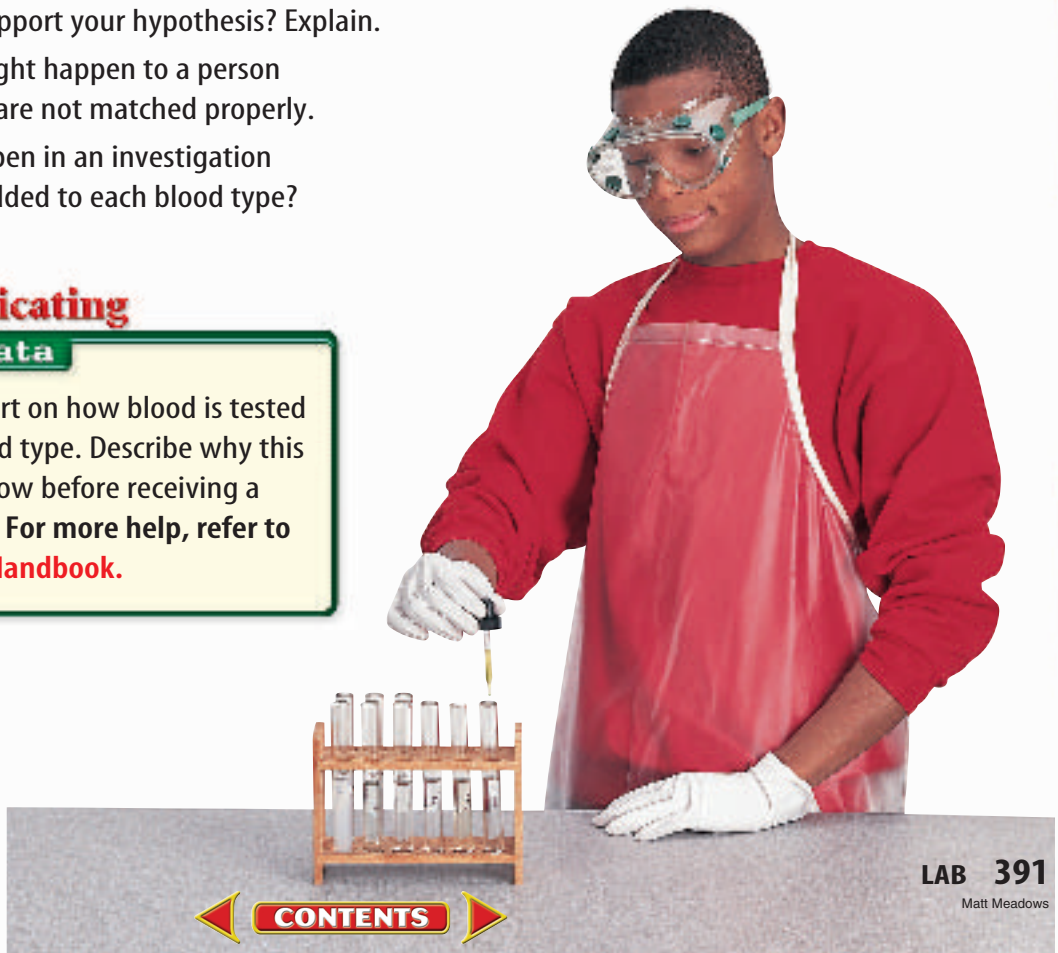
1. **Compare** the reactions of each blood type (A, B, AB, and O) when antigen A was added to the blood.
2. **Observe** where clumping took place.
3. **Compare** your results with those of other groups.
4. What was the control factor in this experiment?
5. What were your variables?

Conclude and Apply

1. Did the results support your hypothesis? Explain.
2. **Predict** what might happen to a person if other antigens are not matched properly.
3. What would happen in an investigation with antigen B added to each blood type?

Communicating Your Data

Write a brief report on how blood is tested to determine blood type. Describe why this is important to know before receiving a blood transfusion. **For more help, refer to the Science Skill Handbook.**



Matt Meadows

Dr. Daniel Hale Williams was a pioneer in open-heart surgery.

Have a Heart

People didn't always know where blood came from or how it moved through the body.

You prick your finger, and when blood starts to flow out of the cut, you put on a bandage. But if you were a scientist living long ago, you might have also asked yourself some questions: How did your blood get to the tip of your finger? And why and how does it flow through (and sometimes out of!) your body?

As early as the 1500s, a Spanish scientist named Miguel Serveto (mee GEL • ser VEH toh) asked that question. His studies led him to the theory that blood circulated throughout the human body, but he didn't know how or why.

About 100 years later, William Harvey, an English doctor, explored Serveto's idea. Harvey studied animals to develop a theory about how the heart and the circulatory system work. Blood was pumped from the heart throughout the body, Harvey hypothesized. Then it returned to the heart and recirculated. He published his ideas in 1628 in his famous book, *On the Motion of the Heart and Blood in Animals.* His theories were correct, and Harvey's book became the basis for all modern research on heart and blood vessels.

Medical Pioneer

More than two centuries later, another pioneer, Dr. Daniel Hale Williams, stepped forward and used Harvey's ideas to change the science frontier again. He performed the first open-heart surgery by removing a knife from the heart of a stabbing victim. He stitched the wound in the fluid sac surrounding the heart, and the patient lived for several years afterward.

Report **Identify a pioneer in science or medicine who has changed our lives for the better. Find out how this person started in the field, and how they came to make an important discovery. Give a presentation to the class.**

ScienceOnline

For more information, visit green.msscience.com/time

Reviewing Main Ideas

Section 1 Blood

1. Red blood cells carry oxygen and carbon dioxide, platelets form clots, and white blood cells fight infection.
2. A, B, AB, and O blood types are determined by the presence or absence of antigens on red blood cells.

Section 2 Circulation

1. Arteries carry blood away from the heart and veins return blood to the heart. Capillaries connect arteries to veins.
2. The circulatory system can be divided into three sections—coronary, pulmonary, and systemic circulation.
3. Lymph structures filter blood, produce white blood cells, and destroy worn out blood cells.

Section 3 Immunity

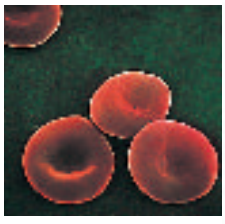
1. Your body is protected against most pathogens by the immune system.
2. Active immunity is long lasting, but passive immunity is not.

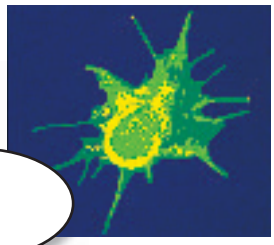
Section 4 Diseases

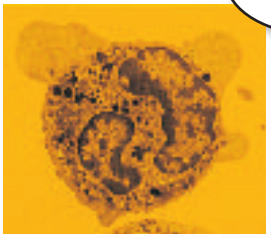
1. Pasteur and Koch discovered that microorganisms cause diseases. Lister learned that cleanliness helps control microorganisms.
2. Bacteria, viruses, fungi, and protists can cause infectious diseases.
3. HIV damages your body's immune system, which can cause AIDS.
4. Causes of noninfectious diseases, such as diabetes and cancer, include genetics, a poor diet, chemicals, and uncontrolled cell growth.

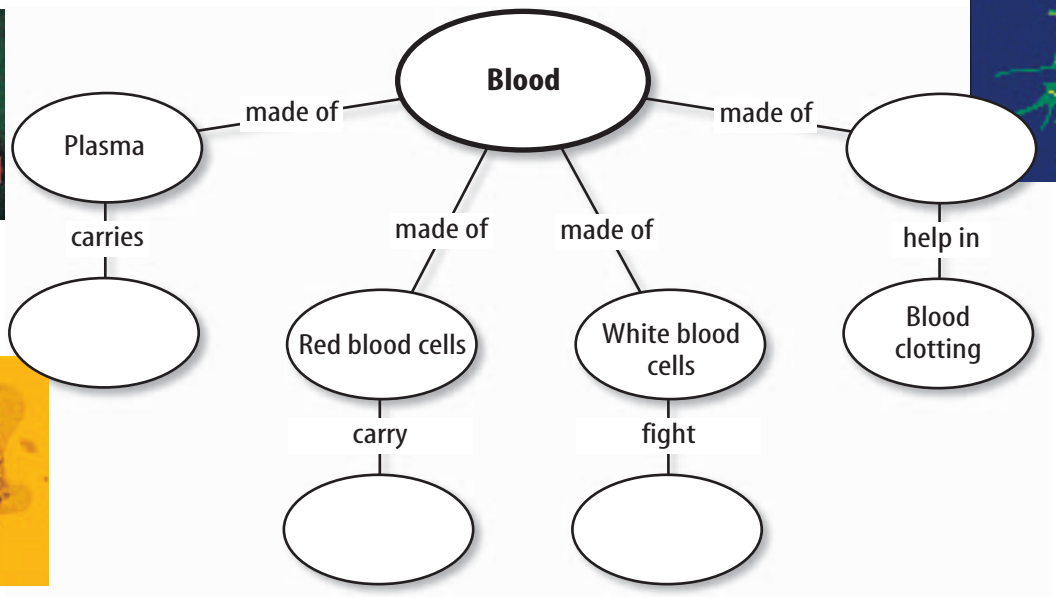
Visualizing Main Ideas

Copy and complete this concept map on the functions of the parts of the blood.









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chapter 13 Review

Using Vocabulary

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pasteurization p. 381
plasma p. 366
platelet p. 367
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Fill in the blanks with the correct vocabulary word or words.

1. _____ is the chemical in red blood cells.
2. _____ are cell fragments that help clot blood.
3. _____ occurs when your body makes its own antibodies.
4. A(n) _____ stimulates histamine release.
5. Heating a liquid to kill harmful bacteria is called _____.

Checking Concepts

Choose the word or phrase that best answers the question.

6. Where does the exchange of food, oxygen, and wastes occur?
   A) arteries **C)** veins
   B) capillaries **D)** lymph vessels
7. How can infectious diseases be caused?
   A) heredity **C)** chemicals
   B) allergies **D)** organisms
8. Where is blood under greatest pressure?
   A) arteries **C)** veins
   B) capillaries **D)** lymph vessels
9. Which cells fight off infection?
   A) red blood **C)** white blood
   B) bone **D)** nerve
10. Of the following, which carries oxygen in blood?
    A) red blood cells **C)** white blood cells
    B) platelets **D)** lymph
11. What is required to clot blood?
    A) plasma **C)** platelets
    B) oxygen **D)** carbon dioxide

Use the table below to answer question 12.

Table 1 Blood Types

Blood Type	Antigen	Antibody
A	A	Anti-B
B	B	Anti-A
AB	A, B	None
O	None	Anti-A, Anti-B

12. Using the table above, what kind of antigen does type O blood have?
    A) A **C)** A and B
    B) B **D)** no antigen
13. Where does oxygen-rich blood enter first?
    A) right atrium
    B) left atrium
    C) left ventricle
    D) right ventricle
14. What is formed in the blood to fight invading antigens?
    A) hormones **C)** pathogens
    B) allergens **D)** antibodies
15. Which disease is caused by a virus that attacks white blood cells?
    A) AIDS **C)** flu
    B) measles **D)** polio

Thinking Critically

16. Compare and contrast the life spans of red blood cells, white blood cells, and platelets.

17. Sequence blood clotting from the wound to forming a scab.

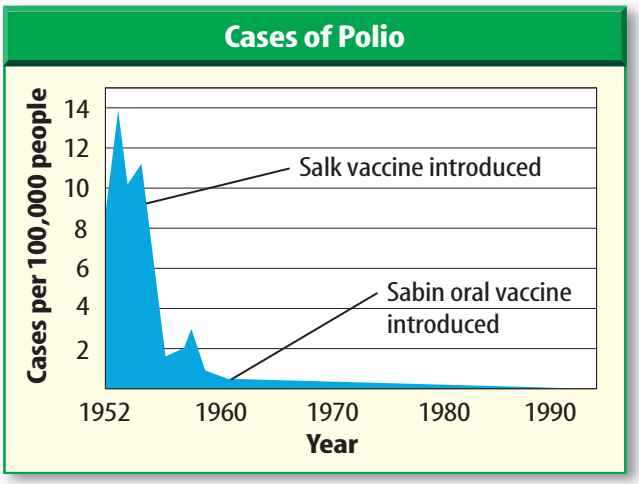
18. Compare and contrast the functions of arteries, veins, and capillaries.

19. Analyze how antibodies, antigens, and antibiotics differ.

20. Recognize Cause and Effect Use library references to identify the cause—bacteria, virus, fungus, or protist—of each of these diseases: athlete's foot, AIDS, cold, dysentery, flu, pinkeye, acne, and strep throat.

21. Classify Using word processing software, make a table to classify the following diseases as infectious or noninfectious: diabetes, gonorrhea, herpes, strep throat, syphilis, cancer, and flu.

Use the graph below to answer question 22.



22. Explain the rate of polio cases between 1952 and 1965. What conclusions can you draw about the effectiveness of the polio vaccine?

Performance Activities

23. Scientific Drawing Prepare a drawing of the human heart and label its parts. Use arrows to show the flow of blood through the heart.

24. Poster Design and construct a poster to illustrate how a person with the flu could spread the disease to family members, classmates, and others.

25. Pamphlet Prepare a pamphlet describing heart transplants. Include an explanation of why the patient is given drugs that suppress the immune system and describe the patient's life after the operation.

Applying Math

26. Percentages of Blood Cells A cubic millimeter of blood has about five million red blood cells, 7,500 white blood cells, and 400,000 platelets. Find the total number of red blood cells, white blood cells, and platelets in 1 mm^3 of blood. Calculate what percentage of the total each type is.

Use the table below to answer question 27.

Gender and Heart Rate

Sex	Pulse/Minute
Male 1	72
Male 2	64
Male 3	65
Female 1	67
Female 2	84
Female 3	74

27. Heart Rates Interpret the data listed in the table above. Find the average heart rate of the three males and the three females and compare the two averages.

Part 1 Multiple Choice

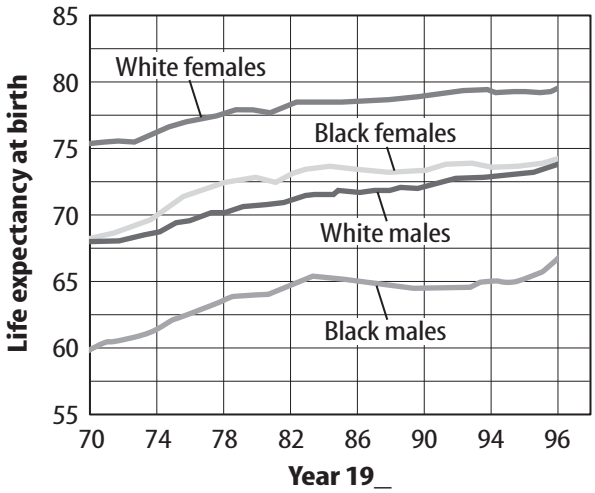
Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Which of the following is a cause of cardiovascular disease?

A. smoking
B. jogging
C. asbestos exposure
D. ultraviolet radiation

Use the graph below to answer questions 2 and 3.

Life Expectancy by Race and Sex, 1970–1997



2. According to the information in the graph, which group had the lowest life expectancy in both 1975 and 1994?

A. white males
B. black females
C. white females
D. black males

3. A reasonable hypothesis based on the information in the graph is that

A. life expectancy has decreased for black males between 1970 and 1984.
B. life expectancy is longer for females than for males.
C. life expectancy has decreased for white males between 1970 and 1980.
D. life expectancy is longer for males than for females.

Use the table below to answer questions 4 and 5.

Results from Ashley's Activities			
Activity	**Pulse Rate (beats/min)**	**Body Temperature**	**Degree of Sweating**
1	80	98.6°F	None
2	90	98.8°F	Minimal
3	100	98.9°F	Little
4	120	99.1°F	Moderate
5	150	99.5°F	Considerable

4. According to the information in the table, which of the following activities caused Ashley's pulse to be less than 100 beats per minute?

A. Activity 2
B. Activity 3
C. Activity 4
D. Activity 5

5. A reasonable hypothesis based on these data is that during Activity 2, Ashley was probably

A. sprinting.
B. marching.
C. sitting down.
D. walking slowly.

6. Which of the following is a function of blood?

A. It carries saliva to the mouth.
B. It excretes salts from the body.
C. It transports nutrients to body cells.
D. It removes lymph from around cells.

7. Which of the following is a noninfectious disease?

A. tetanus
B. malaria
C. influenza
D. diabetes

Test-Taking Tip

Answer Bubbles For each question, double check that you are filling in the correct answer bubble for the question number you are working on.

Part 2 Short Response/Grid In

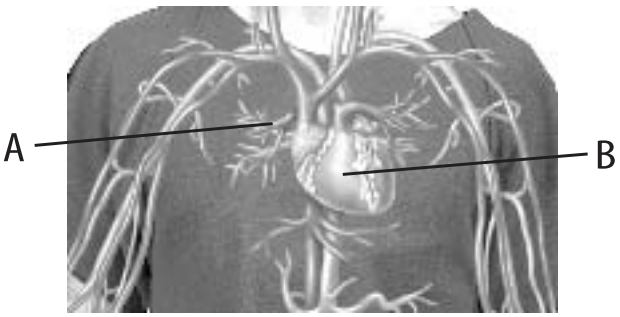
Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

8. If red blood cells are made at the rate of 2 million per second in the center of long bones, how many red blood cells are made in one hour?

9. If a cubic milliliter of blood has 7,500 white blood cells and 400,000 platelets, how many times more platelets than white blood cells are present in a cubic milliliter of blood?

10. What would happen if type A blood was given to a person with type O blood?

Use the illustration below to answer questions 11 and 12.



11. What might happen if there was a blood clot blocking vessel "A" in the illustration?

12. What might happen if there was a blood clot blocking vessel "B" in the illustration?

13. Explain why capillaries do not have thick elastic walls.

14. How does your skin help defend your body from diseases?

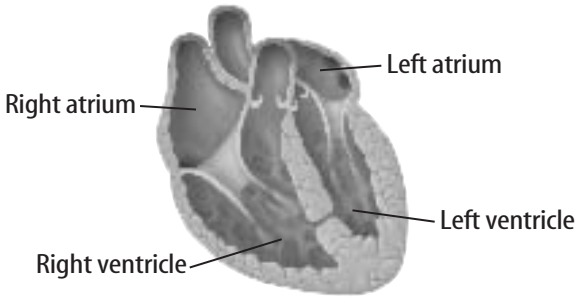
15. Describe some health practices that can help protect you from infectious diseases.

Part 3 Open Ended

Record your answers on a sheet of paper.

16. How do the lymphatic and circulatory systems work together?

Use the illustration below to answer questions 17 and 18.



17. What is wrong with the heart in the illustration above? Explain your answer.

18. The left ventricle pumps blood under higher pressure than the right ventricle does. In which direction would you predict blood would flow through the hole in the heart? Compare the circulation in this heart with that of a normal heart.

19. About 950,000 Americans die from cardiovascular disease each year. What are some ways to prevent cardiovascular disease?

20. Which is longer lasting, active immunity or passive immunity? Explain.

21. Dr. Cavazos has isolated a bacterium that she thinks causes a recently discovered disease. How can she prove her hypothesis? What steps should she follow?

22. Compare and contrast infectious and noninfectious diseases.