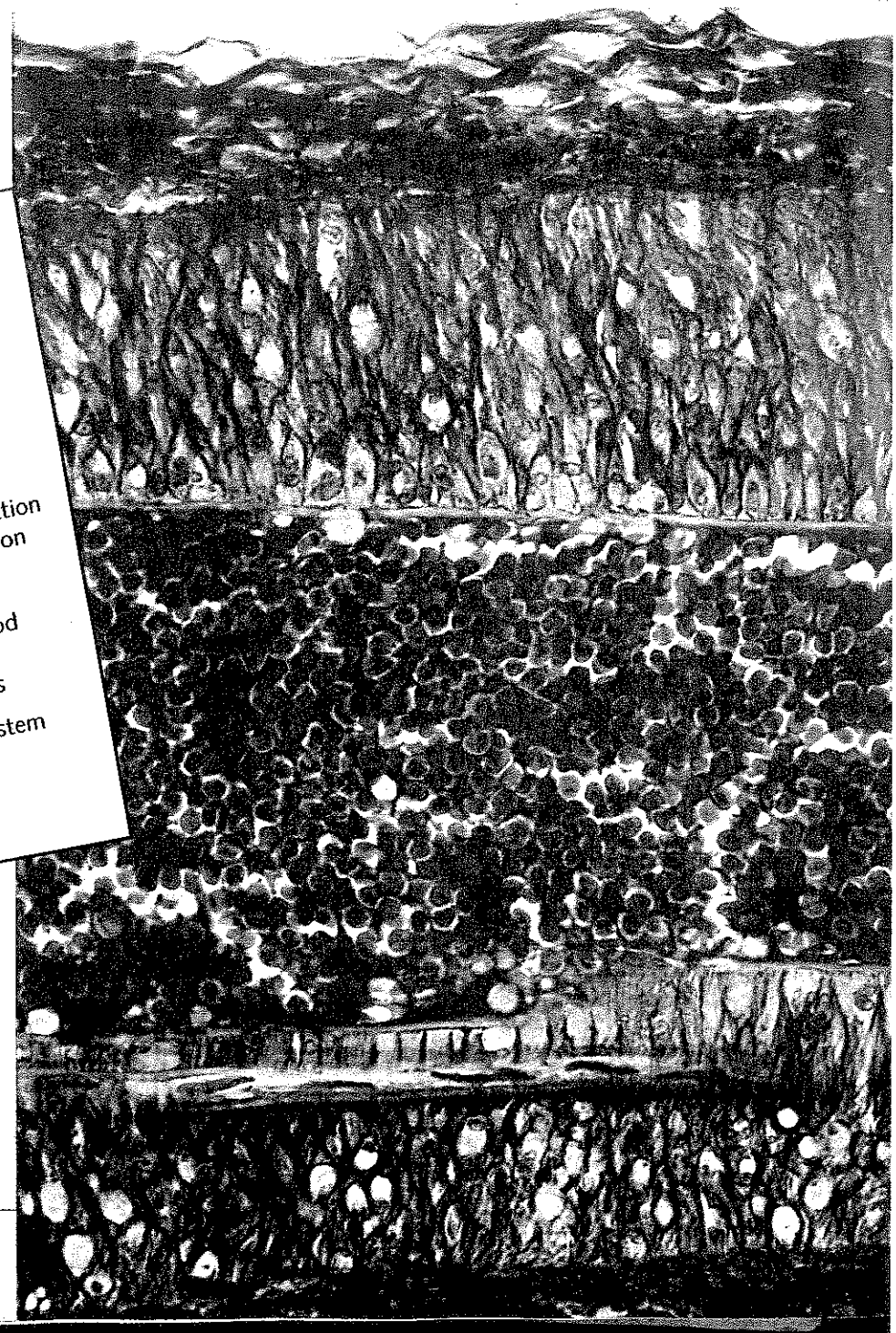
Chapter 22

Circulation



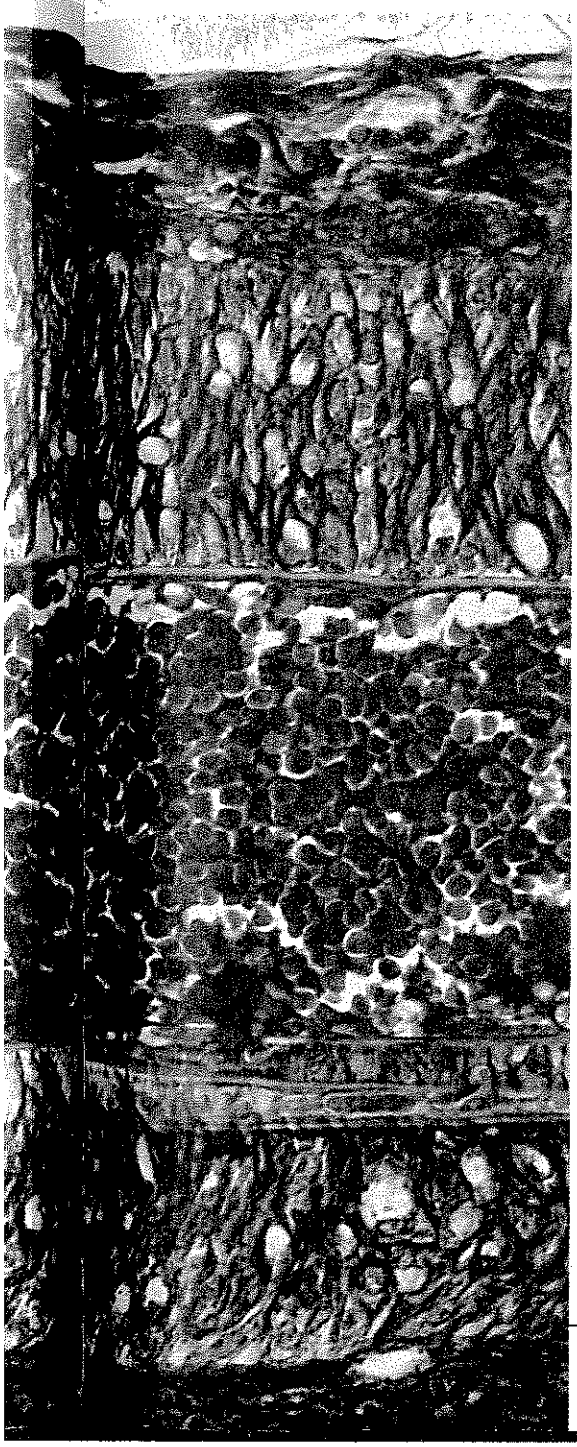
Chapter Outline

I. The Circulatory System
   - A. The Heart
   - B. Blood Vessels
   - C. Circulatory System Problems

II. Circulation
   - A. Pulmonary Circulation
   - B. Systemic Circulation

III. Blood
   - A. Parts of the Blood
   - B. Blood Groups
   - C. Blood Disorders

IV. The Lymphatic System



Objectives

After you have completed this chapter, you will be able to

22-1 **describe** the structure and function of the heart.
22-1 **name** and **describe** three kinds of blood vessels.
22-2 **explain** the two subsystems of circulation.
22-3 **compare** red blood cells and white blood cells.
22-3 **identify** the four major blood types.
22-4 **describe** the structure and function of the lymphatic system.

Science Process Skills

In this chapter, two science skills are highlighted. Symbols show some places where these skills are used.

- **Predicting:** When you predict, you state in advance how and why something will occur.
- **Hypothesizing:** When you hypothesize, you state a suggested answer to a problem based upon known information.

The United States has many roads, railroad tracks, and airline routes that are used to transport food and other items. These pathways make up the transport system of the United States. Trucks, trains, and airplanes carry materials along these pathways.

Your body has a transport system, too. It is called the circulatory system. The circulatory system moves blood throughout your body. What does blood transport? Blood transports many things, including food, oxygen, and waste products. The photograph on the left shows red blood cells moving through a blood vessel. The movement of blood through the body is called **circulation** (sur-kyuh-LAY-shun).

22-1 The Circulatory System

Points

he heart is a four-chambered
ıuscular organ that pumps
lood throughout the body.

rteries, veins, and capillaries
'e three kinds of blood vessels.

Your circulatory system is made up of your heart, blood vessels, and blood. Blood vessels are tubes that carry blood through the body. The blood vessels form a closed circulatory system. In a closed circulatory system, blood never leaves the blood vessels. What other organisms can you name that have a closed circulatory system?

The Heart

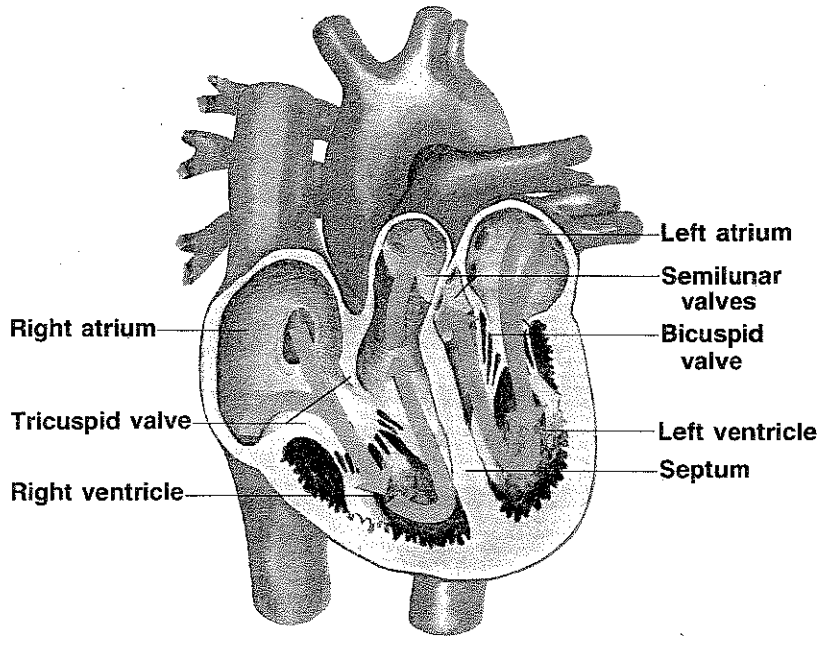
Have you ever been told to memorize something "by heart"? This expression was first used long ago when people thought that the heart was the center of thinking. Today, however, scientists know that the heart's job is to pump blood throughout the body.

You can think of the heart as a double pump. The right side of your heart pumps blood to your lungs. The left side of your heart pumps blood to all other parts of your body. You can see the structure of the heart in Figure 22-1. Notice that the heart is divided into two sides by a thick wall called the **septum.**

The heart also is divided into four chambers. Each side of your heart has an **atrium** (AY-tree-uhm), or upper chamber, and a **ventricle** (VEN-tri-kuhl), or lower

l Builder

'eling When you model, use a copy or an ıtion of an object to explain something. e a model of the heart ; different colors of clay. l the different parts of ıeart. Then display your el in the classroom.



re 22-1 Your heart is scular organ that pumps : 18,175 L of blood ghout your body each

chamber. The atria are like receiving rooms. They receive blood returning to the heart. The ventricles are like shipping rooms. They pump blood through the rest of the body.

How does blood flow through the heart? As you can see in Figure 22-1, blood flows from the atria to the ventricles. When the atria fill with blood, they contract and blood is pushed into the ventricles. The ventricles then contract and pump blood to other parts of the body.

Heart Valves

Figure 22-2 shows that the heart has valves. Each valve is a thin, strong flap of tissue that acts like a one-way door. The valve between the right atrium and right ventricle is the **tricuspid valve.** The valve between the left atrium and left ventricle is the **bicuspid valve.** The **semilunar valves** are found between the ventricles and blood vessels.

What is the job of the valves? The valves open and close at different times to prevent blood from flowing backwards. Blood can pass freely into the ventricles from the atria. However, when the ventricles are filled, the tricuspid and bicuspid valves snap shut. Blood also flows easily from the ventricles into the blood vessels. When the ventricles relax, the semilunar valves snap shut.

Heartbeat

Your heart is a hardworking muscle that is pumping blood all the time. The pumping rhythm of your heart is called your heartbeat. Have you ever listened to your heartbeat?

If you could listen to your heartbeat through a stethoscope (STETH-uh-skohp), you would hear a lub-dup sound with a steady rhythm. What causes the sound of your heartbeat? The lub-dup sounds you hear are the sounds of the heart valves closing. When the tricuspid and bicuspid valves snap shut, the "lub" sound is heard. When the semilunar valves snap shut, the "dup" sound is heard.

Sometimes, a heart valve is damaged and blood flows backwards. The backward flow of blood causes a swishing sound, called a heart murmur. If a lub-swish-dup sound is heard through a stethoscope, which valves are not closing properly?

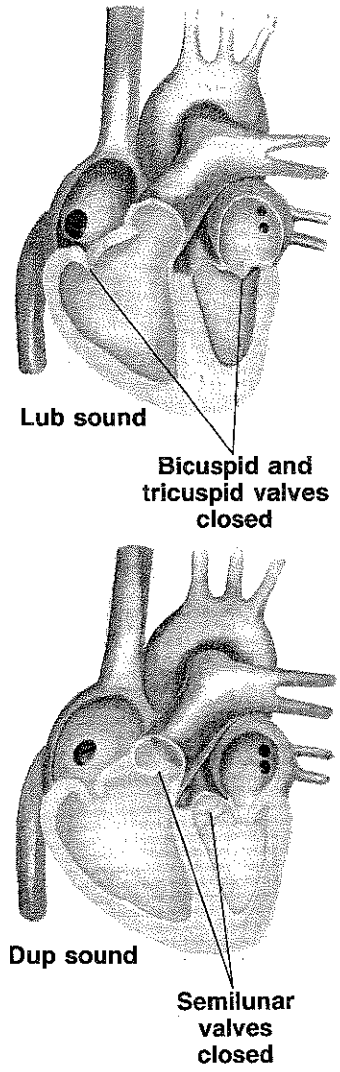


Figure 22-2 The closing of the heart valves causes the lub-dup sounds of a heartbeat.

Blood Vessels

Your circulatory system has three kinds of blood vessels. The **arteries** (ART-uhr-ees) are blood vessels that carry blood away from the heart. The **veins** are blood vessels that carry blood to the heart. Both arteries and veins have many smaller branches. The smallest branches of arteries and veins are connected by **capillaries** (KAP-uh-ler-ees). You can see the relationship among arteries, capillaries, and veins in Figure 22-3.

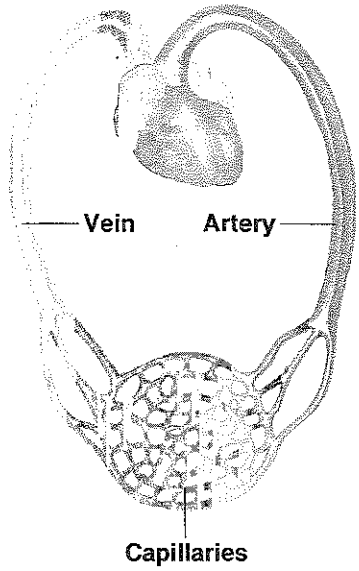


Figure 22-3 Arteries and veins are connected by tiny capillaries.

Arteries

Arteries have thick muscular walls that are both strong and elastic. Why is the structure of arteries important for their job? Think of what happens when you squeeze a tube of toothpaste. When you squeeze the tube, toothpaste moves through the tube under high pressure. As the toothpaste moves through the tube, the tube expands. Each time the heart beats, blood is pushed through the arteries under high pressure. Blood pressure is the force that blood exerts against the walls of a blood vessel. The elastic structure of arteries allows them to stretch as blood flows through. Their strong walls prevent blood pressure from bursting the arteries.

▶ Place your middle and index finger over the inside of your wrist. The beat you feel is your pulse. When you feel your pulse, you are feeling blood pressure against the walls of an artery. The blood pressure in an artery rises and falls with each beat of your heart. Therefore, your pulse rate and heartbeat rate are the same. How do you think strenuous exercise, such as running, would affect your pulse rate?

Study Hint

You may find it easy to remember that arteries carry blood away from the heart by associating the two words beginning with the letter "a": "artery" and "away."

Veins

As you can see in Figure 22-4, veins have thinner walls than arteries. They also are less muscular. By the time blood reaches the veins, it is under less pressure. Therefore, the veins do not need to be as muscular as arteries. Why do you think you cannot feel your pulse in a vein?

Because the blood in the veins is under low pressure, it does not flow through them as easily as it flows through your arteries. What keeps blood flowing through the veins

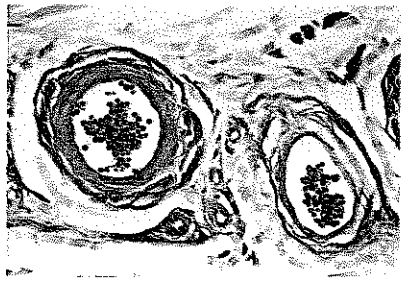


Figure 22-4 Compare the artery (left) with the vein (right).

to the heart? The contraction of skeletal muscles helps move the blood back to the heart. Also, like the heart, some veins have valves that prevent blood from flowing backward. Why do you think the valves in your leg veins are especially important?

Capillaries

Capillaries are microscopic blood vessels with walls that are only one cell thick. Because capillaries are so narrow, red blood cells must move through them in single file. Every substance carried by the blood is exchanged with body cells through the capillary walls. For example, food and oxygen diffuse out of the blood through the capillary wall and into the body cells. Carbon dioxide and other waste products diffuse out of the body cells into the blood through the capillary wall.

Circulatory System Problems

Problems of the circulatory system are among the leading causes of death in the United States. These problems are most common in older people, but the problems often develop gradually over a lifetime. Therefore, it is important for you to know about circulatory system problems and how they might be prevented.

Health and Safety Tip

It is important to have your blood pressure checked at least once a year.

Figure 22-5 Having your blood pressure checked is a simple procedure.

High Blood Pressure

Have you ever had your blood pressure measured? If so, you probably were told that your blood pressure was one number over another number. When your blood pressure is taken, two different measurements are made. The measurements are recorded as a fraction, for example, 120/80. The first number is a measurement of blood pressure in the arteries when the ventricles are contracting. The second number is a measurement of blood pressure in the arteries when the ventricles are relaxed. A blood pressure of 120/80 is normal for humans. A blood pressure reading above 140/90 is considered high. High blood pressure is a serious problem because it increases the risk of serious heart problems.

What causes high blood pressure? In many cases, the cause of high blood pressure is unknown. In other cases, high blood pressure is caused by a narrowing of the

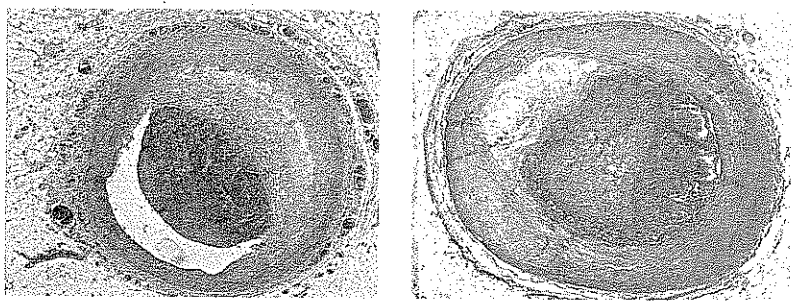


Figure 22-6 Notice the cholesterol buildup on these arteries. The artery on the left is partially blocked. The one on the right is almost completely blocked.

arteries. This is called hardening of the arteries. The arteries become narrow when cholesterol builds up on the walls of the arteries. Cholesterol is a fatty substance found in meats and other foods that come from animals. When the arteries become narrow, there is less room for blood to flow through. As a result, blood exerts a greater pressure on the artery walls.

Heart Attack

Like other body tissues, heart muscle needs a certain amount of blood to stay alive. A narrowed artery blocks the flow of blood to part of the heart. As a result, the part of the heart that does not receive enough blood begins to die. This is called a heart attack. Studies show, however, that lowering blood pressure and cholesterol levels can reduce your risk of a heart attack.

What are some of the signs of a heart attack? Signs of a heart attack include uncomfortable pressure or pain in the center of the chest. This pain sometimes spreads to the left shoulder and arm. Sweating, dizziness, nausea, fainting, or shortness of breath also may occur. Anyone suffering from the signs of a heart attack should be taken to a hospital immediately.

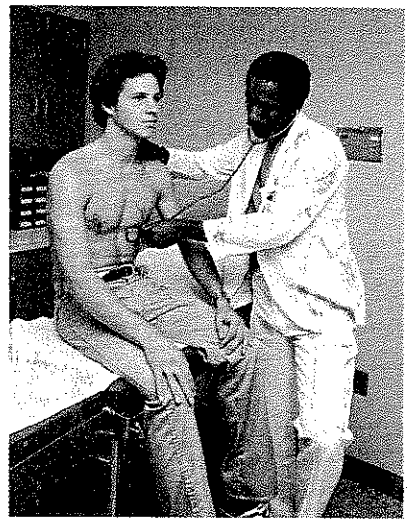


Figure 22-7 A doctor can detect many early signs of circulatory problems.

Think & Discuss

1. What is the function of the bicuspid valve?
2. What is the function of the ventricles?
3. Compare and contrast arteries, veins, and capillaries.
4. What causes a heart attack?
5. ★ Describe the heartbeat sound a doctor would hear if the patient had a defective semilunar valve.

22-2 Circulation

The time is the early seventeenth century. You are working in the office of Dr. William Harvey, an English physician. Dr. Harvey is studying the human circulatory system. He asks you, "If the ventricles of the heart are separated by a wall without any holes and the veins have valves, how could blood travel throughout the body?" How would you answer Dr. Harvey?

Using his knowledge of the structure of the heart and the function of the valves, Dr. Harvey hypothesized that blood flowed in a circular motion. He was the first scientist to show that the heart and blood vessels form a continuous closed system through which blood circulates. Dr. Harvey came to these conclusions by studying the human heart and the circulatory systems of live animals. From his studies of live animals, Harvey inferred that blood circulates through the human body in a closed system.

Today, biologists divide the circulatory system into two smaller systems of circulation. The pathway of the blood between the heart and the lungs is called **pulmonary** (PUL-muh-ner-ee) **circulation.** The pathway of blood between the heart and all other parts of the body is called **systemic circulation.**

Key Points

- Pulmonary circulation is the movement of blood from the heart to the lungs and then back to the heart.
- Systematic circulation is the movement of blood to all parts of the body, except the lungs.

Figure 22-8 Dr. William Harvey, the English physician, demonstrates his theory of the circulation of the blood to King Charles I.

Study Hint

The term "pulmonary" means related to or associated with the lungs.

Pulmonary Circulation

Your heart has a left side and a right side. Each side of the heart pumps blood to different places. Where does blood go from the right side of your heart? The right side of your heart pumps blood to your lungs. Use Figure 22-9 as a model as your read about pulmonary circulation.

Blood from the body enters the right atrium through veins. What does this blood contain? It carries a lot of carbon dioxide and very little oxygen. From the right atrium, blood passes into the right ventricle. The right ventricle pumps blood through the pulmonary artery. The pulmonary artery has two branches. One branch goes to each lung. In the lungs, the arteries divide many times to form a network of capillaries. In the lungs, the blood picks up oxygen and releases carbon dioxide. Then the blood, with its rich oxygen supply, is carried into the left atrium by the pulmonary veins. Through what blood vessels are oxygen and carbon dioxide exchanged?

Skill Builder

Sequencing *One way to organize information is to place events in sequence, or the order in which they take place. Trace the path of blood through the body in sequence, beginning and ending with the blood in the capillaries of the right big toe. Make sure that you mention all the kinds of blood vessels through which the blood passes.*

Systemic Circulation

Once blood gets a fresh supply of oxygen in the lungs, it is ready to be sent to body cells again. Blood passes from the left atrium into the left ventricle. The left ventricle pumps

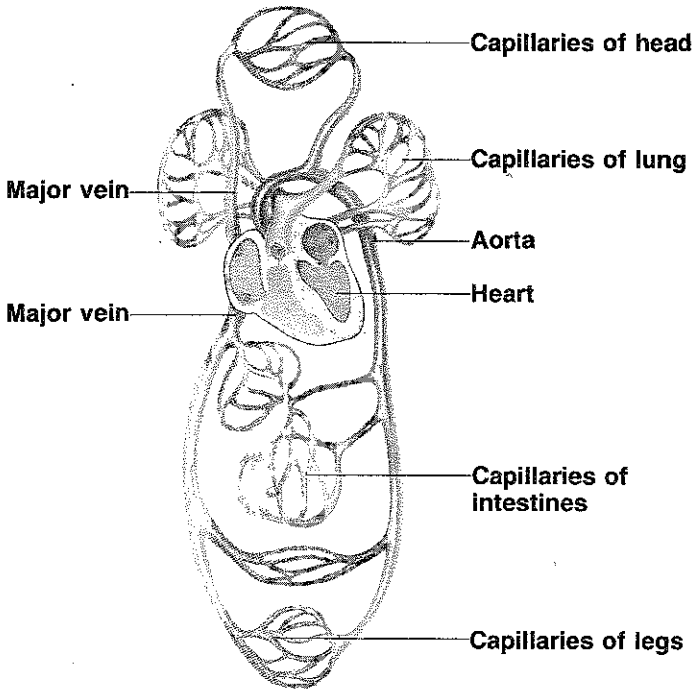


Figure 22-9 Trace the flow of blood in pulmonary and systemic circulation.

blood into the **aorta** (ay-OWR-tuh), the largest artery in the body. The aorta branches off into arteries, which carry blood to all parts of the body.

The names and functions of some of the main arteries of your body are listed in Table 22-1. Notice that branches from the coronary artery carry blood to the heart itself. After blood carries oxygen and food to your body cells, the blood returns to the heart. Where does the blood enter the heart?

Table 22-1 Major Arteries

ARTERY	CARRIES BLOOD TO:
Carotid artery	Neck and head
Femoral artery	Leg
Brachial artery	Arm
Renal artery	Kidneys
Coronary artery	Heart
Pulmonary artery	Lungs

Think & Discuss

6. What is the function of the aorta? Is the aorta involved in pulmonary circulation or systemic circulation?
7. Where does blood go from the pulmonary artery?
★ 8. What changes take place in the blood as it circulates?

22-3 Blood

Would you classify blood as a tissue? Do you think your blood is only a liquid? Actually, your blood is a tissue that is part liquid and part solid. The liquid part of blood is not made up of living material. However, the solid part of blood is made up of many living cells.

Besides transporting materials, blood also has other jobs. What other jobs does blood have? Blood helps regulate your body temperature. Blood also helps maintain the chemical balance in your body, and protects you against disease.

Key Points

- Red blood cells carry oxygen. White blood cells fight disease.
- The four major blood types are A, B, AB, and O.

Parts of the Blood

You have about 5 L of blood in your body. The liquid part of the blood is called **plasma** (PLAZ-muh). Plasma is a straw-colored liquid that is 90 percent water. Plasma carries dissolved vitamins, minerals, digested nutrients, wastes, and different kinds of proteins through the body. The plasma also has substances that are needed to keep the blood working properly. Floating in the plasma are the solid parts of blood.

Study Hint

After you read Section 22-3, Blood, list the parts of blood and the function of each part.

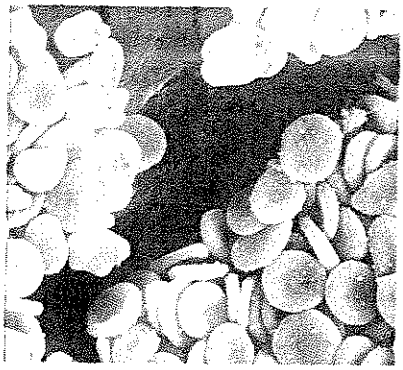


Figure 22-10 Notice the disklike shape of these red blood cells.

Red Blood Cells

Have you ever wondered why your blood is red? Blood gets its color from the 25 trillion **red blood cells** in it. The job of red blood cells is to carry oxygen. Their red color comes from a red, iron-containing molecule called **hemoglobin** (HEE-moh-gloh-bin). Hemoglobin is actually the part of a red blood cell that carries oxygen. Hemoglobin also carries some carbon dioxide away from body cells. Blood that is carrying oxygen is bright red. Blood that is carrying carbon dioxide is dark red. Your blood is never blue.

Look at the red blood cells in Figure 22-10. Do you notice anything unusual about them? Red blood cells do not have a nucleus or any cell parts. When red blood cells first form, they have all cell parts. However, as red blood cells mature, the part of the cell that contains the nucleus breaks apart. Therefore, a mature red blood cell is little more than a sac filled with cytoplasm and hemoglobin.

White Blood Cells

The cells that defend your body against disease are called **white blood cells.** White blood cells are almost colorless and do not have a definite shape. They are larger than red blood cells. You have far fewer white blood cells than red blood cells. In fact, you have only one white blood cell for every 1000 red blood cells.

Have you ever had a cut that became infected? An infection usually is caused by bacteria. The pus that forms around an infected cut is made up of dead white blood cells, bacteria, and tiny pieces of dead tissue.

Why does pus form around an infected cut? The formation of pus shows that your body is fighting the

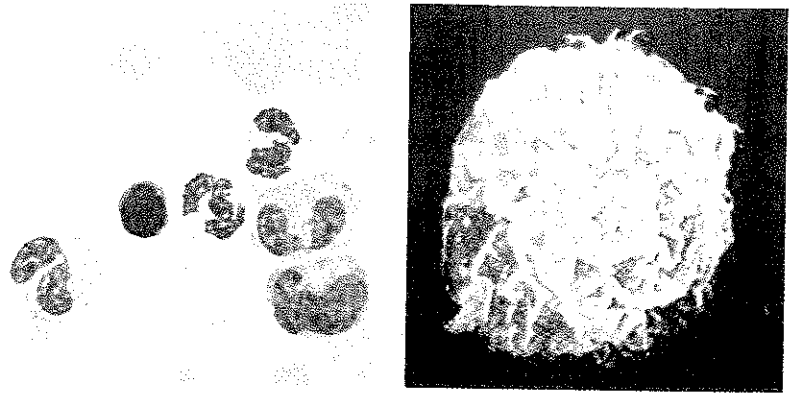


Figure 22-11 Phagocytes (left) and the macrophage (right) are two different kinds of white blood cells.

infection. When you cut yourself, your body goes to work fast. The number of white blood cells in your body increases quickly. White blood cells called phagocytes (FAG-uh-syts) squeeze through capillary walls and move through body tissue to the infected area. The phagocytes then surround bacteria and digest them. After a phagocyte digests many bacteria, the phagocyte dies and becomes part of the pus.

Other white blood cells fight infections by making **antibodies** (AN-ti-bahd-ees). Antibodies are proteins that circulate in plasma and protect the body from **antigens,** or foreign substances. Bacteria and viruses that invade the body are examples of antigens. Antibodies destroy antigens by binding, or joining, to them.

Platelets

Your body has an amazing ability to prevent blood loss as a result of an injury. This ability is called clotting. What controls clotting? Clotting is controlled by **platelets,** which are tiny colorless pieces of cells.

When you are injured and a blood vessel is broken, the injured cells send out chemical signals. The chemicals cause platelets to go to the injured area. The platelets then stick together and form a plug. The platelets also release chemicals, which cause proteins in the plasma to form a mesh over the cut. As you can see in Figure 22-12, platelets and red blood cells get trapped in the mesh, forming a blood clot. The clot acts like a plug, blocking the cut and preventing blood loss. The seal over a cut, or scab, is really a clot on the skin's surface. Predict what would happen if you cut yourself and your blood did not form clots.

Study Hint

The way phagocytes engulf and digest bacteria is similar to the way amoebas eat. Use the Index to find information about the way amoebas get food. Then review the process.

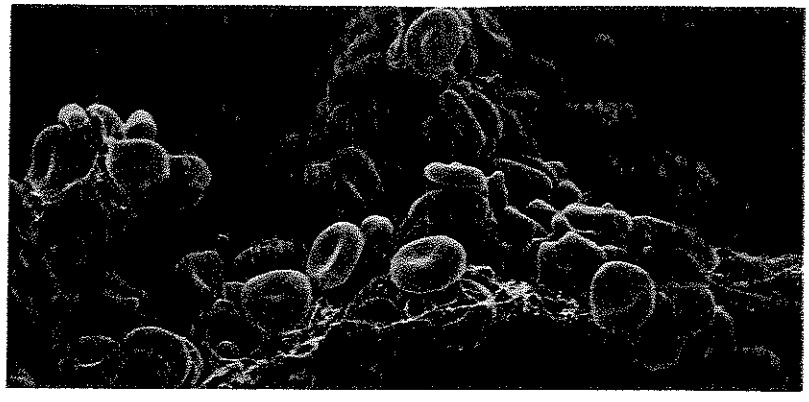


Figure 22-12 A threadlike mesh holds these red blood cells in a clot.

Table 22-2 Blood Types		
BLOOD TYPE	ANTIGEN	ANTIBODY IN BLOOD PLASMA
A	A	Anti-B
B	B	Anti-A
AB	AB	None
O	none	Anti-A and Anti-B

Blood Groups

Did you know that not everyone's blood is the same? In 1900, Karl Landsteiner, an American doctor, discovered that people have four main types of blood. The four main blood types are A, B, AB, and O.

How is blood type determined? Blood type depends on the presence or absence of certain proteins on the surface of red blood cells. These proteins are called antigens, because people build up antibodies against blood-type proteins that are not their own. Blood types are summarized in Table 22–2. Notice that type AB blood has no plasma antibodies and type O blood has no antigens.

If you lose a lot of blood, you may need a blood transfusion. It is very important that your doctor know your blood type before giving you a transfusion. Why? If certain blood types are mixed together, the antibodies and antigens join together and form clumps. For example, if type A blood is mixed with type B blood, anti-B forms clumps with antigen B and anti-A forms clumps with antigen A. The clumps can block blood vessels and lead to death.

Health and Safety Tip

You should know your blood type in case of emergency. Knowing your blood type and carrying the information in your wallet can be helpful to a doctor if you ever need a transfusion.

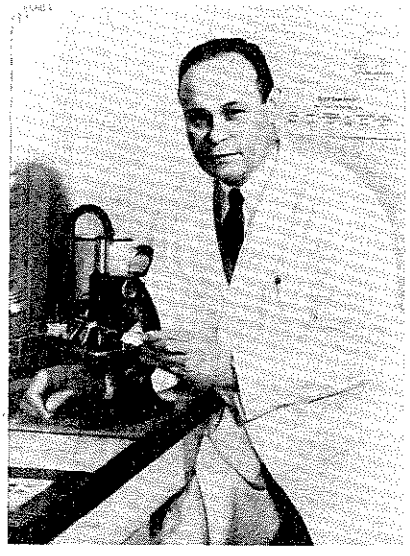


Figure 22-13 Dr. Charles Drew set up the first blood bank in the United States.

Blood Disorders

The blood is sometimes referred to as the "river of life." Similar to a river, blood streams through the body performing functions that are essential for life. However, sometimes problems occur in blood. These problems are called blood diseases or blood disorders.

Anemia

The most common blood disorder is called **anemia** (uh-NEE-mee-uh). Anemia is a blood disorder in which the blood cannot carry normal amounts of oxygen to body cells. This causes a person suffering from anemia to be tired, pale, and unable to tolerate cold.

What causes anemia? In some cases, anemia is caused by too few red blood cells. In other cases, enough red blood cells are present in the blood, but the red blood cells do not contain normal amounts of hemoglobin. You may remember that hemoglobin contains iron. People with low amounts of hemoglobin have an iron deficiency. Iron-deficiency anemia is especially common in teenage girls.

Anemia caused by too few red blood cells can be treated with vitamin B-12, which helps make red blood cells. Folic acid is another B vitamin that helps make red blood cells. Foods with a lot of iron, such as liver, lean meat, and leafy green vegetables also can help correct iron-deficiency anemia.

Leukemia

Cancer of the blood, or **leukemia** (loo-KEE-mee-uh), is a disease in which the body produces millions of abnormal immature white blood cells. Because the white blood cells are immature, they cannot carry out their job of fighting infection. These abnormal cells also interfere with the production of red blood cells.

What are the symptoms of leukemia? People with leukemia may have anemia, internal bleeding, and many infections. Why would a person with leukemia be likely to get many different infections?

In many cases, the cause of leukemia is not known. Some cases have been linked to exposure to radiation. Other cases may be caused by viruses. Leukemia often is treated with drugs, radiation therapy, or bone marrow transplants.

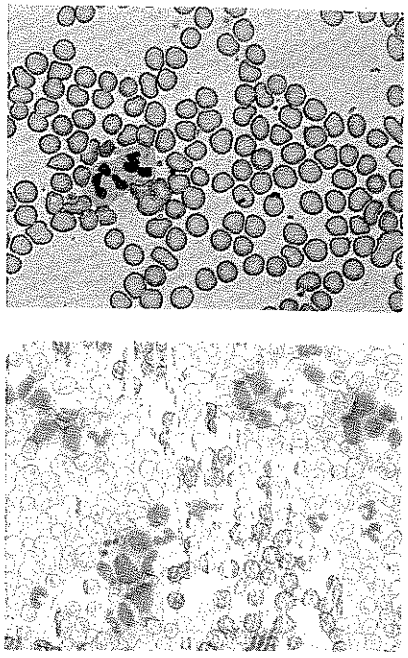


Figure 22-14 A healthy person has fewer white blood cells (top) than a person with leukemia (bottom).

Think & Discuss

9. What is the job of red blood cells?

10. What causes anemia?

11. What are three functions of the blood?

12. How do phagocytes fight disease?

★ **13.** Why do you think people with type O blood are referred to as universal blood donors?

22–4 The Lymphatic System

As blood flows through the capillaries, it loses fluid. Why? Pressure from the pumping heart forces plasma through the thin capillary walls. This fluid is called tissue fluid. Tissue fluid fills the spaces between and around all of your body cells.

Key Points

- The lymphatic system is made up of the lymph nodes and lymph vessels.
- Lymph nodes filter and clean lymph.

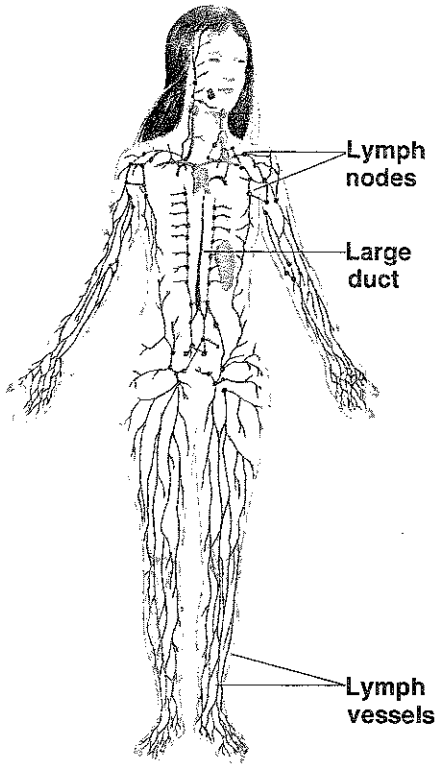


Figure 22-15 Lymph nodes are concentrated in the neck, armpits, and groin.

You may think that tissue fluid is the same as plasma, but it is not. Tissue fluid has a different chemical makeup from plasma because some of the substances in plasma cannot pass through the capillary walls. What substance do you think makes up most of tissue fluid?

Tissue fluid is needed for the exchange of materials between capillaries and cells. Why is tissue fluid important? Most of the substances in body tissues will not pass through a cell membrane unless they are dissolved in a fluid. For example, oxygen, carbon dioxide, nutrients, and wastes must dissolve in tissue fluid to pass between the capillaries and body cells.

Eventually, tissue fluid must be returned to the blood. A separate system of tubes returns tissue fluid to the blood. This system is called the lymphatic (lim-FAT-ik) system. You can see the lymphatic system in Figure 22–15. Once tissue fluid enters the lymphatic system, the fluid is called **lymph** (LIMF). All lymph vessels eventually carry lymph into two large ducts. The ducts empty into large veins in the upper chest.

Scattered along the tubes of the lymphatic system are small bean-shaped structures called **lymph nodes.** Your tonsils are lymph nodes. What is the function of lymph nodes? The lymph nodes clean and filter lymph before it is returned to the blood. The lymph nodes also produce white blood cells that fight disease. When you have an infection, the lymph nodes get bigger because they are producing more white blood cells.

Have you ever had swollen glands? Swollen glands are really enlarged, sore lymph nodes. Lymph nodes get swollen when lymph entering the lymph nodes has more bacteria than the white blood cells can kill. Then, the nodes become infected. If you have had your tonsils removed, it is probably because they became infected often. In addition to the tonsils, lymph tissue also is found in the adenoids, thymus gland, and spleen.

Study Hint

Use Figure 22-15 to locate the places where lymph nodes are most concentrated.

Think & Discuss

14. What is the function of the lymphatic system?

15. What is the function of lymph nodes?

16. What would happen if tissue fluid was not returned to the blood?

Chapter Review

CHAPTER SUMMARY

22–1 The Circulatory System

- The heart is divided into two sides, each with an atrium and a ventricle.
- The right side of the heart pumps blood to the lungs. The left side pumps blood to all other parts of the body.
- Arteries carry blood away from the heart. Veins carry blood to the heart.
- Capillaries connect arteries to veins.

22–2 Circulation

- In pulmonary circulation, blood from the right ventricle moves through the pulmonary artery to the lungs. Blood is carried back to the heart by pulmonary veins.
- In systemic circulation, blood is pumped from the left ventricle through the aorta to all parts of the body, except the lungs.

22–3 Blood

- Red blood cells carry oxygen to all parts of the body.
- White blood cells are larger than red blood cells, but fewer in number. White blood cells help to defend the body against disease.

22–4 The Lymphatic System

- Lymphatic vessels carry tissue fluid to large veins.
- Lymph nodes filter tissue fluid as it passes through them.

VOCABULARY LIST

anemia (390)
antibodies (389)
antigens (389)
aorta (387)
arteries (381)
atrium (378)
bicuspid valve (379)
capillaries (381)
circulation (377)
hemoglobin (388)
leukemia (391)
lymph (392)
lymph nodes (392)
plasma (387)
platelets (389)
pulmonary circulation (385)
red blood cells (388)
semilunar valves (379)
septum (378)
systemic circulation (385)
tricuspid valve (379)
veins (381)
ventricle (378)
white blood cells (388)

VOCABULARY REVIEW

Matching Write the word or term from the Vocabulary List that best matches each description.

1. vessels that carry blood to the heart veins
2. movement of blood throughout the body circulation
3. blood cells needed for clotting platelets
4. separates the right and left sides of the heart septum
5. vessels that connect arteries and veins capillaries
6. filter lymph lymph nodes
7. oxygen-carrying compound of red blood cells hemoglobin
8. located between the ventricles and arteries semilunar valves

Applying Definitions Explain the difference between the words in each pair.

Accept all logical answers.

1. atrium, ventricle
2. red blood cells, white blood cells
3. antibodies, antigens
4. arteries, veins
5. bicuspid valve, tricuspid valve
6. pulmonary circulation, systemic circulation
7. aorta, pulmonary vein
8. anemia, leukemia
9. plasma, lymph
10. pulse, heartbeat

CONTENT REVIEW

True or False Write true if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

1. The disease in which the body produces large numbers of abnormal white blood cells is leukemia. true
2. The smallest blood vessels in the body are arteries. capillaries
3. The liquid part of blood is plasma. true
4. The tricuspid valve is between the right atrium and the right ventricle. true
5. Blood returning from the body enters the right ventricle. atrium
6. The path of blood between the heart and all parts of the body except the lungs is called systemic circulation. true
7. Antibodies are produced by red blood cells. white
8. Blood returning to the heart carries a lot of oxygen. carbon dioxide
9. Fluid that surrounds body cells is called lymph. tissue fluid

Question and Answer Rewrite each heading in the Chapter Outline on page 376 as a question. Then, answer each of the questions you have written.

Interpreting a Table Use the information in Table 22–2 to answer each of the following.

1. What antibody is found in the plasma of blood type A? anti-B
2. What antigen is found in the plasma of blood type B? B
3. Which blood type can give blood to all other blood types? O
4. Which blood type can get blood from all other blood types? AB

CONCEPT REVIEW

For answers, see page T-123.

Writing the Main Ideas Using the Chapter Outline on page 376, write the main idea for each heading in the outline.

Critical Thinking Answer each of the following in complete sentences.

1. Why do you think infants have much higher heartbeat rates than adults?
2. What do you think would happen to a vein if blood entered the vein under the same pressure as blood enters an artery? Explain your answer.
3. Write a hypothesis stating what would happen if type O blood was mixed with type A blood.
4. The circulatory system is a closed system. Is the lymphatic system also a closed system? Explain your answer.
5. Why does untreated high blood pressure strain the heart?

EXTENSIONS

1. Some people suffer damage to their heart valves as a result of disease. Surgeons can replace a damaged valve with an artificial valve. Do research and write a report on heart valve replacement operations.
2. Interview a cardiologist to find out about coronary bypass surgery. Then write your findings in a report.
3. Doctors believe that regular, strenuous exercise over a period of time can increase the efficiency of the heart. Design an experiment that could confirm or disprove this idea. Use the pulse rate before and after exercise as a measure of heart efficiency. Remember to include a control group as part of the experiment.