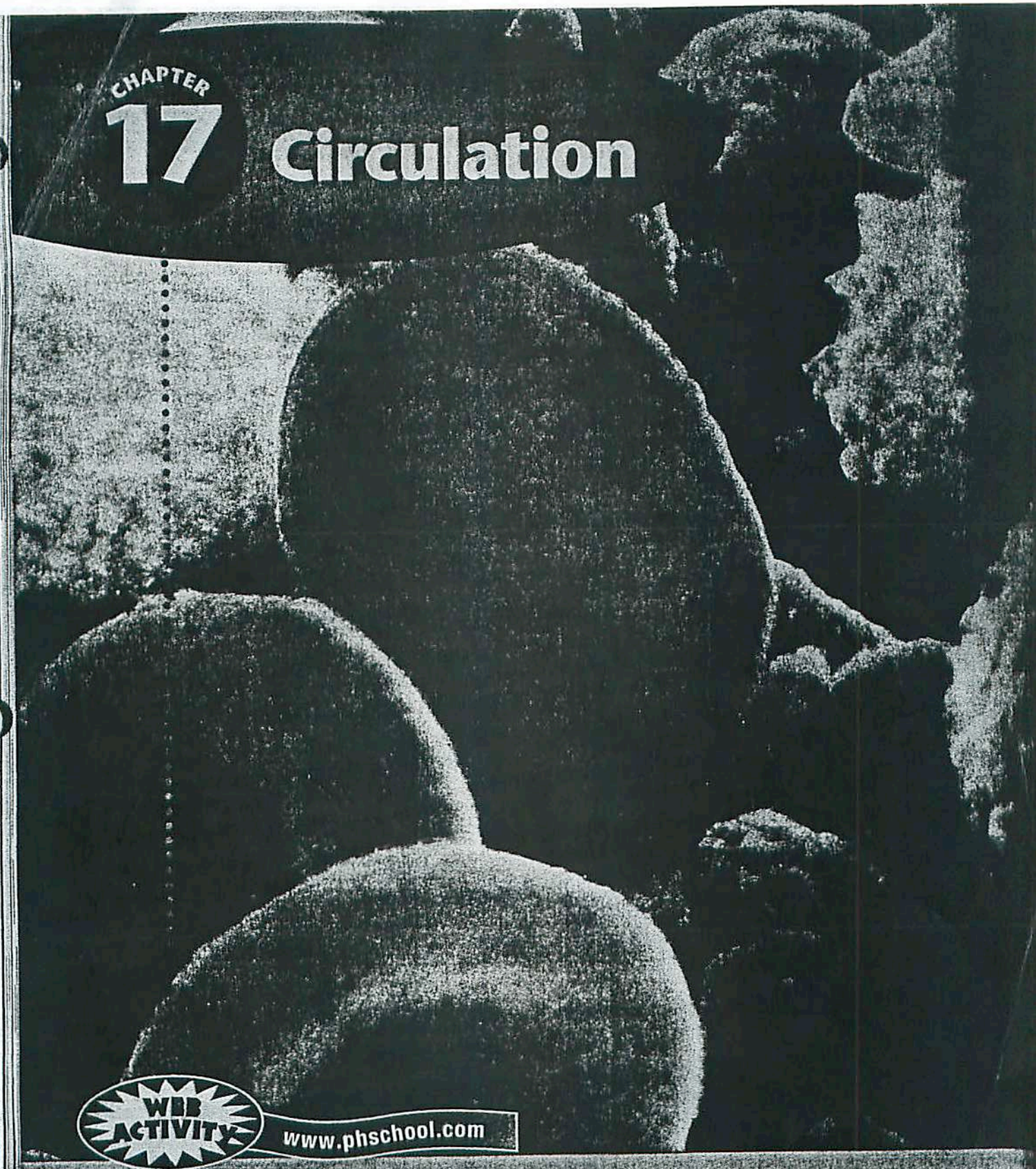
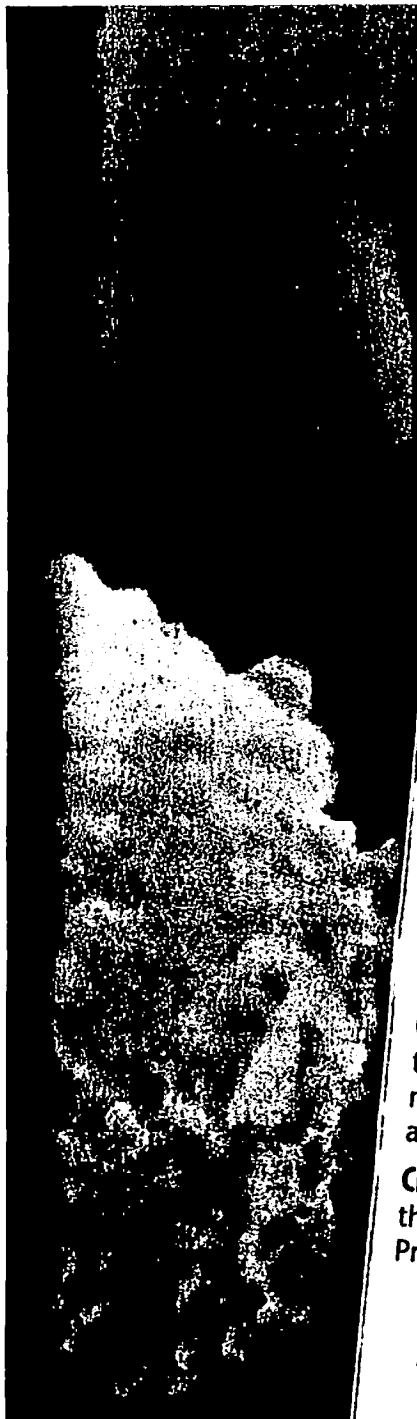


CHAPTER

17 Circulation

WEB ACTIVITY www.phschool.com

MC PIERRO



lood cells travel in
lood vessels to all
arts of the body.

CHAPTER 17 PROJECT

Travels of a Red Blood Cell

Every day, you travel from home to school and then back home again. Your path makes a loop, or circuit, ending where it began. In this chapter, you'll learn how your blood also travels in circuits. You'll find out how your heart pumps your blood throughout your body, bringing that essential fluid to all your living cells. As you learn more about the heart and circulatory system, you'll create a display to show how blood circulates throughout the body.

Your Goal To design and construct a display showing a complete journey of a red blood cell through the human body.

To complete the project successfully, your display must

- show a red blood cell that leaves from the heart and returns to the same place
- show where the red blood cell picks up and delivers oxygen and carbon dioxide
- provide written descriptions of the circuits made by the red blood cell, either with captions or in a continuous story
- be designed following the safety guidelines in Appendix A

Get Started Look ahead at the diagrams in the chapter. Then discuss the kinds of displays you could use, including a three-dimensional model, posters, a series of drawings, a flip-book, or a video animation. Write down any content questions you'll need to answer.

Check Your Progress You'll be working on this project as you study this chapter. To keep your project on track, look for Check Your Progress boxes at the following points.

Section 1 Review, page 542: Make a sketch of your display.
Section 2 Review, page 547: Begin to construct your display.
Section 3 Review, page 554: Add a written description to your display.

Present Your Project At the end of the chapter (page 563), you will use your display to show how blood travels through the body.

SECTION 1

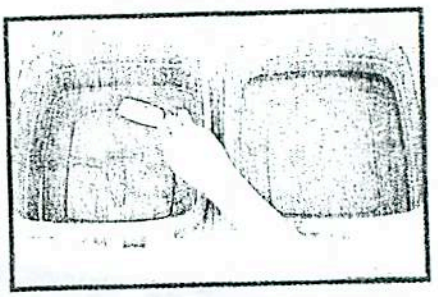
The Body's Transportation System

DISCOVER ACTIVITY

How Hard Does Your Heart Work?

1. Every minute, your heart beats about 75 to 85 times. With each beat, it pumps about 60 milliliters of blood. Can you work as hard and fast as your heart does?
2. Cover a table or desk with newspapers. Place two large plastic containers side by side on the newspapers. Fill one with 2.5 liters of water, which is about the volume of blood that your heart pumps in 30 seconds. Leave the other container empty.
3. With a plastic cup that holds about 60 milliliters, transfer water as quickly as possible into the empty container without spilling any. Have a partner time you for 30 seconds. As you work, count how many transfers you make in 30 seconds.
4. Multiply your results by 2 to find the number of transfers for one minute.

Inferring Compare your performance with the number of times your heart beats every minute. What do your results tell you about the strength and speed of a heartbeat?



GUIDE FOR READING

- What is the function of the cardiovascular system?
- What role does the heart play in the cardiovascular system?
- What path does blood take through the circulatory system?

Reading Tip As you read, create a flowchart that shows the path that blood follows as it circulates through the body.

In the middle of the night, a truck rolls rapidly through the darkness. Loaded with fresh fruits and vegetables, the truck is headed for a city supermarket. The driver steers off the interstate and onto a smaller highway. Finally, after driving through narrow city streets, the truck reaches its destination. As dawn begins to break, store workers unload the cargo. They work quickly, because other trucks—carrying meats, canned goods, and freshly baked breads—are waiting to be unloaded. And while workers fill the store with products to be sold, a garbage truck removes yesterday's trash. All these trucks have traveled long distances over roads. Without a huge network of roads, big and small, the supermarket couldn't stay in business.

Like the roads that link all parts of the country, your body has a "highway" network, called the cardiovascular system, that links all parts of your body. The **cardiovascular system,** or circulatory system, consists of the heart, blood vessels, and blood. The **cardiovascular system carries needed substances to cells and carries waste products away from cells.** In addition, blood contains cells that fight disease.

Needed Materials Most substances that need to get from one part of the body to another are carried by blood. For example, blood carries oxygen from your lungs to your body cells. Blood also transports the glucose your cells use to produce energy.

Waste Products The cardiovascular system also picks up wastes from cells. For example, when cells use glucose, they produce carbon dioxide as a waste product. The carbon dioxide passes from the cells into the blood. The cardiovascular system then carries carbon dioxide to the lungs, where it is exhaled.

Disease Fighters The cardiovascular system also transports cells that attack disease-causing microorganisms. This process can keep you from becoming sick. If you do get sick, these disease-fighting blood cells will kill the microorganisms to help you get well.

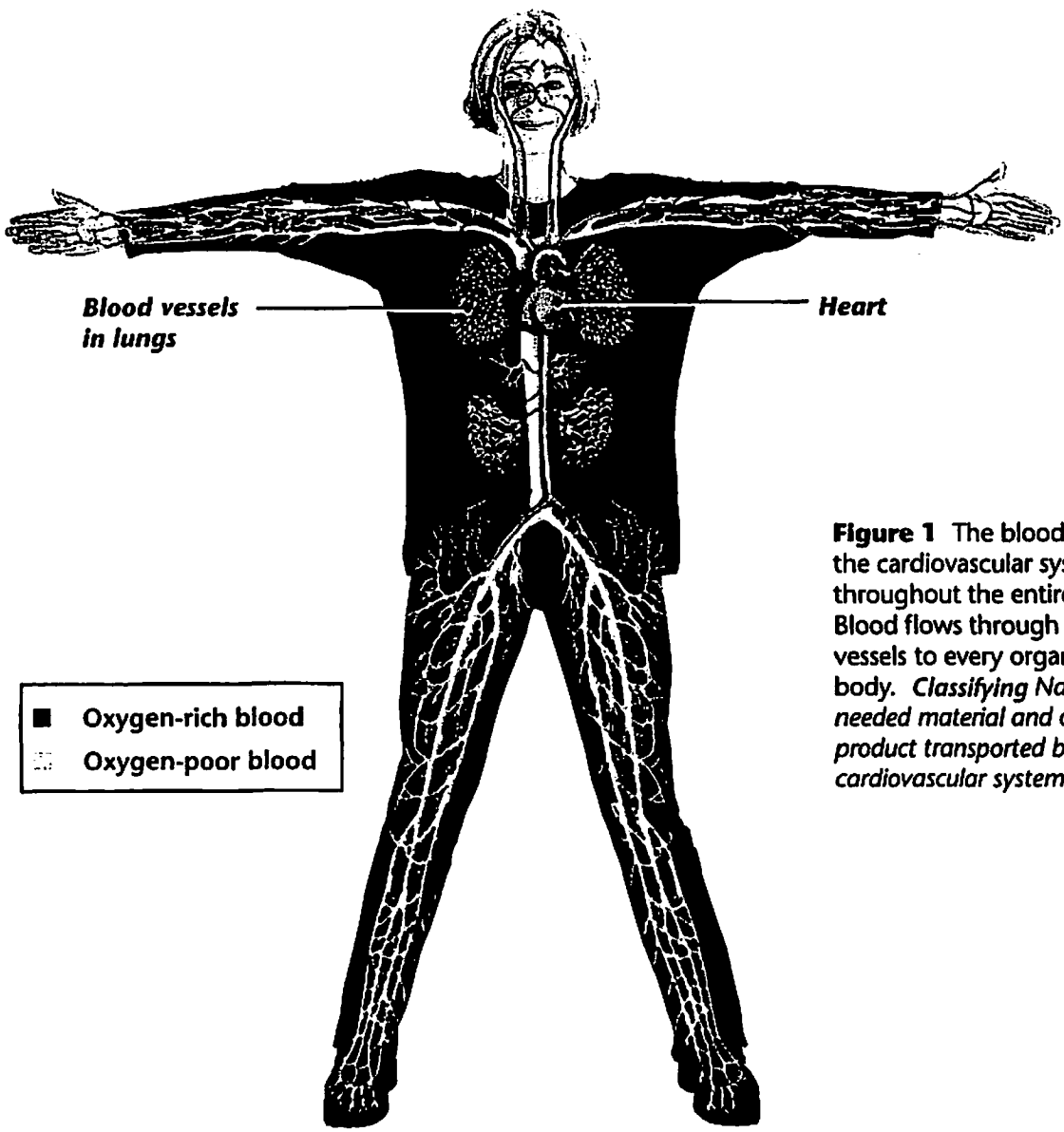


Figure 1 The blood vessels of the cardiovascular system reach throughout the entire body. Blood flows through these vessels to every organ in the body. *Classifying Name one needed material and one waste product transported by the cardiovascular system.*

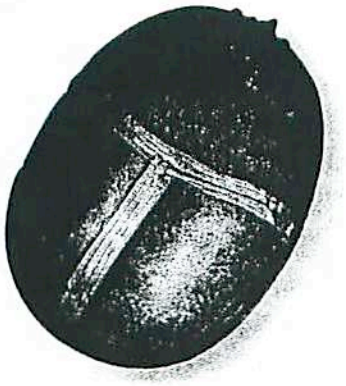


Figure 2 This small stone sculpture, created by ancient Egyptians, represents the heart. Ancient Egyptians believed that feelings, thoughts, and memories were created by the heart.

The Heart

Without the heart, blood wouldn't go anywhere. The **heart** is a hollow, muscular organ that pumps blood throughout the body. Your heart, which is about the size of your fist, is located in the center of your chest. The heart lies behind the breastbone and inside the ribs. These bones protect the heart from injury.

Each time the heart beats, it pushes blood through the blood vessels of the cardiovascular system. As you learned in Chapter 15, the heart is made of cardiac muscle, which can contract over and over without getting tired. The heart beats continually throughout a person's life, resting only between beats. During your lifetime, your heart may beat over 3 billion times. In a year, it pumps enough blood to fill over 30 competition-size swimming pools.

The Heart's Structure Look closely at *Exploring the Heart* as you read about the structure of the heart. Notice that the heart has two sides—a right side and a left side—completely separated from each other by a wall of tissue. Each side has two compartments, or chambers—an upper and a lower chamber. The two upper chambers, each called an **atrium** (AY tree um) (plural *atria*), receive blood that comes into the heart. The two lower chambers, each called a **ventricle,** pump blood out of the heart. The atria are separated from the ventricles by valves. A **valve** is a flap of tissue that prevents blood from flowing backward. Valves are also located between the ventricles and the large blood vessels that carry blood away from the heart.

How the Heart Works The action of the heart has two main phases. In one phase, the heart muscle relaxes and the atria fill with blood. In the other phase, the atria contract and fill the ventricles, and then the ventricles contract to pump blood forward. The sound of a heartbeat, which sounds something like *lub-dup,* is made during this pumping phase.

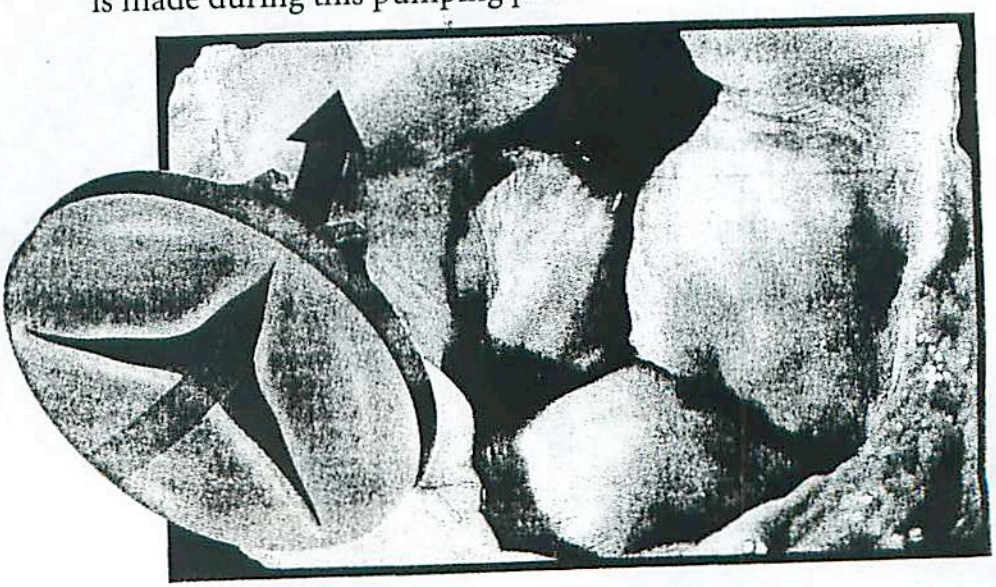


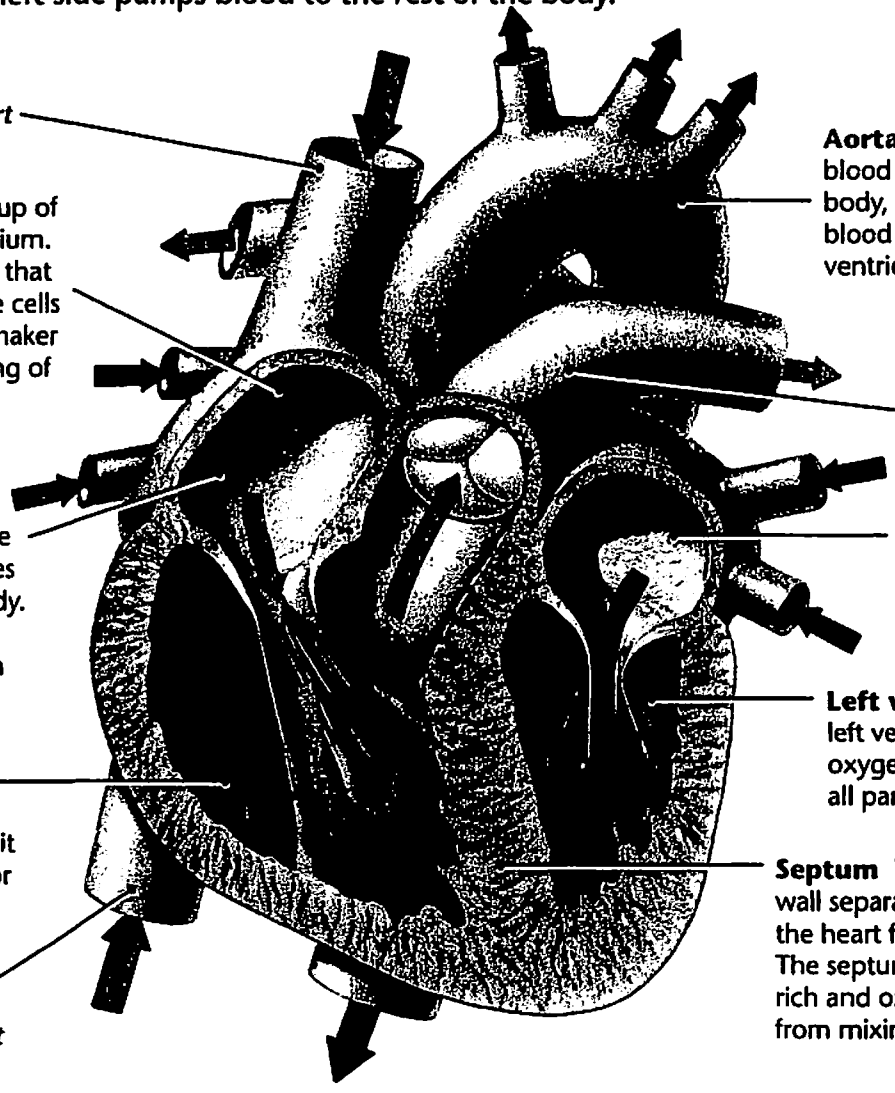
Figure 3 As blood flows out of the heart and toward the lungs, it passes through the valve shown in the photograph. The illustration shows how blood flows through the open valve.
Applying Concepts What is the function of the valves in the heart?

When the heart muscle relaxes, blood flows into the chambers. Then the atria contract. This muscle contraction squeezes blood out of the atria, through the valves, and then into the ventricles. Next the ventricles contract. This contraction closes the valves between the atria and ventricles, making the *lub* sound and squeezing blood into large blood vessels. As the valves between the ventricles and the blood vessels snap shut, they make the *dup* sound. All of this happens in less than a second.

Checkpoint *Contrast the functions of atria and ventricles.*

EXPLORING *the Heart*

very second of your life, your heart pumps blood through your body. The right side of the heart pumps blood to the lungs, while the left side pumps blood to the rest of the body.



Major vein from upper body to heart

Pacemaker The pacemaker is a group of cells in the right atrium. By sending a signal that makes heart muscle cells contract, the pacemaker regulates the beating of the heart.

Right atrium The right atrium receives blood from the body. The blood is low in oxygen and high in the waste product carbon dioxide.

Right ventricle When the right ventricle contracts, it pumps oxygen-poor blood to the lungs.

Major vein from lower body to heart

Aorta The largest blood vessel in the body, the aorta carries blood from the left ventricle to the body.

Artery from heart to lungs

Left atrium Oxygen-rich blood moves from the lungs into the left atrium.

Left ventricle The left ventricle pumps oxygen-rich blood to all parts of the body.

Septum This thick muscular wall separates the left side of the heart from the right side. The septum prevents oxygen-rich and oxygen-poor blood from mixing in the heart.

Arts CONNECTION

When you say that a person has a "heart of gold," you mean that the person is kind and generous—not that the person's heart is actually made of gold metal. "Heart of gold" is an idiom—an expression with a meaning that cannot be understood from the ordinary meanings of the words in it. The words *heart* and *blood* are found in many idioms. For example, a "blood-chilling scream" frightens you, but it doesn't lower the temperature of your blood.

In Your Journal

Learn what each of the following idioms means:

- a change of heart
- a heart-to-heart talk
- make the blood boil

Then write a sentence using each of these idioms.

A group of cells called the **pacemaker,** which is located in the right atrium, sends out signals that make the heart muscle contract. The pacemaker constantly receives messages about the body's oxygen needs. It then adjusts the heart rate to match. Your heart beats much faster when you are exercising than when you are sitting quietly. When you are exercising, the entire process from the beginning of one heartbeat to the beginning of the next can take less than half a second. Your muscles need more oxygen during exercise. Your rapid heartbeat supplies blood that carries the oxygen.

INTEGRATING TECHNOLOGY In some people, the pacemaker becomes damaged as a result of disease or an accident. This often results in an irregular or slow heartbeat. In the 1950s, doctors and engineers developed an artificial, battery-operated pacemaker. The artificial pacemaker is implanted beneath the skin and connected by wires to the heart. Tiny electric impulses travel from the battery through the wires. These impulses make the heart contract at a normal rate.

Checkpoint *What is the function of the pacemaker?*

After leaving the heart, blood travels in blood vessels through the body. Your body has three kinds of blood vessels—arteries, capillaries, and veins. **Arteries** are blood vessels that carry blood away from the heart. From the arteries, blood flows into tiny vessels called **capillaries.** In the capillaries, substances are exchanged between the blood and body cells. From capillaries, blood flows into **veins,** which are the vessels that carry blood back to the heart.

The overall pattern of blood flow through the body is something like a figure eight. The heart is at the center where the two

Figure 4 Activities such as swimming require a lot of energy. A person's heart beats fast in order to supply the muscles with the blood they need. The heart's pacemaker regulates the speed at which the heart beats.

loops cross. **In the first loop, blood travels from the heart to the lungs and then back to the heart. In the second loop, blood is pumped from the heart throughout the body and then returns again to the heart.** The heart is really two pumps, one on the right and one on the left. The right side pumps blood to the lungs, and the left side pumps blood to the rest of the body.

Blood travels in only one direction. If you were a drop of blood, you could start at any point in the figure eight and eventually return to the same point. The entire trip would take less than a minute. As you read about the path that blood takes through the cardiovascular system, trace the path in Figure 5.

Loop One: to the Lungs and Back When blood from the body flows into the right atrium, it contains little oxygen but a lot of carbon dioxide. This oxygen-poor blood is dark red. The blood then flows from the right atrium into the right ventricle. Then the ventricle pumps blood into the arteries that lead to the lungs.

As blood flows through the lungs, large blood vessels branch into smaller ones. Eventually, blood flows through tiny capillaries that are in close contact with the air that comes into the lungs. The air in the lungs has more oxygen than the blood in the capillaries, so oxygen moves from the lung into the blood. In contrast, carbon dioxide moves in the opposite direction—from the blood into the lung. As the blood leaves the lungs, it is now rich in oxygen and poor in carbon dioxide. This blood, which is bright red, flows to the left side of the heart to be pumped through the second loop.

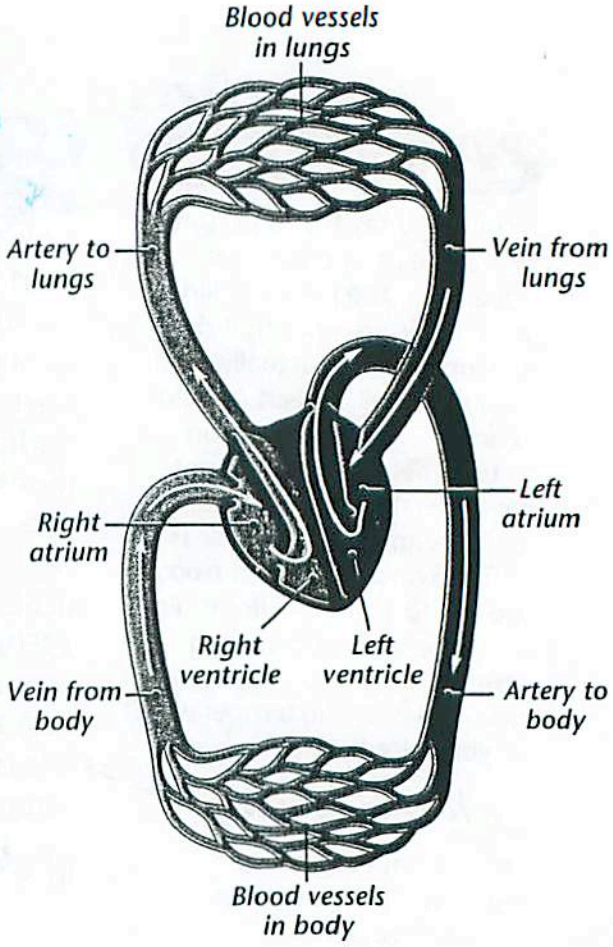
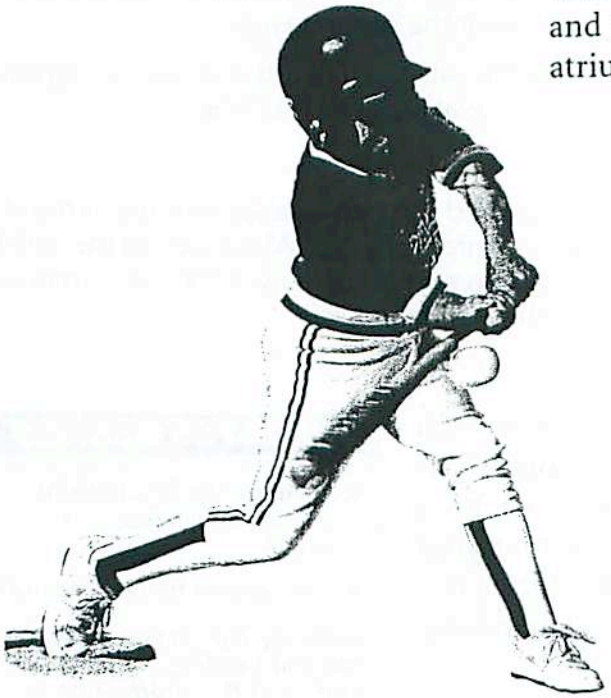


Figure 5 Blood circulates through the body in two loops with the heart at the center. Use the arrows to trace the path of blood, beginning at the right atrium. *Interpreting Diagrams Where does the blood that enters the left atrium come from?*

Loop Two: to the Body and Back The second loop begins as the left atrium fills with oxygen-rich blood coming from the lungs. The blood then moves into the left ventricle. From the left ventricle, the blood is pumped into the **aorta** (ay AWR tuh), the largest artery in the body.

Eventually, after passing through branching arteries, blood flows through tiny capillaries in different parts of your body, such as your brain, liver, and legs. These vessels are in close contact with body cells. Oxygen moves out of the blood and into the body cells. At the same time, carbon dioxide passes from the body cells and into the blood. The blood then flows back to the right atrium of the heart through veins, completing the second loop.

Figure 6 If the batter hits the ball, the bat will exert a force on the ball. This force will make the ball zoom through the air. Similarly, when the ventricles of the heart contract, they exert a force on the blood inside them. This force pushes blood through the blood vessels.



The Force of the Ventricles

Integrating Physics

When the ventricle muscles contract, they exert a force on the blood that is inside them. A **force** is a push or a pull. You see examples of forces all around you. When you lift a book off a table, for example, you exert a force on the book, making it move upward. The force exerted by the ventricles moves blood out of your heart and into arteries.

The contraction of the left ventricle exerts much more force than the contraction of the right ventricle. The right ventricle only pumps blood to the lungs. In contrast, the left ventricle pumps blood throughout the body. As a way of understanding this, think of the force it would take to bunt a baseball. Then think about how hard you would need to hit the ball if you wanted to hit a home run.

Section 1 Review

1. What is the function of the cardiovascular system?
2. What function does the heart perform?
3. Describe the route that blood takes through the cardiovascular system. Begin with blood leaving the left ventricle.
4. What is the heart's pacemaker? What causes the pacemaker to change the rate at which the heart beats?
5. **Thinking Critically Comparing and Contrasting** Most of the arteries in the body carry oxygen-rich blood away from the heart. One artery, however, carries blood that has little oxygen away from the heart. From which ventricle does that artery carry blood? To where does that artery carry blood?

CHAPTER PROJECT

Check Your Progress

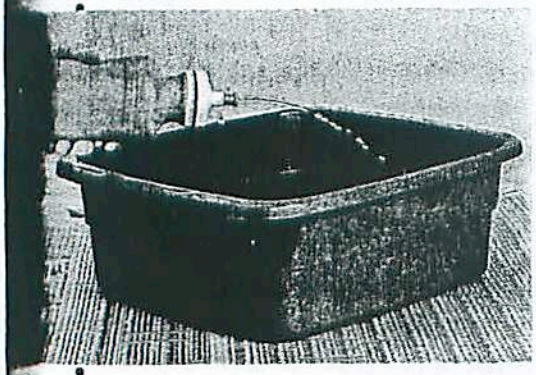
At this point, you should have sketched out the two loops your red blood cell will travel. Make sure each pathway forms a complete circuit back to the heart. Begin to plan how you will construct your display. Keep a running list of the materials or equipment you'll need. *(Hint:* Think about how you will show the movement of the blood cell in your display.)

SECTION 2

A Closer Look at Blood Vessels

DISCOVER ACTIVITY

How Does Pressure Affect the Flow of Blood?



1. Spread newspapers over a table or desktop. Then fill a plastic squeeze bottle with water.
2. Hold the bottle over a dishpan. Squeeze the bottle with one hand. Observe how far the water travels.
3. Now grasp the bottle with both hands and squeeze again. Observe how far the water travels this time.

Think It Over

Inferring Blood is pushed through arteries with much more force than it is pushed through veins. Which part of the activity models an artery? Which part models a vein? Which organ in the body provides the pushing force?

GUIDE FOR READING

- **What are the functions of arteries, capillaries, and veins?**
- **What causes blood pressure?**

Reading Tip **As you read, use the text headings to make an outline of the information in this section.**

Like corridors in a large building, blood vessels run through all of the tissues of your body. While some blood vessels are as wide as your thumb, most of them are much finer than a human hair. If all the arteries, capillaries, and veins in your body were hooked together, end to end, they would stretch a distance of almost 100,000 kilometers. That's long enough to wrap around Earth twice—with a lot left over!

Arteries

When blood leaves the heart, it travels through arteries. The right ventricle pumps blood into the arteries that go to the lungs. The left ventricle pumps blood into the aorta, the largest artery in your body. Every organ receives blood from arteries that branch off the aorta. The first branches, called the **coronary arteries,** carry blood to the heart itself. Other branches carry blood to the brain, intestines, and other organs. Each artery branches into smaller and smaller arteries.

Artery Structure The walls of arteries are generally very thick. In fact, artery walls consist of three layers. The innermost layer, which is made up of epithelial

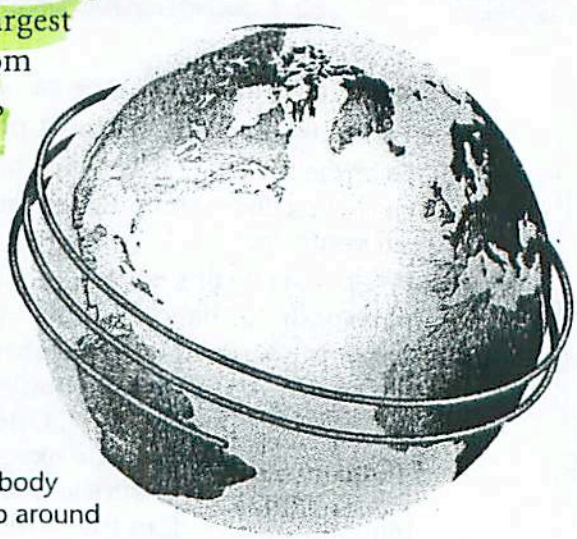
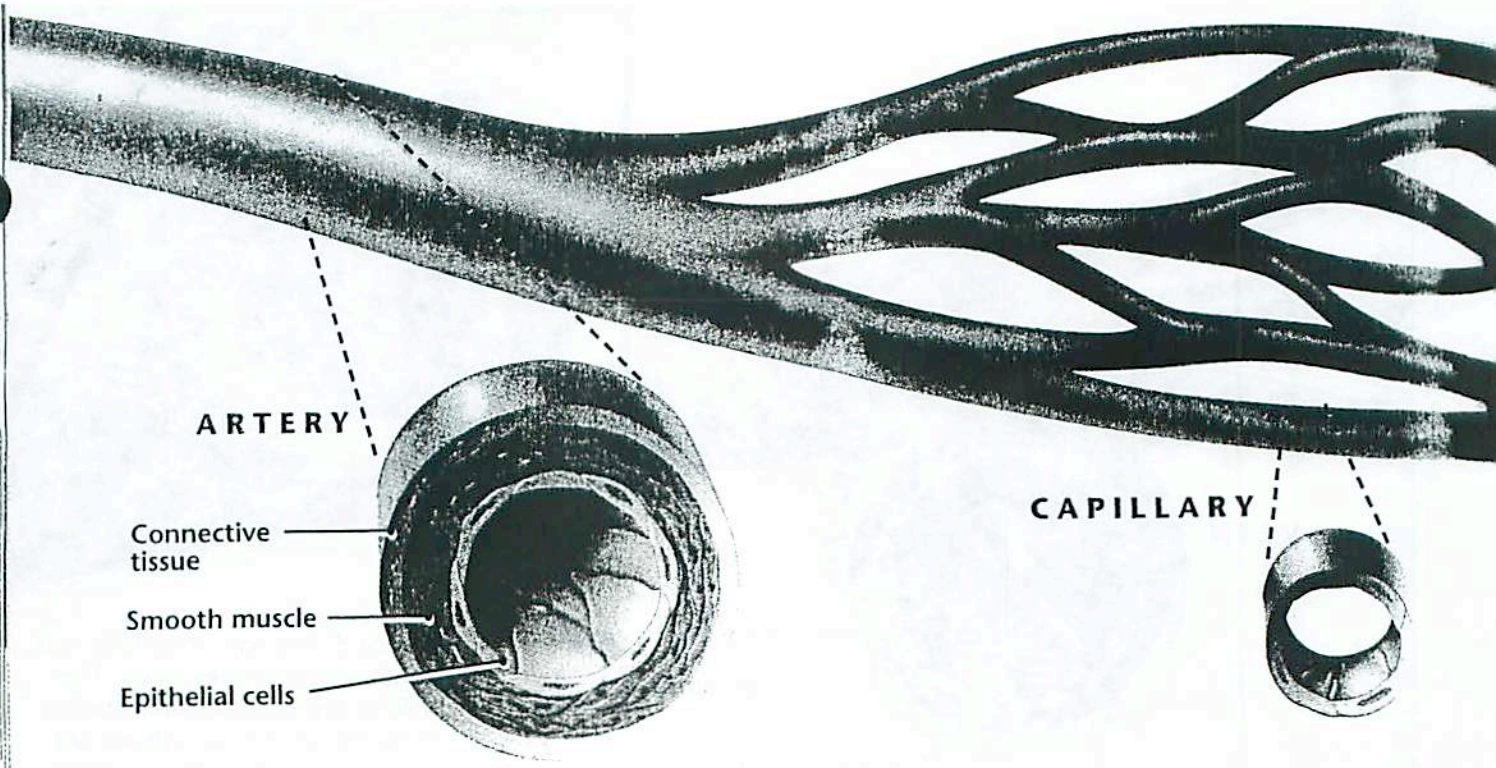


Figure 7 If all the blood vessels in your body were joined end to end, they would wrap around the world almost two and a half times.



tissue, is smoc This smooth surface enables blood to flow freely. The middle layer consists mostly of muscle tissue. The outer wall is made up of flexible connective tissue. Because of this layered structure, arteries have both strength and flexibility. Arteries are able to withstand the enormous pressure of blood pumped by the heart, and to expand and relax in response to that pumping.

Pulse If you lightly touch the inside of your wrist, you can feel the artery in your wrist rise and fall repeatedly. The pulse that you feel is caused by the alternating expansion and relaxation of the artery wall. Every time the heart's ventricles contract, they send a spurt of blood out through all the arteries in your body. As this spurt travels through the arteries, it pushes the artery walls and makes them expand. After the spurt passes, the artery walls become narrower again. When you count the number of times an artery pulses beneath your fingers, you are counting heartbeats. By taking your pulse rate, you can determine how fast your heart is beating.

Regulating Blood Flow The muscles in the middle wall of an artery are involuntary muscles, which contract without you thinking about it. When they contract, the opening in the artery becomes smaller. When they relax, the opening becomes larger. These muscles act control gates, adjusting the amount of blood sent to different organs. For example, after you eat, your stomach

Math TOOLBOX

Pulse Rate

A rate is the speed at which something happens. When you calculate a rate, you compare the number of events with the time period in which they occur. Here is how you can calculate the pulse rate of a person whose heart beats 142 times in 2 minutes.

1. Write the comparison as a fraction.

$$\frac{142 \text{ heartbeats}}{2 \text{ minutes}}$$

2. Divide the numerator and the denominator by the denominator.

$$\frac{142 \div 2}{2 \div 2} = \frac{71}{1}$$

The person's pulse rate is 71 heartbeats per minute.

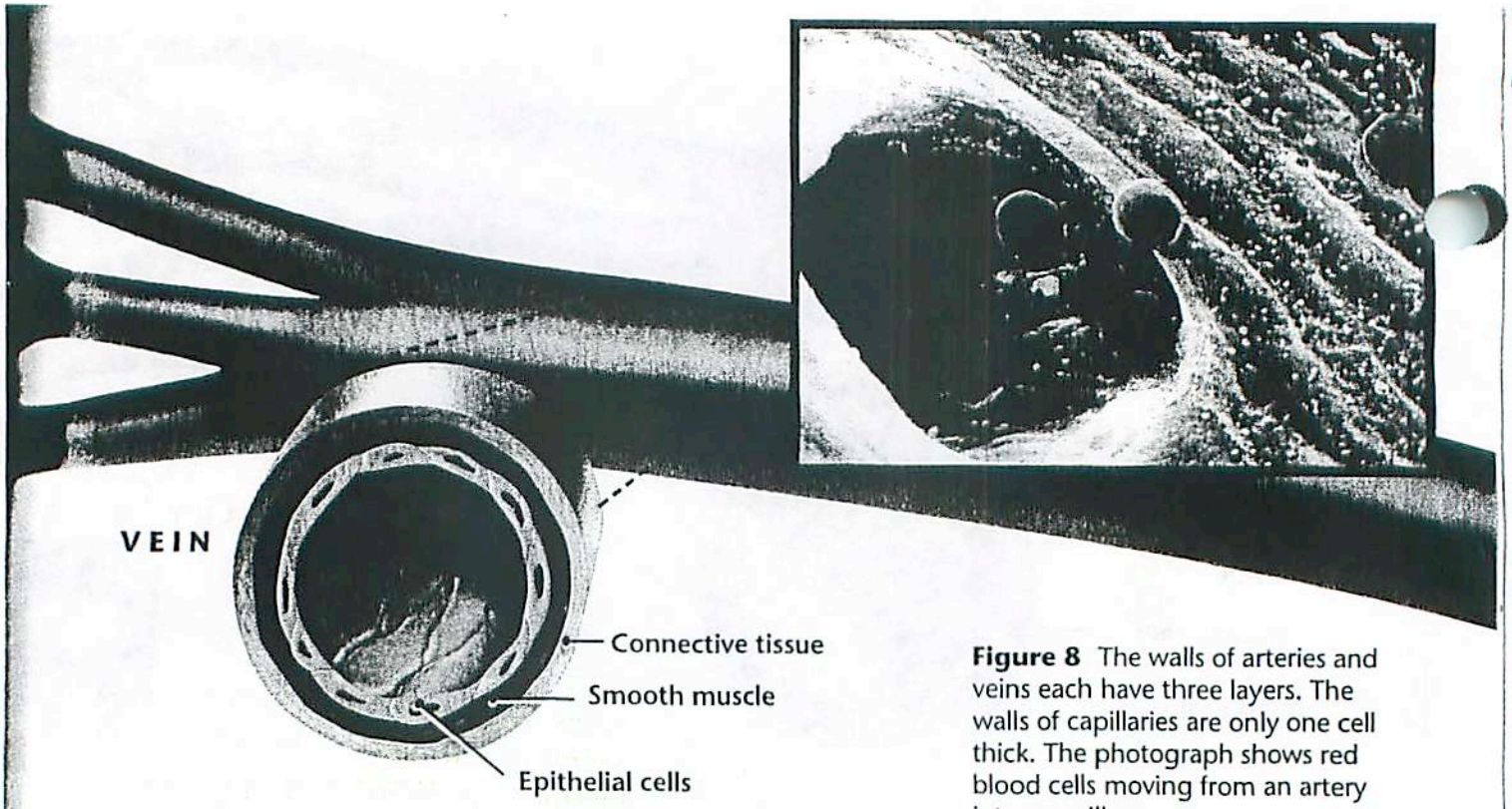


Figure 8 The walls of arteries and veins each have three layers. The walls of capillaries are only one cell thick. The photograph shows red blood cells moving from an artery into a capillary.

and intestines need a greater blood supply to help power digestion. The arteries leading to those organs open wider, so that more blood flows through them. In contrast, when you are running, your stomach and intestines need less blood than the muscles in your legs. The arteries leading to your leg muscles open wider. The arteries leading to the stomach and intestines become narrower, which decreases the blood flow to those organs.

Capillaries

Eventually, blood flows from small arteries into the tiny capillaries. **In the capillaries, materials are exchanged between the blood and the body's cells.** Capillary walls are only one cell thick. Because capillaries have thin walls, materials can pass easily through them. Materials such as oxygen and glucose pass from blood, through the thin capillary walls, to the cells. Cellular waste products travel in the opposite direction—from cells, through the capillary walls, and into blood.

INTEGRATING CHEMISTRY Recall from Chapter 2 that materials are exchanged between the blood and the body cells by diffusion. **Diffusion** is the process by which molecules move from an area in which they are highly concentrated to an area in which they are less concentrated. For example, glucose is more highly concentrated in blood than it is in the body cells. Therefore, glucose diffuses from the blood, through the capillary wall, and into the body cells.

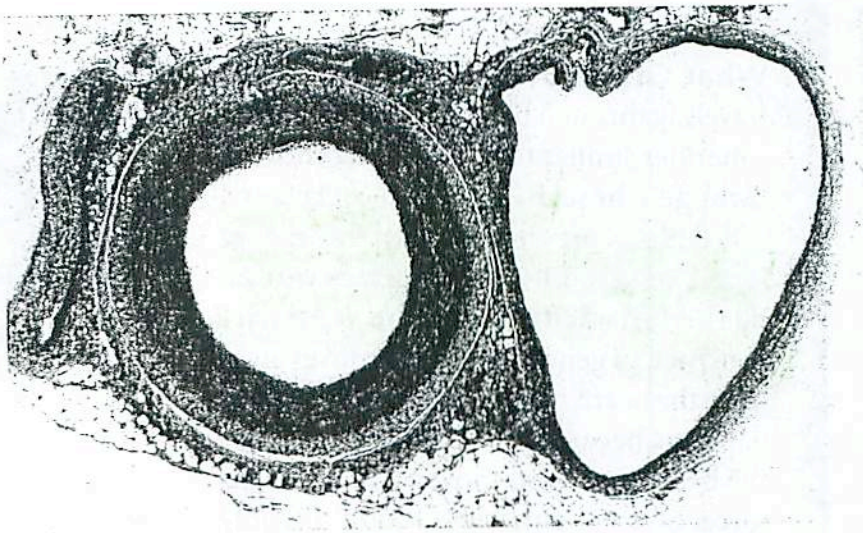


Figure 9 The wall of the artery (left) is much thicker than that of the vein (right).
Making Generalizations Why is it important for artery walls to be both strong and flexible?

Sharpen Skills

ACTIVITY

Scientists measured the volume of blood that different organs receive, first when a person was resting and then when the person was engaged in vigorous exercise.

- At rest, the organs of the abdomen received approximately 1,400 mL of blood per minute (mL/min). During vigorous exercise, they received 600 mL/min.
- At rest, skeletal muscles received about 1,200 mL/min. During vigorous exercise, the same muscles received about 12,500 mL/min.
- At rest, the kidneys received about 1,100 mL/min. During vigorous exercise, they received 600 mL/min.

Create a table to record these data. Then use the data to explain why some organs receive more blood during exercise, while some receive less.

After blood moves through capillaries, it enters larger blood vessels called veins, which carry blood back to the heart. The walls of veins, like those of arteries, have three layers, with muscle in the middle layer. However, the walls of veins are generally thinner than those of arteries.

By the time blood flows into veins, the pushing force of the heart has little effect. Several factors help move blood through veins. First, because many veins are located near skeletal muscles, the contraction of the muscles helps push the blood along. For example, as you run or walk, the skeletal muscles in your legs contract and squeeze the veins in your legs. Second, larger veins in your body have valves in them that prevent blood from flowing backward. Third, breathing movements, which exert a squeezing pressure against veins in the chest, also force blood toward the heart.

☑ *Checkpoint How do skeletal muscles help move blood in veins?*

INTEGRATING PHYSICS

Suppose that you are washing a car. You attach the hose to the faucet and turn on the faucet. The water flows out in a slow, steady stream. Then, while your back is turned, your little brother turns the faucet on all the way. Suddenly, the water spurts out rapidly, and the hose almost jumps out of your hand.

As water flows through a hose, it pushes against the walls of the hose, creating pressure on the walls. **Pressure** is the force that something exerts over a given area. When your brother turned on the faucet all the way, the additional water flow increased the pressure exerted on the inside of the hose. The extra pressure made the water spurt out of the nozzle faster.

What Causes Blood Pressure? Blood traveling through blood vessels behaves in a manner similar to that of water moving through a hose. Blood exerts a pressure, called **blood pressure**, against the walls of blood vessels. **Blood pressure is caused by the force with which the ventricles contract.** In general, as blood moves away from the heart, its pressure decreases. This happens because the farther away from the heart the blood moves, the lower the force of the ventricles. Blood flowing through arteries exerts the highest pressure. Blood pressure in capillaries and veins is much lower than in arteries.

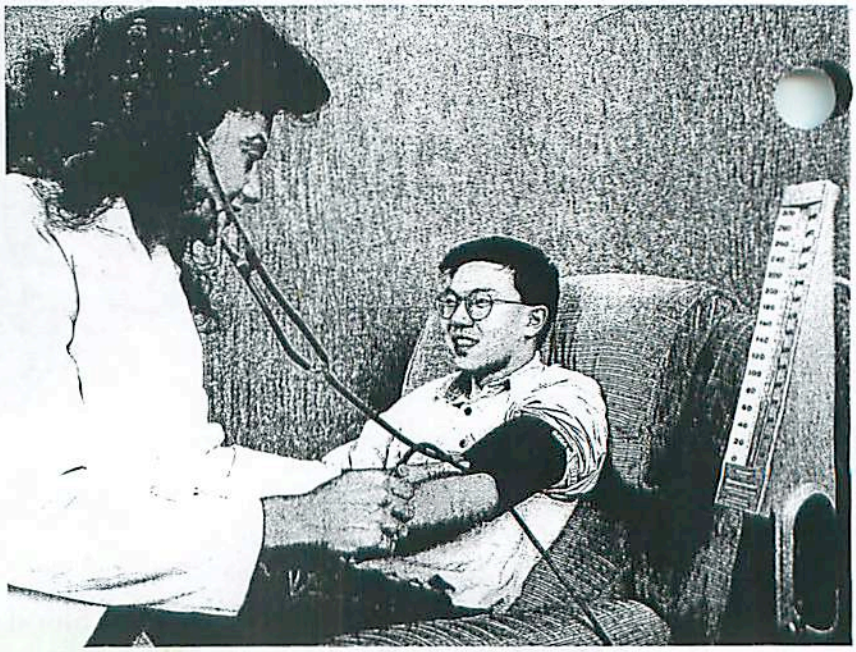


Figure 10 Blood pressure is measured with a sphygmomanometer. The cuff is wrapped around the patient's arm. *His blood* pressure is recorded by the height of the mercury column in the instrument on the right.

Measuring Blood Pressure Blood pressure can be measured with an instrument called a **sphygmomanometer** (sfig moh muh NAHM uh tur). Many sphygmomanometers contain a tube of mercury. Blood pressure is expressed in millimeters of mercury and is recorded as two numbers. The first number, which is the higher of the two numbers, is a measure of the blood pressure while the ventricles contract and pump blood into the arteries. The second number measures the blood pressure while the ventricles relax between heartbeats. The two numbers are written as a fraction. A typical, healthy blood pressure reading for a young adult is 120/80. This is expressed as 120 over 80, or the contraction pressure over the relaxation pressure. You will learn about the effects of high blood pressure in Section 4.

Section 2 Review

1. Contrast the functions of arteries, capillaries, and veins.
2. What causes blood pressure?
3. Explain the factors that enable blood in your leg veins to return to the heart in spite of the downward pull of gravity.
4. **Thinking Critically Applying Concepts** Arteries adjust the amount of blood flowing to different parts of the body, depending on where blood is needed. Use this fact to explain why it may not be a good idea to exercise vigorously shortly after you eat.

CHAPTER PROJECT

Check Your Progress

By now you should have begun constructing your display. Make sure that the blood vessels are depicted accurately. Also check that your display correctly shows the path of a red blood cell and the place where the red blood cell picks up oxygen. *(Hint:* Start to prepare a rough draft of your written description.)

Skills Lab

Measuring

Heart Beat, Health Beat

Problem

How does physical activity affect your pulse rate?

Materials

watch or clock with second hand
graph paper

Procedure

1. Predict how your pulse rate will change as you go from resting to being active, then back to resting again. Then copy the data table into your notebook.
2. Locate your pulse by placing the index and middle finger of one hand on your other wrist at the base of your thumb. Move the two fingers slightly until you feel your pulse.
3. Work with a partner for the rest of this lab. Begin by determining your resting pulse rate. Count the number of beats in your pulse for exactly one minute while your partner times you. Record the number in your data table. **CAUTION:** *Do not complete the rest of these procedures if there is any medical reason why you should avoid physical activities.*
4. Walk in place for one minute while your partner times you. Stop and immediately take your pulse for one minute. Record the number in your data table.
5. Run in place for one minute. Take your pulse again, and record the result.
6. Sit down right away, and have your partner time you as you rest for one minute. Then take your pulse rate again.
7. Have your partner time you as you rest for 3 more minutes. Then take your pulse rate again and record it.

DATA TABLE

Activity	Pulse Rate
Resting	
Walking	
Running	
Resting after Exercise	
(1 min) Resting after Exercise	
(3+ min) Resting after Exercise	

Analyze and Conclude

1. Use the data you obtained to create a bar graph of your pulse rate under the different conditions you tested.
2. What conclusion can you draw about the relationship between physical activity and a person's pulse rate?
3. What happens to the pulse rate when the physical activity has stopped?
4. What can you infer about the heartbeat when the pulse rate increases?
5. **Think About It** Do you think the pulse measurements you made are completely accurate? Why or why not? How could you improve the accuracy of your measurements?

Design an Experiment

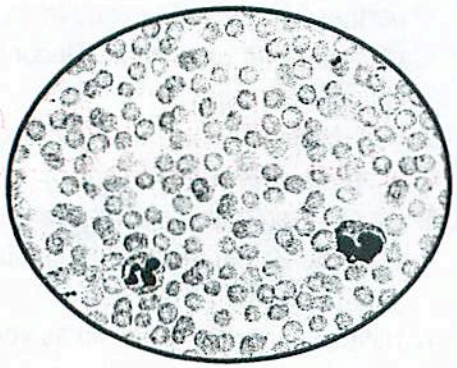
Do the resting pulse rates of adults, teens, and young children differ? Write a plan to answer this question. Obtain your teacher's permission before carrying out your plan.

SECTION 3

Blood and Lymph

DISCOVER ACTIVITY

What Kinds of Cells Are in Blood?



1. Obtain a microscope slide of human blood. Look at the slide under the microscope, first under low power and then under high power.
2. Look carefully at the different kinds of cells that you see.
3. Make several drawings of each kind of cell. Use red pencil for the red blood cells.

Think It Over

Observing How many kinds of cells did you see? How do they differ from one another?

If someone fills a test tube with blood and lets it sit for a while, the blood separates into layers. The top layer is a clear, yellowish liquid. A dark red material rests on the bottom. The top layer is **plasma**, which is the liquid part of blood. The red material at the bottom is a mixture of blood cells. **Blood is made up of four components: plasma, red blood cells, white blood cells, and platelets.** About 45 percent of the volume of blood is made up of cells. The rest consists of plasma.

GUIDE FOR READING

- **What are the four components of blood?**
- **What determines the type of blood that a person can receive in transfusion?**

Reading Tip **As you read, write definitions for each boldfaced term in your own words.**

Plasma

Blood, as you have learned, transports materials from one part of the body to another. Most of those materials travel in plasma. In fact, 10 percent of plasma is made up of these dissolved materials. The other 90 percent of plasma is water.

Plasma carries molecules that come from the breakdown of digested food, such as glucose and fats. The vitamins and minerals your body needs also travel in plasma. Plasma also carries chemical messengers that direct body activities such as the uptake of glucose by your cells. In addition, many wastes produced by cell processes are carried away by plasma.

Protein molecules give plasma its yellow color. There are *three groups of plasma* proteins. One group helps to regulate the amount of water in blood. The second group, which is produced by white blood cells, helps fight disease. The third group of proteins interacts with platelets to form blood clots.

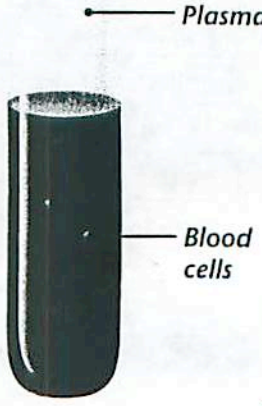


Figure 11 Blood in a test tube separates into two layers.

Red Blood Cells

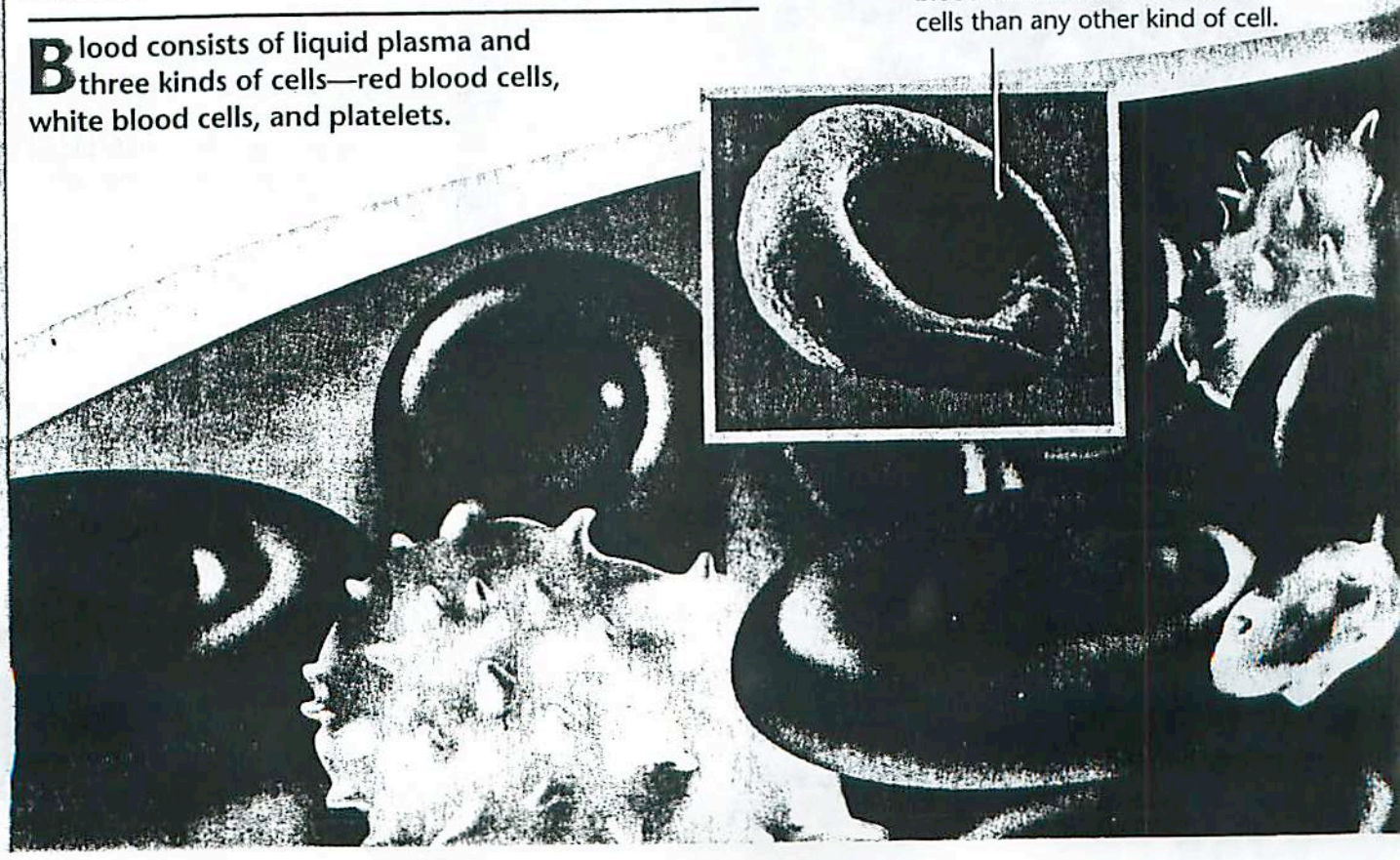
Without red blood cells, your body could not use the oxygen that you breathe in. **Red blood cells** take up oxygen in the lungs and deliver it to cells elsewhere in the body. Red blood cells, like most blood cells, are produced in bone marrow.

Exploring Blood Cells shows what red blood cells look like. Under a microscope, these cells look like disks with pinched-in centers. Because they are thin, red blood cells can bend and twist easily. This flexibility enables them to squeeze through narrow capillaries.

A red blood cell is made mostly of **hemoglobin** (HEE muh gloh bin), which is an iron-containing protein that binds chemically to oxygen molecules. When hemoglobin combines with oxygen, the cells become bright red. Without oxygen, they are dark red. Hemoglobin picks up oxygen in the lungs and releases it as blood travels through capillaries in the rest of the body. Hemoglobin also picks up some of the carbon dioxide produced by cells. However, most of the carbon dioxide is carried by plasma. The blood carries the carbon dioxide to the lungs, where it is released from the body.

EXPLORING *Blood Cells*

Blood consists of liquid plasma and three kinds of cells—red blood cells, white blood cells, and platelets.



Red Blood Cells
Oxygen is carried throughout your body by red blood cells. Your blood contains more red blood cells than any other kind of cell.

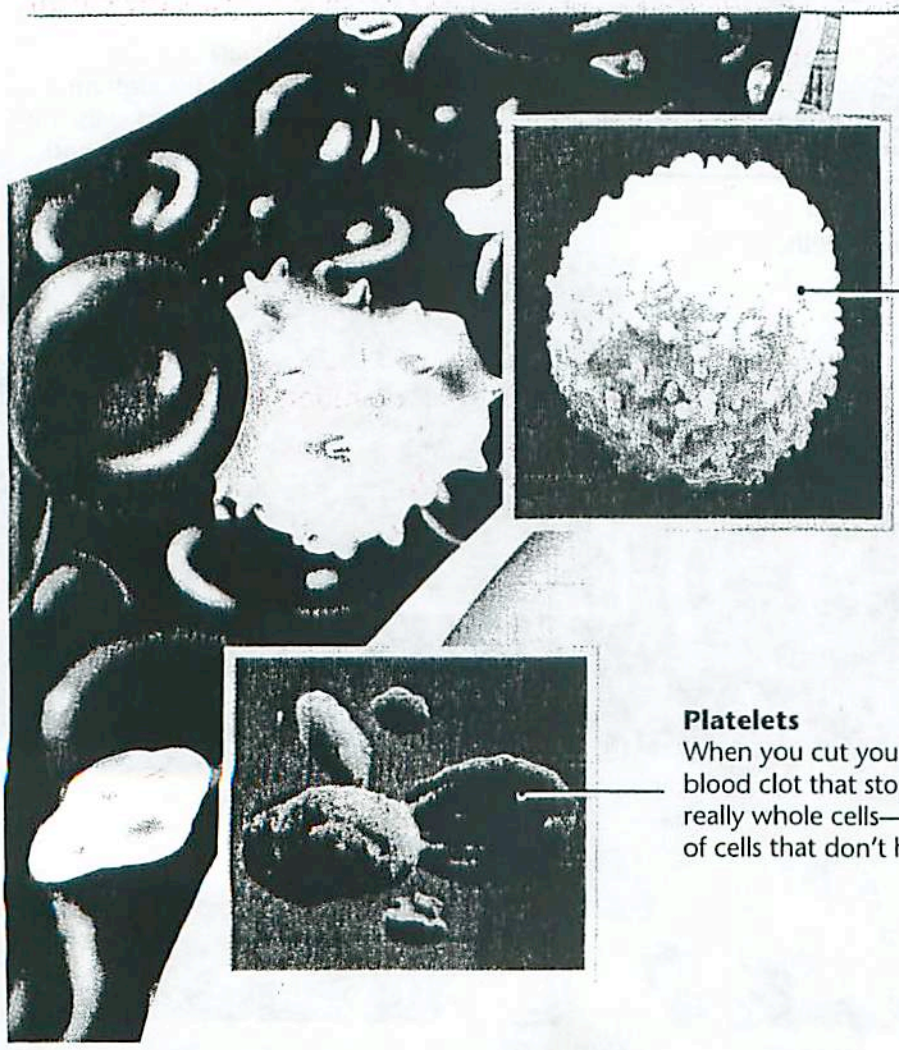
Red blood cells have no nuclei. Without a nucleus, a red blood cell cannot live very long. In fact, red blood cells live only about 120 days. Every second, about 2 million red blood cells in your body die. Fortunately, your bone marrow produces new red blood cells at the same rate.

Checkpoint *What is the shape of a red blood cell?*

White Blood Cells

Like red blood cells, white blood cells begin their existence in bone marrow. **White blood cells** are the body's disease fighters. Some white blood cells recognize disease-causing organisms such as bacteria and alert the body that it has been invaded. Other white blood cells produce chemicals to fight the invaders. Still others surround and kill the organisms. You will learn more about the functions of white blood cells in Chapter 19.

White blood cells are different from red blood cells in several important ways. There are fewer of them—only about one white blood cell for every 500 to 1,000 red blood cells. White blood cells are also bigger than red blood cells, and they have nuclei. Most white blood cells live for months or even years.



White Blood Cells
By finding and destroying disease-causing organisms, white blood cells fight disease. Most white blood cells are larger than red blood cells.

Platelets
When you cut yourself, platelets help form the blood clot that stops the bleeding. Platelets aren't really whole cells—instead, they are small pieces of cells that don't have nuclei.

Figure 12 When you cut your skin, a blood clot forms. The blood clot consists of blood cells trapped in a fiber net. Platelets produce the material of which the fibers are made.

When you cut your finger, blood flows out of the cut. After a short time, however, a blood clot forms, stopping the blood flow. **Platelets** (PLAYT lits) are cell fragments that play an important part in forming blood clots.

When a blood vessel is cut, platelets collect and stick to the vessel at the site of the wound. The platelets release chemicals that start a chain reaction. This series of reactions eventually produces a protein called **fibrin** (FY brin). Fibrin gets its name from the fact that it weaves a net of tiny fibers across the cut in the blood vessel. The fiber net traps blood cells. As more and more platelets and blood cells become trapped in the net, a blood clot forms. A scab is a dried blood clot on the skin surface.

Checkpoint *What role do platelets play in forming blood clots?*

TRY THIS

ACTIVITY

In this activity, you will model part of the process by which a blood clot forms.

1. Cover the opening of a sturdy plastic cup with a piece of cheesecloth. Use a rubber band to hold the cheesecloth in place.
2. Put some water, paper clips, and coins in another cup.
3. Carefully pour the water, coins, and paper clips into the middle of the cheesecloth.

Making Models The paper clips and coins represent blood cells. What does the cheesecloth represent? What starts the production of the substance that the cheesecloth represents?

If a person loses a lot of blood—from a wound or during surgery—he or she may be given a **blood transfusion.** A blood transfusion is the transference of blood from one person to another. Most early attempts at blood transfusion failed, but no one knew why until the early 1900s. At that time Karl Landsteiner, an Austrian American physician, tried mixing blood samples from pairs of people. Sometimes the two blood samples blended smoothly. In other cases, however, the red blood cells clumped together. This clumping accounted for the failure of many blood transfusions. If clumping occurs within the body, it clogs the capillaries and may kill the person.

Marker Molecules Landsteiner went on to discover that there are four types of blood—A, B, AB, and O. Blood types are determined by marker molecules on red blood cells. If your blood type is A, you have the A marker. If your blood type is B, you

have the B marker. People with type AB blood have both A and B markers. The red blood cells of people with type O blood contain neither A nor B markers.

Your plasma contains clumping proteins that recognize red blood cells with "foreign" markers and make those cells clump together. For example, if you have blood type A, your blood contains clumping proteins that act against cells with B markers. So if you receive a transfusion of type B blood, your clumping proteins will make the "foreign" type B cells clump together.

Safe Transfusions Landsteiner's work led to a better understanding of transfusions. **The marker molecules on your red blood cells determine your blood type and the type of blood that you can safely receive in transfusions.** A person with type A blood can receive transfusions of either type A or type O blood. Neither of these two blood types has B markers. Thus they would not be recognized as foreign by the clumping proteins in type A blood. A person with type AB blood can receive all blood types in transfusion, because type AB blood has no clumping proteins. Figure 13 shows which transfusions are safe for each blood type.

If you ever receive a transfusion, your blood type will be checked. Donated blood that you can safely receive will then be found. This process is called cross matching. You may have heard a doctor on a television show give the order to "type and cross." The doctor wants to find out what blood type the patient has and then cross match it against donated blood.

Blood Types

Blood Type	Marker Molecules on Red Blood Cells	Clumping Proteins	Blood Types That Can Be Safely Received in a Transfusion
A		anti-B	A and O
B		anti-A	B and O
AB		no clumping proteins	A, B, AB, and O
O		anti-A and anti-B	O

Figure 13 The chemical markers on a person's red blood cells determine the types of blood he or she can safely receive in a transfusion. *Interpreting Charts What types of blood can be given safely to a person with blood type AB? Who can safely receive blood type O?*

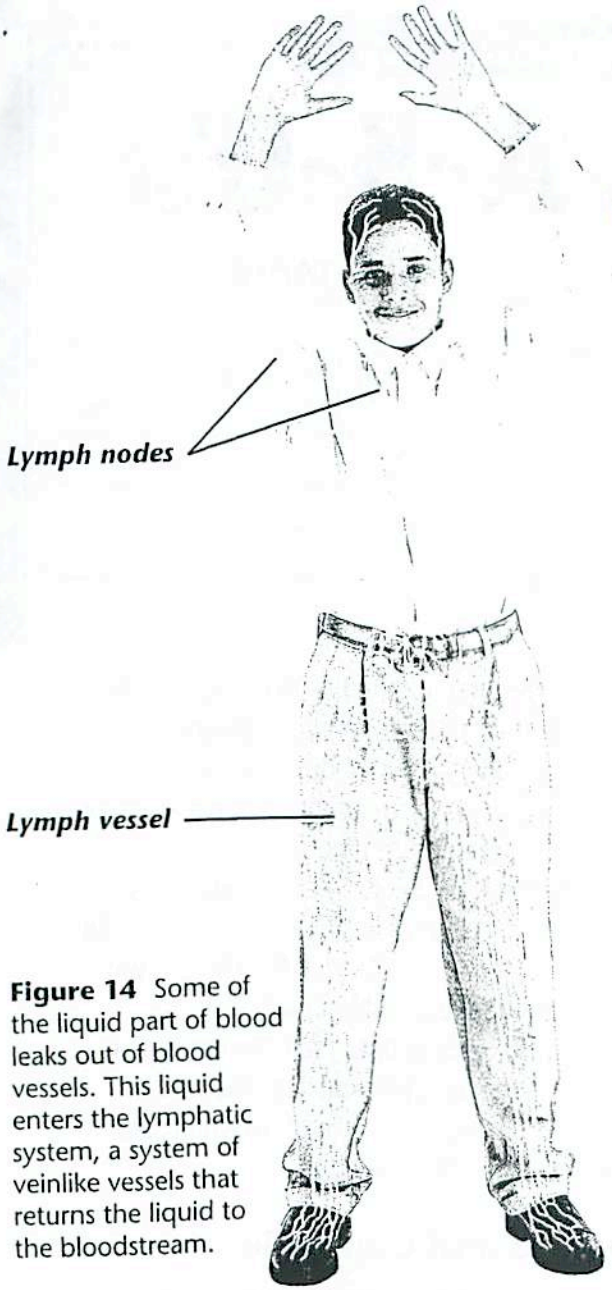


Figure 14 Some of the liquid part of blood leaks out of blood vessels. This liquid enters the lymphatic system, a system of veinlike vessels that returns the liquid to the bloodstream.

As blood travels through the capillaries in the cardiovascular system, some of the fluid leaks out. It moves through the walls of capillaries and into surrounding tissues. This fluid carries material that the cells in the tissues need.

After bathing the cells, this fluid moves into the lymphatic system. The **lymphatic system** (lim FAT ik) is a network of veinlike vessels that returns the fluid to the bloodstream. The lymphatic system acts something like rain gutters after a rainstorm, carrying the fluid away.

Lymph Once the fluid is inside the lymphatic system, it is called **lymph.** Lymph consists of water and dissolved materials such as glucose. It also contains some white blood cells that have left the capillaries.

The lymphatic system has no pump, so lymph moves slowly. Lymphatic vessels, which are part of the cardiovascular system, connect to large veins in the chest. Lymph empties into these veins and once again becomes part of blood plasma.

Lymph Nodes As lymph flows through the lymphatic system, it passes through small knobs of tissue called **lymph nodes.** Lymph nodes filter the lymph, trapping bacteria and other microorganisms that cause disease. When the body is fighting an infection, lymph nodes often enlarge. If you've ever had "swollen glands" when you've been sick, you've actually had swollen lymph nodes.

Section 3 Review

1. List the four components of blood. Identify whether each is a cell, a part of a cell, or a liquid.
2. Explain why a person with type O blood cannot receive a transfusion of type A blood.
3. Where does lymph come from? What happens to lymph after it travels through the lymphatic system?
4. **Thinking Critically Relating Cause and Effect** People with the disease hemophilia do not produce the chemical fibrin. Explain why hemophilia is a serious disease.

CHAPTER PROJECT

By now, you should be completing your display. Write out your description using the correct names of blood vessels and other terms that you've learned in this chapter. *(Hint:* If your display has moving parts, test it to make sure that it works the way you expect it to.)

Real-World Lab

Do You Know Your A-B-O's?

Donated blood is used for blood transfusions. But not every type of blood can be safely donated to every individual. In this lab, you'll investigate why type O blood is especially useful in blood transfusions.

Problem

Which blood types can safely receive transfusions of type A blood? Which can receive type O blood?

Materials

4 paper cups
4 plastic droppers
white paper
four model "blood" types
marking pen
8 plastic petri dishes
toothpicks

Procedure

1. Write down your ideas about why type O blood might be in higher demand than other blood types. Then make two copies of the data table in your notebook.
2. Label 4 paper cups A, B, AB, and O. Fill each cup about one-third full with the model "blood" supplied by your teacher. Insert one clean plastic dropper into each cup. Use each dropper to transfer only that one type of blood.
3. Label the side of each of 4 petri dishes with a blood type: A, B, AB, or O. Place the petri dishes on a sheet of white paper.
4. Use the plastic droppers to place 10 drops of each type of blood in its labeled petri dish. Each sample represents the blood of a potential receiver of a blood transfusion. Record the original color of each sample in your data table as yellow, blue, green, or colorless.

DATA TABLE

Donor: Type _____

Potential Receiver	Original Color	Final Color of Mixture	Safe or Unsafe?
A			
B			
AB			
O			

5. Label your first data table Donor: Type A. To test whether each potential receiver can safely receive type A blood, add 10 drops of type A blood to each sample. Stir each mixture with a separate, clean toothpick.
6. Record the final color of each mixture in the data table. If the color stayed the same, write "safe" in the last column. If the color of the mixture changed, write "unsafe."
7. Label your second data table Donor: Type O. Obtain four clean petri dishes, and repeat Steps 3 through 6 to determine who could safely receive type O blood.

Analyze and Conclude

1. Which blood types can safely receive a transfusion of type A blood? Type O blood?
2. If some blood types are not available, how might type O blood be useful?
3. **Apply** Why should hospitals have an adequate supply of different types of blood?

More to Explore

Repeat this activity to find out which blood types can safely receive donations of type B and type AB blood.

SECTION 4 Cardiovascular Health

DISCOVER ACTIVITY

Which Foods Are "Heart Healthy"?

1. Your teacher will give you an assortment of foods. If they have nutrition labels, read the information.
2. Sort the foods into three groups. In one group, put those foods that you think are good for your cardiovascular system. In the second group, put foods that you think might damage your cardiovascular system if eaten often. Place foods you aren't sure about in the third group.

Think It Over

Forming Operational Definitions How did you define a "heart-healthy" food?

GUIDE FOR READING

- What behaviors can help maintain cardiovascular health?

Reading Tip Before you read, rewrite the headings in the section as questions that begin with *how*, *why*, or *what*. Write short answers to these questions as you read.

Shortly after sunrise, when most people are just waking up, the rowers are already out on the river. Rhythmically, with perfectly coordinated movement, the rowers pull on the oars, making the boat glide swiftly through the water. Despite the chilly morning air, sweat glistens on the rowers' faces and arms. And inside their chests, their hearts are pounding, delivering blood to the arm and chest muscles that power the oars.

Rowers cannot perform at their peaks unless their cardiovascular systems are in excellent condition. But cardiovascular health is important to all people, not just athletes. Cardiovascular

disease is the leading cause of death in the United States. However, people can practice behaviors that decrease their risks of developing cardiovascular problems.

Cardiovascular Disease

Compare the two arteries shown in Figure 15. The one on the left is a healthy artery. It has a large space in the center through which blood can flow easily. The artery on the right, in contrast, has a thick wall and only a small space in the middle. This artery exhibits **atherosclerosis** (ath uh roh skluh ROH sis), a condition in which an artery wall thickens as a result of the buildup of fatty materials. One of these fatty materials is cholesterol, a waxy, fat-like substance. Atherosclerosis restricts the flow of blood in the arteries.

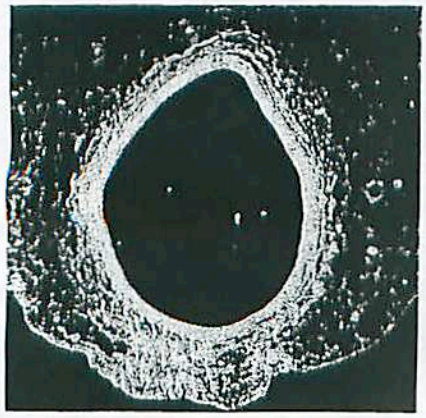
Atherosclerosis can develop in the coronary arteries that supply the heart. When that happens, the heart muscle receives less blood and therefore less oxygen. This condition may lead to a heart attack. A **heart attack** occurs when blood flow to part of the heart muscle is blocked. Cells die in the part of the heart that does not receive blood. This permanently damages the heart.

Treatment for mild atherosclerosis usually includes a low-fat diet and a moderate exercise program. In addition, medications that lower the levels of cholesterol and fats in the blood may be prescribed. People with severe atherosclerosis may need to undergo surgery or other procedures to unclog blocked arteries.

Checkpoint *Why is atherosclerosis especially serious when it affects the coronary arteries?*

Hypertension

High blood pressure, or **hypertension** (hy pur TEN shun), is a disorder in which a person's blood pressure is consistently higher than normal—greater than 140/90. Hypertension makes the heart work harder. It also may damage the walls of the blood



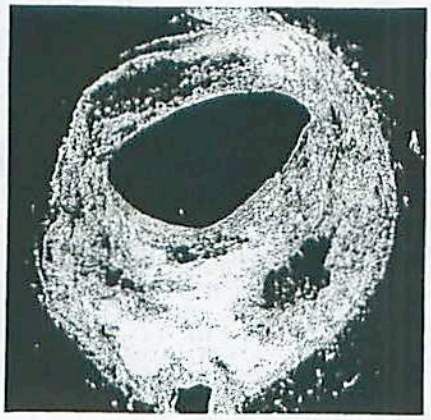


Figure 15 The healthy artery on the left is unblocked. In contrast, notice the narrow opening in the artery on the right. This person has atherosclerosis, which is caused by fatty deposits on the artery walls. *Relating Cause and Effect* *What kind of diet can lead to atherosclerosis?*

TRY THIS

Blocking the Flow

ACTIVITY

Use this activity to find out how fatty deposits affect the flow of blood through an artery.

1. Put a funnel in the mouth of a plastic jar. The funnel will represent an artery.
2. To model blood flowing through the artery, slowly pour 100 mL of water into the funnel. Have your partner time how many seconds it takes for all the water to flow through the funnel. Then discard the water.
3. Use a plastic knife to spread a small amount of peanut butter along the bottom of the funnel's neck. Then, with a toothpick, carve out a hole in the peanut butter so that the funnel is partly, but not completely, clogged.
4. Repeat Steps 1 and 2.

Predicting If the funnels were arteries, which one—blocked or unblocked—would do a better job of supplying blood to tissues? Explain.

vessels. Over time, both the heart and arteries can be severely harmed by hypertension. Because people with hypertension often have no obvious symptoms to warn them, hypertension is sometimes called the "silent killer."

Hypertension and atherosclerosis are closely related. As the arteries narrow, blood pressure increases. Being overweight and failing to get enough exercise can also increase a person's risk of developing hypertension.

SCIENCE & History

Cardiovascular Advances in the Twentieth Century

Scientists today have an in-depth understanding of how the cardiovascular system works and how to treat cardiovascular problems. This time line describes some advances of the twentieth century.

1900 1920 1940

1901

Discovery of Blood Types

Karl Landsteiner demonstrated that people have different blood types, which are determined by marker molecules on their red blood cells. Landsteiner's discovery enabled blood transfusions to be done safely.

1944

Treatment for "Blue Babies"

Helen Taussig identified the heart defect that causes the skin of some newborn babies to be bluish in color. The blood of these "blue babies" does not receive an adequate amount of oxygen. Taussig and another surgeon, Alfred Blalock, developed an operation to correct the defect and save these babies' lives.

1930s–1940s

Blood Banks

Charles Drew demonstrated that emergency transfusions could successfully be done with plasma if whole blood was not available. During World War II, Drew established blood banks for storing donated blood. His work helped save millions of lives on and off the battlefield.

For mild hypertension, regular exercise and careful food choices may be enough to lower blood pressure. People with hypertension need to limit their intake of sodium, which can increase their blood pressure. Sodium is found in salt and in processed foods such as soups and packaged snack foods. For some people who have hypertension, however, medications are needed to reduce their blood pressure.

Checkpoint *Why is hypertension called the "silent killer"?*

In Your Journal

Choose one of the scientists whose work is described here. Imagine that you are on a committee that has chosen him or her to receive an award. Write the speech you would give at the award ceremony. The speech should explain the importance of the scientist's contributions.

1967

First Heart Transplant

Christiaan Barnard, a South African surgeon, performed the first transplant of a human heart. Louis Washkansky, the man who received the heart, lived for only 18 days after the transplant. But Barnard's work paved the way for future successes in transplanting hearts and other organs.

1992

Laser Beam Unclogs Arteries

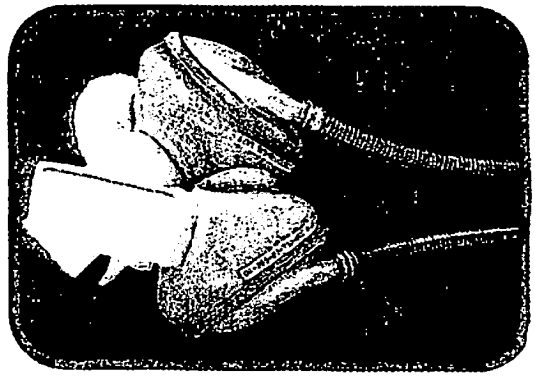
The United States government approved a device that uses a laser beam to burn away the material causing blockage in some arteries. This device can help some people with atherosclerosis.

1960 1980 2000

1982

Artificial Heart

An artificial heart, developed by Robert Jarvik, was implanted into a patient by surgeon William DeVries at the University of Utah. Barney Clark, the man who received the artificial heart, lived for 112 days. Today artificial hearts are sometimes used temporarily in people waiting for heart transplants.



Keeping Your Cardiovascular System Healthy

Few young people have heart attacks, but atherosclerosis can begin to develop in people as young as 20 years old. You can establish habits now that will lessen your risk of developing atherosclerosis and hypertension. **To help maintain cardiovascular health, people should exercise regularly; eat a balanced diet that is low in fat, cholesterol, and sodium; and avoid smoking.**

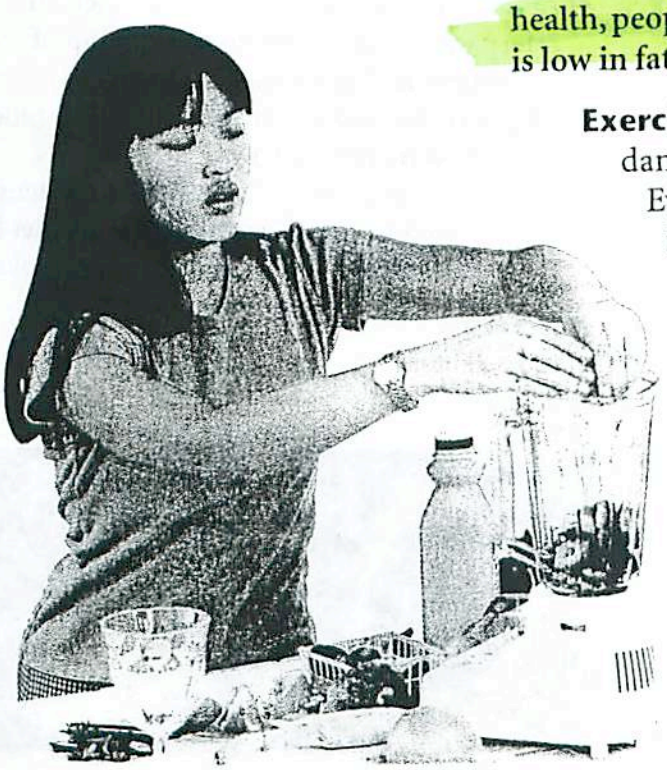


Figure 16 Eating foods that are low in fat can help keep your cardiovascular system healthy.

Exercise Do you participate in sports, ride a bike, swim, dance, or climb stairs instead of taking the elevator? Every time you do one of those activities, you are helping to maintain your cardiovascular health. Exercise strengthens your heart muscle and also helps prevent atherosclerosis.

A Balanced Diet Foods that are high in cholesterol and fats can lead to a buildup of fatty deposits on artery walls. In addition, eating too many high-fat foods can lead to excessive weight gain. Foods such as red meats, eggs, and cheese are high in cholesterol. These foods also contain substances that your body needs. Therefore, a smart approach might be to eat them, but only in small quantities. Some foods that are especially high in fat include butter and margarine, potato chips, doughnuts, and fried foods such as French fries. Eat high-fat foods only occasionally, if at all.

Avoid Smoking Smokers are more than twice as likely to have a heart attack than are nonsmokers. Every year, almost 180,000 people in the United States die from cardiovascular disease caused by smoking. If smokers quit, however, their risk of death from cardiovascular disease decreases.

Section 4 Review

1. List three things you can do to help your cardiovascular system stay healthy.
2. What is atherosclerosis?
3. How does hypertension affect blood vessels?
4. **Thinking Critically Relating Cause and Effect** Coronary heart disease is much less common in some countries than it is in the United States. What factors might account for this difference?

Science at Home

Healthy Hearts With your family, discuss some things that you all can do to maintain healthy cardiovascular systems. Make a list of exercise activities, such as bicycling and swimming, that family members can enjoy together. You might also work with your family to cook and serve a "heart-healthy," low-fat meal.

CHAPTER 17 STUDY GUIDE

SECTION 1 The Body's Transportation System

Key Ideas

- The heart pumps blood through the blood vessels. The heart has four chambers. The two atria receive blood, and the two ventricles pump blood out of the heart.
- Blood travels from the heart to the lungs and back to the heart. It is then pumped to the body and returns again to the heart.

Key Terms

cardiovascular system	valve	vein
heart	pacemaker	aorta
atrium	artery	force
ventricle	capillary	

SECTION 2 A Closer Look at Blood Vessels

Key Ideas

- Arteries carry blood from the heart to capillaries. In the capillaries, materials are exchanged between the blood and the body's cells. From the capillaries, blood flows into veins that carry it back to the heart.

Key Terms

coronary artery	blood pressure
diffusion	sphygmomanometer
pressure	

SECTION 3 Blood and Lymph

Key Ideas

- Red blood cells, which contain hemoglobin, carry oxygen and deliver it to body cells. White blood cells fight disease. Platelets are important in forming blood clots.

Key Terms

plasma	fibrin
red blood cell	blood transfusion
hemoglobin	lymphatic system
white blood cell	lymph
platelet	lymph node

SECTION 4 Cardiovascular Health

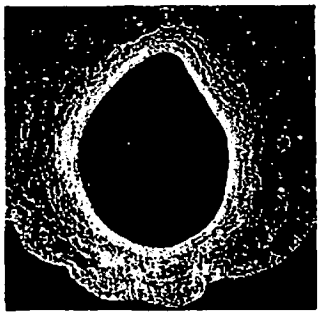
INTEGRATING HEALTH

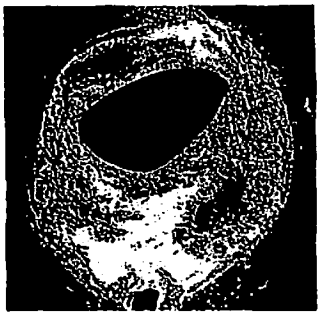
Key Ideas

- Atherosclerosis is a condition in which an artery wall thickens due to the buildup of cholesterol and other fatty materials.
- Hypertension is a disorder in which the blood pressure is higher than normal.
- To help prevent atherosclerosis and hypertension, people need to exercise regularly; eat a diet low in fat, cholesterol, and salt; and avoid smoking.

Key Terms

atherosclerosis	hypertension
heart attack	





Organizing Information

Compare/Contrast Table Compare the three types of blood vessels by copying and completing the table below. (For more on compare/contrast tables, see the Skills Handbook.)

Blood Vessel	Function	Structure of Wall
Artery	a. ?	3 layers: inner–epithelial tissue middle–muscle outer–connective tissue
b. ?	exchange of materials between cells and blood	c. ?
Vein	d. ?	e. ?

Reviewing Content

For more review of key concepts, see the Interactive Student Tutorial CD-ROM.

Multiple Choice

Choose the letter of the best answer.

1. The heart's upper chambers are called
   a. ventricles. b. atria.
   c. valves. d. hemoglobins.
2. Oxygen-rich blood enters the heart through the
   a. left atrium.
   b. right atrium.
   c. left ventricle.
   d. right ventricle.
3. Which of the following is *not* important in moving blood through veins?
   a. the force with which the atria contract
   b. valves
   c. breathing movements of the chest
   d. the contraction of skeletal muscles
4. Platelets help the body to
   a. control bleeding.
   b. carry oxygen.
   c. fight infection.
   d. regulate the amount of water in plasma.
5. Cholesterol is a fatlike substance associated with
   a. lymph nodes.
   b. fibrin.
   c. atherosclerosis.
   d. salt.

True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

6. The two lower heart chambers are called <u>ventricles</u>.
7. <u>White blood cells</u> contain hemoglobin.
8. The <u>capillaries</u> are the narrowest blood vessels in the body.
9. A person with blood type B can receive a transfusion of blood types B and <u>AB</u>.
10. Elevated blood pressure is called <u>hypertension</u>.

Checking Concepts

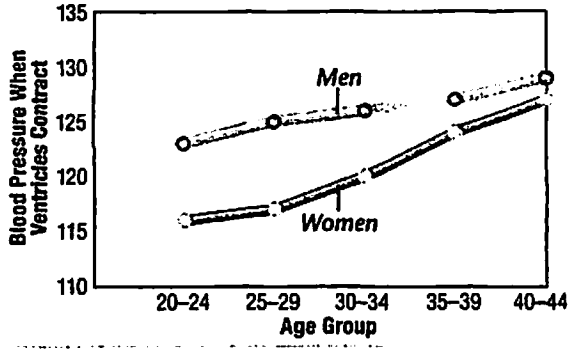
11. A red blood cell is moving through an artery in your leg. Describe the path that blood cell will follow back to your heart. Identify the chamber of the heart to which it will return.
12. Contrast the forces with which the right and left ventricles contract. How does this relate to each ventricle's function?
13. How is a capillary's structure adapted to its function?
14. What is the function of hemoglobin in the body?
15. Give two reasons why the food choices that people make are important to their cardiovascular health.
16. **Writing to Learn** Write an ad that encourages teenagers to exercise. Your ad will appear in a teen magazine. The ad should point out the health benefits of exercise and identify some ways that teenagers can exercise.

Thinking Critically

17. **Predicting** Some babies are born with an opening between the left and right ventricles of the heart. How would this heart defect affect the ability of the cardiovascular system to deliver oxygen to body cells?
18. **Comparing and Contrasting** Contrast the direction of movement of oxygen in lung capillaries and other capillaries in the body.
19. **Relating Cause and Effect** People who do not have enough iron in their diets sometimes develop a condition in which their blood cannot carry a normal amount of oxygen. Explain why this is so.
20. **Making Generalizations** Why are atherosclerosis and hypertension sometimes called "lifestyle diseases"?

Applying Skills

The graph below shows how average blood pressure, measured when the ventricles contract, changes as men and women grow older. Use the graph to answer Questions 21–23.



21. **Interpreting Data** At age 20, who is likely to have the higher blood pressure—a man or a woman?
22. **Drawing Conclusions** In general, what happens to people's blood pressure as they age?
23. **Predicting** Do you think that there is some age at which both men and women have about the same blood pressure? Use the graph lines to explain your prediction.

Performance Assessment — CHAPTER PROJECT

Present Your Project You should now be ready to present your display. First show it to a small group of classmates to make sure it is clear and accurate. When you present your display, be ready to answer questions.

Reflect and Record As you look at all the different projects, decide which display did the best job of teaching you. Use your journal to write about how the display looked and worked. Did you learn more from that display or from working on your own? As you write, try to decide which way of learning works best for you.

Test Preparation

Use these questions to prepare for standardized tests.

Study the table. Then answer Questions 24–27.

Blood Types

Name	Blood Type	Marker Molecules	Clumping Proteins
Juan	A	A	anti-B
Wanda	B	B	anti-A
Kyoko	AB	A and B	none
Eddie	O	none	anti-A and anti-B

24. What clumping proteins does Kyoko have in her blood?
    a. anti-A
    b. anti-B
    c. anti-A and anti-B
    d. none
25. What marker molecules does Wanda have on her red blood cells?
    a. A b. B
    c. A and B d. none
26. If you have Type B blood, from whom could you receive a blood transfusion?
    a. Wanda and Kyoko
    b. Wanda and Eddie
    c. only Wanda
    d. only Eddie
27. If you have Type AB blood, from whom could you receive a blood transfusion?
    a. only Juan
    b. only Juan and Wanda
    c. only Eddie
    d. Juan, Wanda, Kyoko, and Eddie

Name _____ Date _____ Class _____

SECTION 17-1 SECTION SUMMARY

The Body's Transportation System

Guide for Reading

- **What is the function of the cardiovascular system?**
- **What role does the heart play in the cardiovascular system?**
- **What path does blood take through the circulatory system?**

The **cardiovascular system,** or circulatory system, consists of the heart, blood vessels, and blood. **The cardiovascular system carries needed substances to cells and carries waste products away from cells.** Blood carries needed oxygen to cells and carries waste products away from cells.

The **heart** is a muscular organ that pumps blood throughout the body. **Each time the heart beats, it pushes blood through the blood vessels of the cardiovascular system.**

The heart has a right side and a left side. Each side has two compartments, or chambers. Each upper chamber, or **atrium,** receives blood that comes into the heart. Each lower chamber, or **ventricle,** pumps blood out of the heart. In each side of the heart, the atrium and ventricle are separated by a valve. A **valve** is a flap of tissue that prevents blood from flowing backward.

The **pacemaker** in the right atrium sends out signals that make the heart muscle contract. The pacemaker adjusts the heart rate according to the body's oxygen needs. When the body needs more oxygen, the heart beats faster.

After leaving the heart, blood travels through three kinds of blood vessels. **Arteries** carry blood away from the heart and into the capillaries. **Capillaries** are tiny vessels where substances are exchanged between the blood and body cells. Blood flows from capillaries into veins. The **veins** carry blood back to the heart.

The overall pattern of the body's blood flow consists of two loops. **In the first loop, blood travels from the heart to the lungs and then back to the heart. In the second loop, blood is pumped from the heart through the body and then returns again to the heart.** In the first loop, oxygen-poor blood is pumped by the right ventricle to the lungs, where it picks up oxygen. Blood is then carried back to the left atrium. In the other loop, the oxygen-rich blood moves from the left atrium to the left ventricle. The left ventricle pumps the oxygen-rich blood to the rest of the body. Blood leaves the left ventricle through the **aorta,** the largest artery in the body. After the blood has traveled through the body, oxygen-poor blood comes back to the right atrium of the heart.

When the ventricle muscles contract, they exert a force on the blood that is inside them. A **force** is a push or pull.

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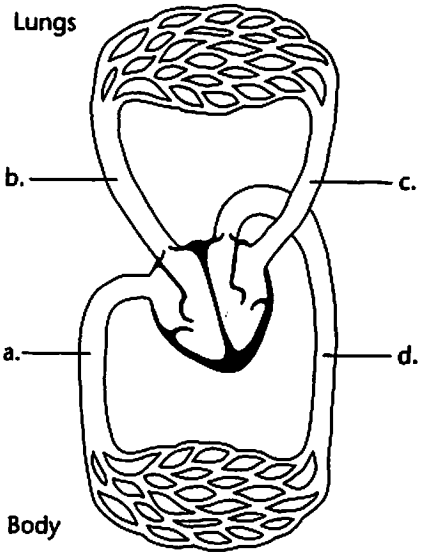
SECTION 17-1 **REVIEW AND REINFORCE**

The Body's Transportation System

◆ Understanding Main Ideas

Use the diagram to answer the following questions on a separate sheet of paper.

1. Draw arrows on the diagram to show the path of the blood flow throughout the body.
2. What is the function of the atria? What is the function of the ventricles?
3. Which of the large blood vessels labeled *a*, *b*, *c*, and *d* are arteries and which are veins? Explain how you know.



◆ Building Vocabulary

From the list below, choose the term that best completes each sentence.

aorta	capillaries	cardiovascular system	force
heart	pacemaker	valve	

4. The _____ is a group of cells that adjusts the heart rate.
5. The muscular organ that pumps blood through the body is called the _____.
6. The _____ is made up of the heart, blood vessels, and blood.
7. A(n) _____ is a flap of tissue that prevents blood from flowing backward.
8. The largest artery is called the _____.
9. Substances are exchanged between the blood and body cells in the _____.

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