Chapter

16

Circulation

The BIG Idea

Structure and Function

What are the major functions of the circulatory system?

Chapter Preview

Blood cells travel in blood vessels to all parts of the body.

Discovery CHANNEL SCHOOL

Circulation

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ Chapter **Project**

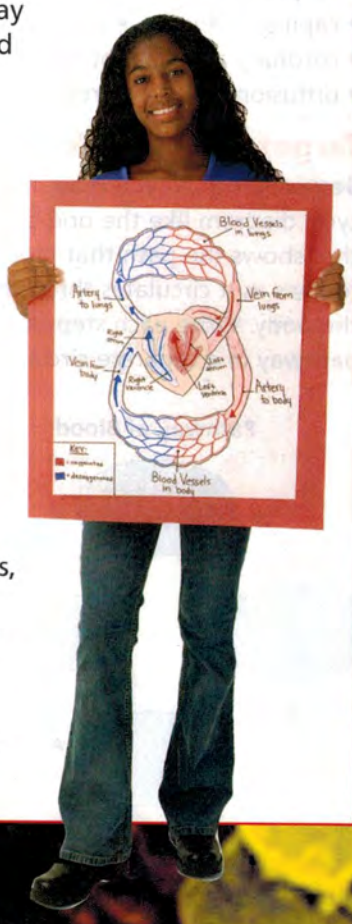
Travels of a Red Blood Cell

Every day, you travel from home to school and back home again. Your travel path makes a loop, or circuit, ending where it began. In this chapter, you'll learn how your blood also travels in circuits. In this project, 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

Your display must

- show a red blood cell that leaves from the heart and returns to the same place
- show where the exchange of oxygen and carbon dioxide takes place
- provide written descriptions of the circuits made by the red blood cell
- be designed following the safety guidelines in Appendix A



Plan It! Preview the chapter and find diagrams that show the heart, red blood cells, and the pathway of blood throughout the body. 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.

Section 1

The Body's Transport System

Reading Preview

Key Concepts

- What are the functions of the cardiovascular system?
- What is the function and structure of the heart?
- What path does blood take through the cardiovascular system?
- What are the functions and structures of arteries, capillaries, and veins?

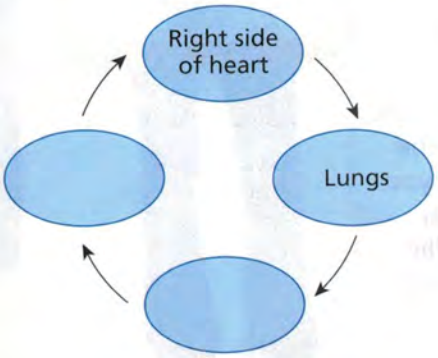
Key Terms

- cardiovascular system • heart
- atrium • pacemaker
- ventricle • valve • artery
- capillary • vein • aorta
- coronary artery • pulse
- diffusion • blood pressure

Target Reading Skill

Sequencing As you read, make a cycle diagram like the one below that shows the path that blood follows as it circulates throughout the body. Write each step of the pathway in a separate circle.

Pathway of Blood



Lab zone **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, trying not to spill any. **CAUTION:** *Wipe up spills on the floor immediately.* 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 in 1 minute.

Think It Over

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?

Late at night, a truck rolls 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 breaks, store workers unload the cargo. At the same time, a garbage truck removes yesterday's trash and drives off down the road.

The Cardiovascular System

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,** also called the 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.**

Delivering 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 other body cells. Blood also transports the glucose your cells use to produce energy.

Removing Waste Products The cardiovascular system picks up wastes from cells. For example, when cells break down 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.

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

Reading Checkpoint **How does the cardiovascular system help fight disease?**

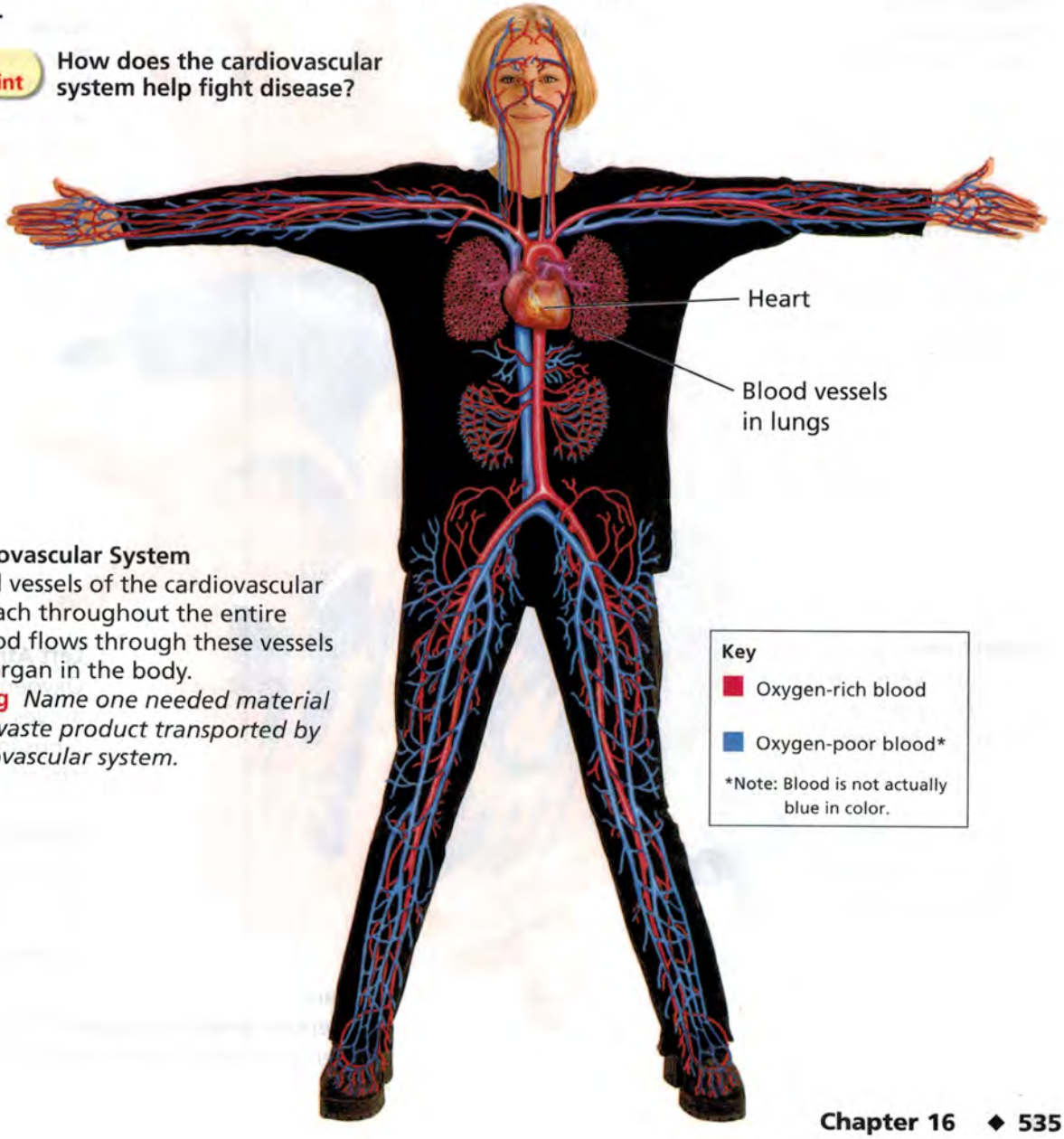


FIGURE 1
The Cardiovascular System
The blood vessels of the cardiovascular system reach throughout the entire body. Blood flows through these vessels to every organ in the body.
Classifying *Name one needed material and one waste product transported by the cardiovascular system.*

The Heart

Without the heart, blood wouldn't go anywhere. The **heart** is a hollow, muscular organ that pumps blood throughout the body. **Each time the heart beats, it pushes blood through the blood vessels of the cardiovascular system.**

Your heart, shown in Figure 2, is about the size of your fist. It is located in the center of your chest. The heart lies behind the sternum (breastbone) and inside the rib cage. It is made of cardiac muscle, which can contract over and over without getting tired.

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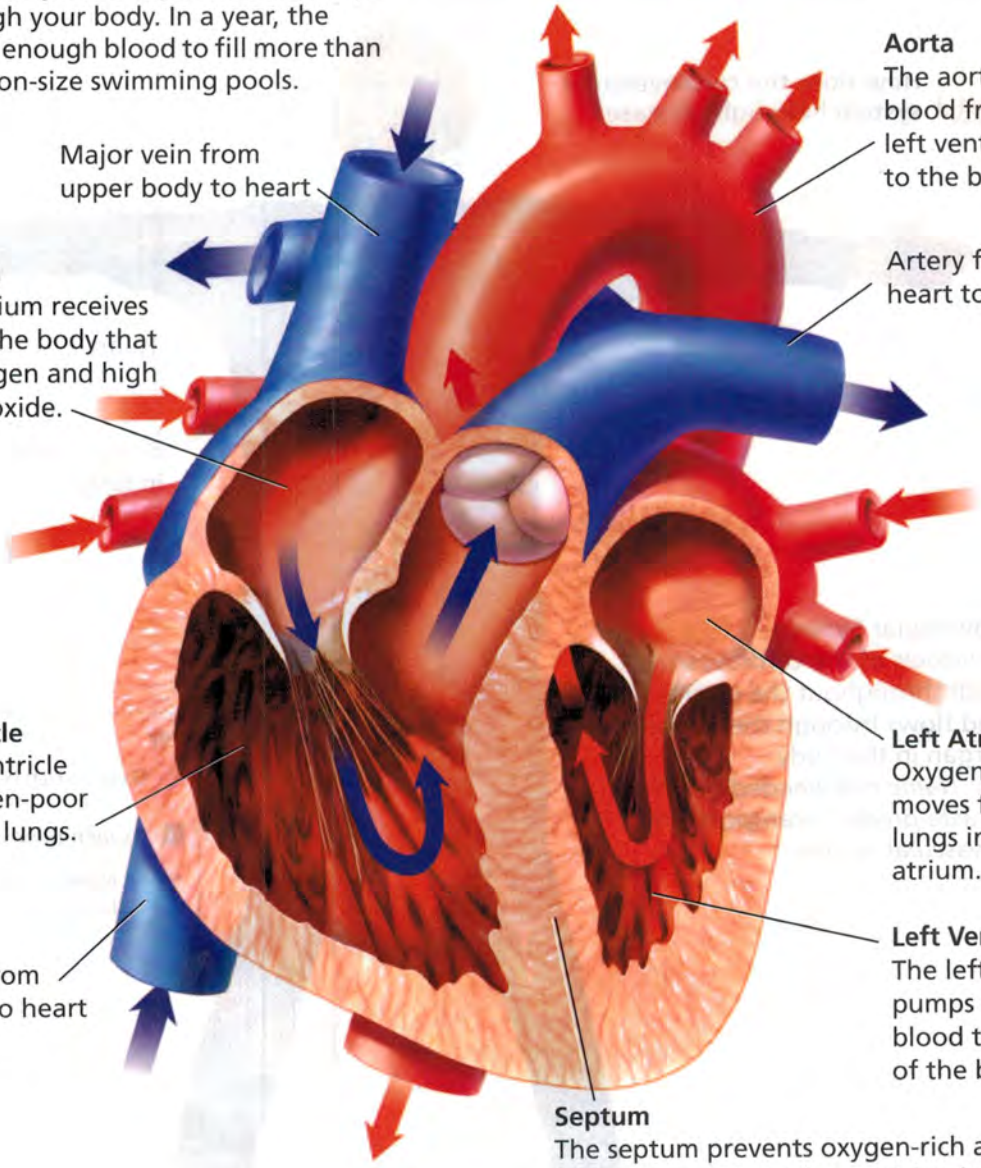
FIGURE 2
The Heart

Every second of your life, your heart pumps blood through your body. In a year, the heart pumps enough blood to fill more than 30 competition-size swimming pools.



The Heart's Structure The heart has a right side and a left side. **The right side of the heart is completely separated from the left side by a wall of tissue called the septum. Each side has two compartments, or chambers—an upper chamber and a lower chamber.** Each of the two upper chambers, called an **atrium** (AY tree um) (plural *atria*), receives blood that comes into the heart. Located in the right atrium is a group of heart cells called the **pacemaker,** which sends out signals that make the heart muscle contract.

Each lower chamber, called a **ventricle,** pumps 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 heart fills with blood. In the other phase, the heart muscle contracts and pumps blood forward. A heartbeat, which sounds something like *lub-dup*, can be heard during the pumping phase.

When the heart muscle relaxes, blood flows into the chambers. Then, the atria contract, squeezing blood out of the atria, through the valves, and 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.

When muscle cells in the ventricles contract, they exert a force on the blood. A force is a push or a pull. The force exerted by the ventricles pushes 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.

Reading Checkpoint **What is the role of the pacemaker?**

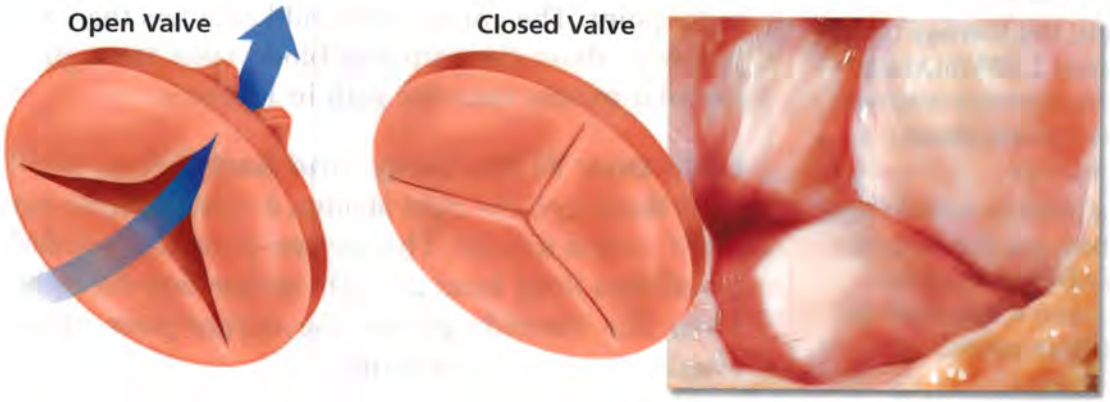


FIGURE 3
Open and Closed Heart Valves As blood flows out of the heart and toward the lungs, it passes through a valve like the one in the photograph. **Applying Concepts** *What is the function of a closed heart valve?*

FIGURE 4
Getting Blood to Body Cells
During strenuous exercise, such as swimming, the pattern of blood flow through the body ensures that body cells get the oxygen they need quickly and efficiently.

Two Loops

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, narrow vessels called **capillaries.** In the capillaries, substances are exchanged between the blood and body cells. From capillaries, blood flows into **veins,** blood vessels that carry blood back to the heart.

Pattern of Blood Flow The overall pattern of blood flow through the body is something like a figure eight. The heart is at the center where the two 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 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 the oxygen-poor blood into the arteries that lead to the lungs.

Lab zone Skills Activity

Creating Data Tables

Scientists measured the volume of blood that different organs receive, at rest and during vigorous exercise.

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

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

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 lungs into the blood. For the same reason, carbon dioxide moves in the opposite direction—from the blood into the lungs. 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 and will be pumped through the second loop.

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. This blood, which is low in oxygen, then flows back to the right atrium of the heart through veins, completing the second loop.

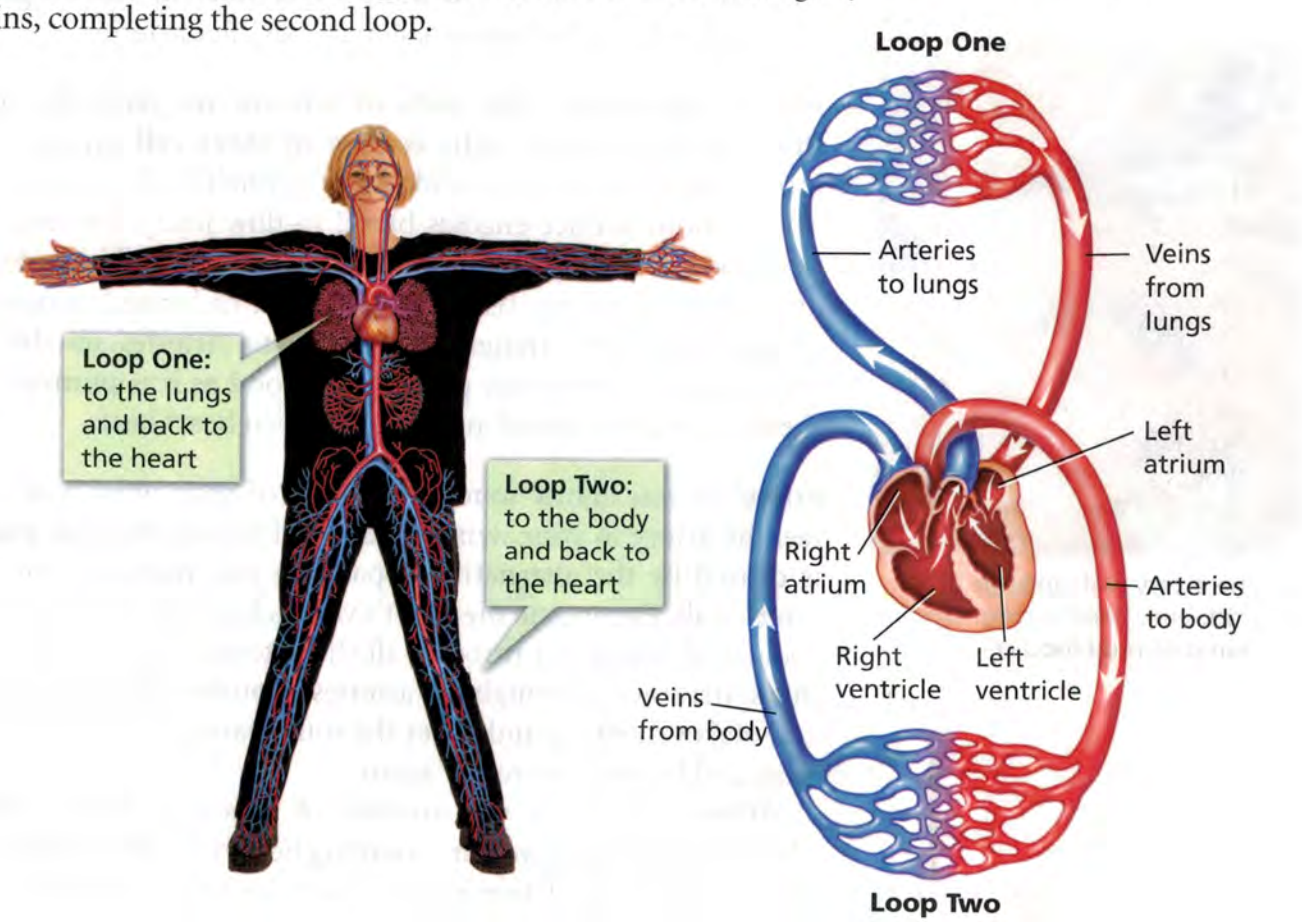


FIGURE 5
Direction of Blood Flow
Blood circulates through the body in two loops, with the heart at the center. Loop one goes from the heart to the lungs and back. Loop two circulates blood throughout the rest of the body.
Interpreting Diagrams *Where does the blood that enters the left atrium come from?*

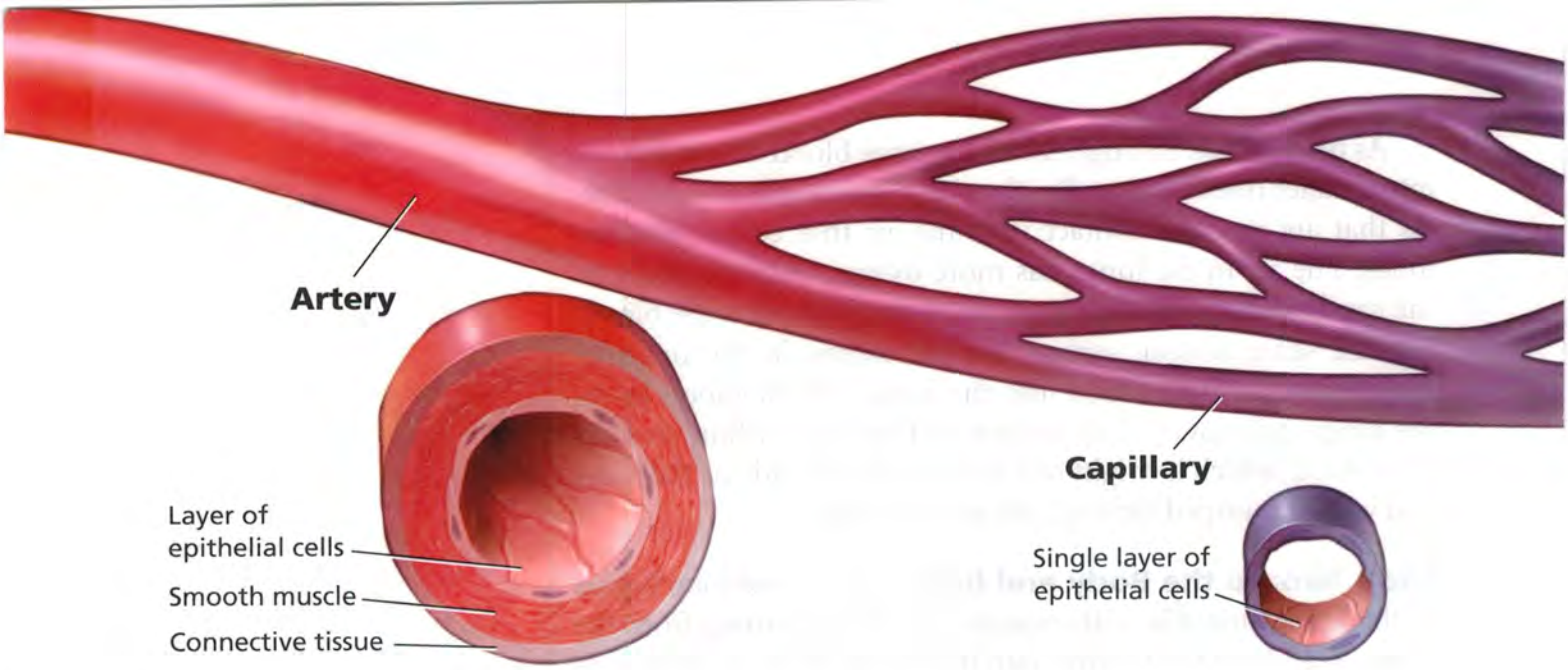
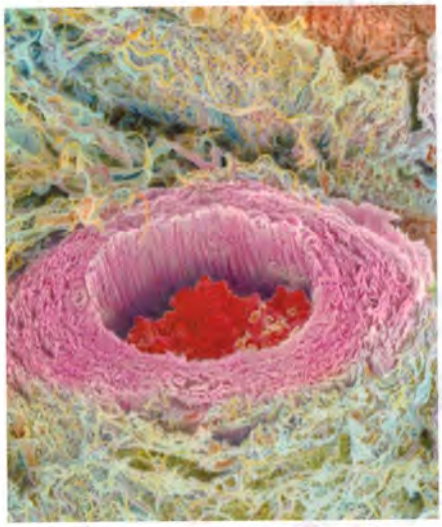


FIGURE 6
Artery, Capillary, and Vein
The walls of arteries and veins have three layers. The walls of capillaries are only one cell thick. **Relating Cause and Effect** *How does material get from inside capillaries to body cells?*



▲ The artery wall appears as a thick pink band surrounding a clump of red blood cells.

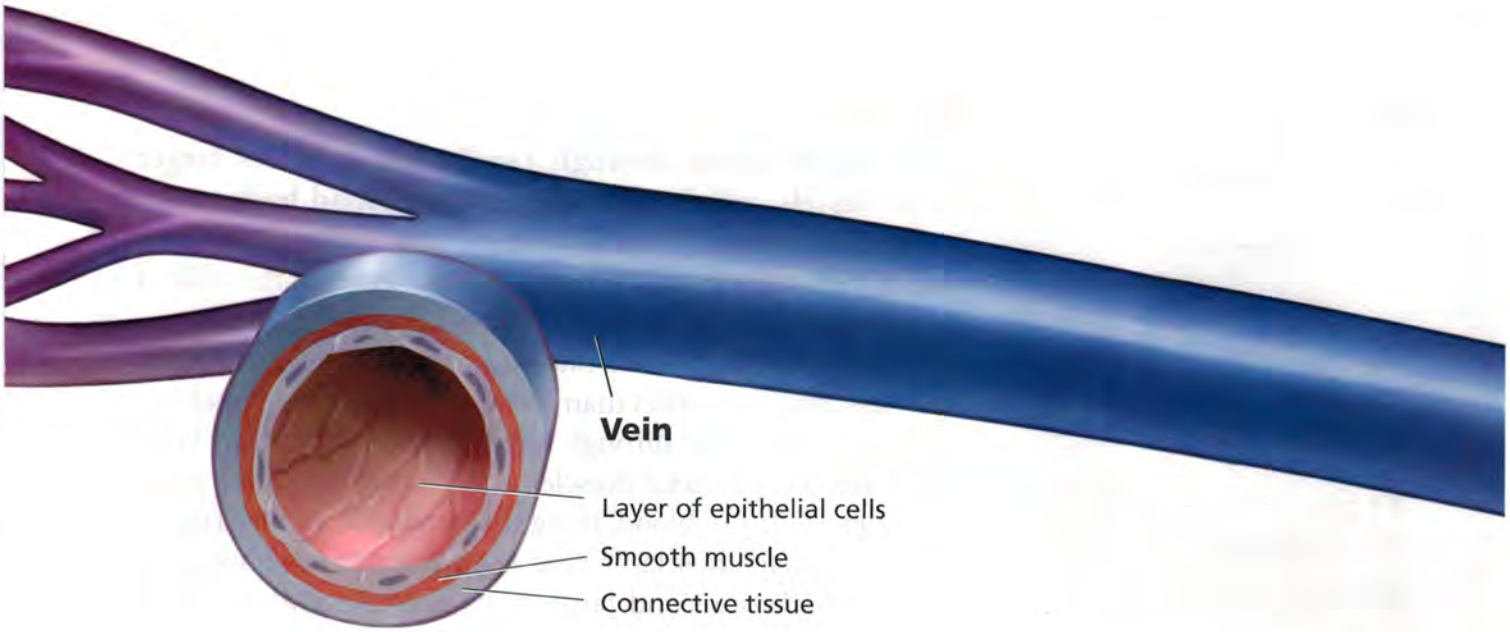
Arteries

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. Smaller arteries 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 cell layers.** The innermost layer, which is made up of epithelial cells, is smooth. 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 as it is pumped by the heart and to expand and relax between heart beats.

Pulse If you lightly touch the inside of your wrist, you can feel the artery in your wrist rise and fall repeatedly. This **pulse** 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 relax and 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 layer of muscle in an artery acts as a control gate, adjusting the amount of blood sent to different organs. When the muscle contracts, the opening in the artery becomes smaller. When the muscle relaxes, the opening becomes larger. For example, after you eat, your stomach and intestines need a greater blood supply for digestion. The arteries leading to those organs open wider, and 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 the digestive organs become narrower, decreasing the blood flow to these organs.

Reading Checkpoint **What causes your pulse?**

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.** Thus, materials can pass easily through them. Materials such as oxygen and glucose pass from the blood, through the capillary walls, to the cells. Cellular waste products travel in the opposite direction—from cells, through the capillary walls, and into the blood.

One way that materials are exchanged between the blood and body cells is by diffusion. **Diffusion** is the process by which molecules move from an area of higher concentration to an area of lower concentration. For example, glucose is more highly concentrated in the blood than it is in the body cells. Therefore, glucose diffuses from the blood into the body cells.

Math Skills

Calculating a 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's how to 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 2.

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

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

Practice Problem Calculate your pulse rate if your heart beats 170 times in 2.5 minutes.

FIGURE 7
Artery and Vein
In this photo, you can compare the wall of an artery (top) with the wall of a vein (bottom).
Comparing and Contrasting
Where is the pushing force of the heart greater—in arteries or in veins?

Veins

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 much thinner than those of arteries.

By the time blood flows into veins, the pushing force of the heart has much less effect than it did in the arteries. 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.

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

Blood Pressure

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 force, 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, blood pressure decreases. This change happens because the farther away from the ventricle the blood moves, the lower its force is. Blood flowing through the arteries exerts the highest pressure. Blood pressure in arteries farther from the heart is much lower.

Measuring Blood Pressure Blood pressure can be measured with an instrument called a sphygmomanometer (sfig moh muh NAHM uh tur). A cuff is wrapped around the upper arm. Air is pumped into the cuff until the blood flow through the artery is stopped. As the pressure is released, the examiner listens to the pulse and records two numbers. Blood pressure is expressed in millimeters of mercury. The first number is a measure of the blood pressure while the heart's ventricles contract and pump blood into the arteries. The second number, which is lower, measures the blood pressure while the ventricles relax. The two numbers are expressed as a fraction: the contraction pressure over the relaxation pressure.

FIGURE 8
Measuring Blood Pressure
Blood pressure can be measured with a sphygmomanometer. A typical blood pressure reading for a healthy person is 120/80 or lower.

Section 1 Assessment

Target Reading Skill **Sequencing** Refer to your cycle diagram about the pathway of blood flow as you answer Question 3.

Reviewing Key Concepts

1. a. **Reviewing** What does the cardiovascular system consist of?
   b. **Classifying** What three functions does the cardiovascular system perform?
2. a. **Identifying** What function does the heart perform?
   b. **Summarizing** What are the four chambers of the heart? What structures separate one chamber from another?
   c. **Predicting** What would happen if the valve between the right atrium and the right ventricle did not work properly?
3. a. **Identifying** Where does blood returning from the body enter the heart?
   b. **Sequencing** Where does the blood move next?
4. a. **Describing** What roles do arteries, capillaries, and veins play in the cardiovascular system?
   b. **Comparing and Contrasting** How are the structures of arteries, capillaries, and veins similar? How are they different?

Math Practice

Before a run, you take your pulse rate for 30 seconds and count 29 beats. Immediately after the run, you count 63 beats in 30 seconds.

5. **Calculating a Rate** What was your pulse rate per minute before the run?
6. **Calculating a Rate** What was your pulse rate immediately after the run?

Lab zone **Skills Lab**

Heart Beat, Health Beat

Problem

How does physical activity affect your pulse rate?

Skills Focus

graphing, interpreting data, drawing conclusions

Materials

- graph paper
- watch with second hand or heart rate monitor

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. If you are using a heart rate monitor, see your teacher for instructions.
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 1 minute while your partner times you. Record your resting pulse rate in your data table. **CAUTION:** *Do not complete the rest of this lab if there is any medical reason why you should avoid physical activities.*
4. Walk in place for 1 minute while your partner times you. Stop and immediately take your pulse for 1 minute. Record the number in your data table.
5. Run in place for 1 minute. Take your pulse again, and record the result.
6. Sit down right away, and have your partner time you as you rest for 1 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)	

Analyze and Conclude

1. **Graphing** Use the data you obtained to create a bar graph of your pulse rate under the different conditions you tested.
2. **Interpreting Data** What happens to the pulse rate when the physical activity has stopped?
3. **Inferring** What can you infer about the heartbeat when the pulse rate increases?
4. **Drawing Conclusions** What conclusion can you draw about the relationship between physical activity and a person's pulse rate?
5. **Communicating** How could you improve the accuracy of your pulse measurements? Write a paragraph in which you discuss this question in relation to the steps you followed in your procedure.

Design an Experiment

Design an experiment to determine whether the resting pulse rates of adults, teens, and young children differ. *Obtain your teacher's permission before carrying out your investigation.*

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Section 2

Blood and Lymph

Reading Preview

Key Concepts

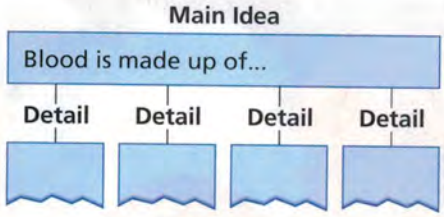
- What are the components of blood?
- What determines the type of blood that a person can receive in a transfusion?
- What are the structures and functions of the lymphatic system?

Key Terms

- plasma • red blood cell
- hemoglobin
- white blood cell • platelet
- lymphatic system • lymph
- lymph node

Target Reading Skill

Identifying Main Ideas As you read the section titled Blood, write the main idea in a graphic organizer like the one below. Then, write four supporting details that give examples of the main idea.



Lab zone **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?

While riding your bike through the neighborhood, you take a tumble and scrape your knee. Your knee begins to sting, and you notice blood oozing from the wound. You go inside to clean the wound. As you do, you wonder, "Just what is blood?"

Blood

Blood may seem like just a plain red liquid, but it is actually a complex tissue that has several parts. **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 cells. The rest is plasma.

Plasma Most of the materials transported in the blood travel in the plasma. **Plasma** is the liquid part of the blood. Water makes up 90 percent of plasma. The other 10 percent is dissolved materials. Plasma carries nutrients, such as glucose, fats, vitamins, and minerals. 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.

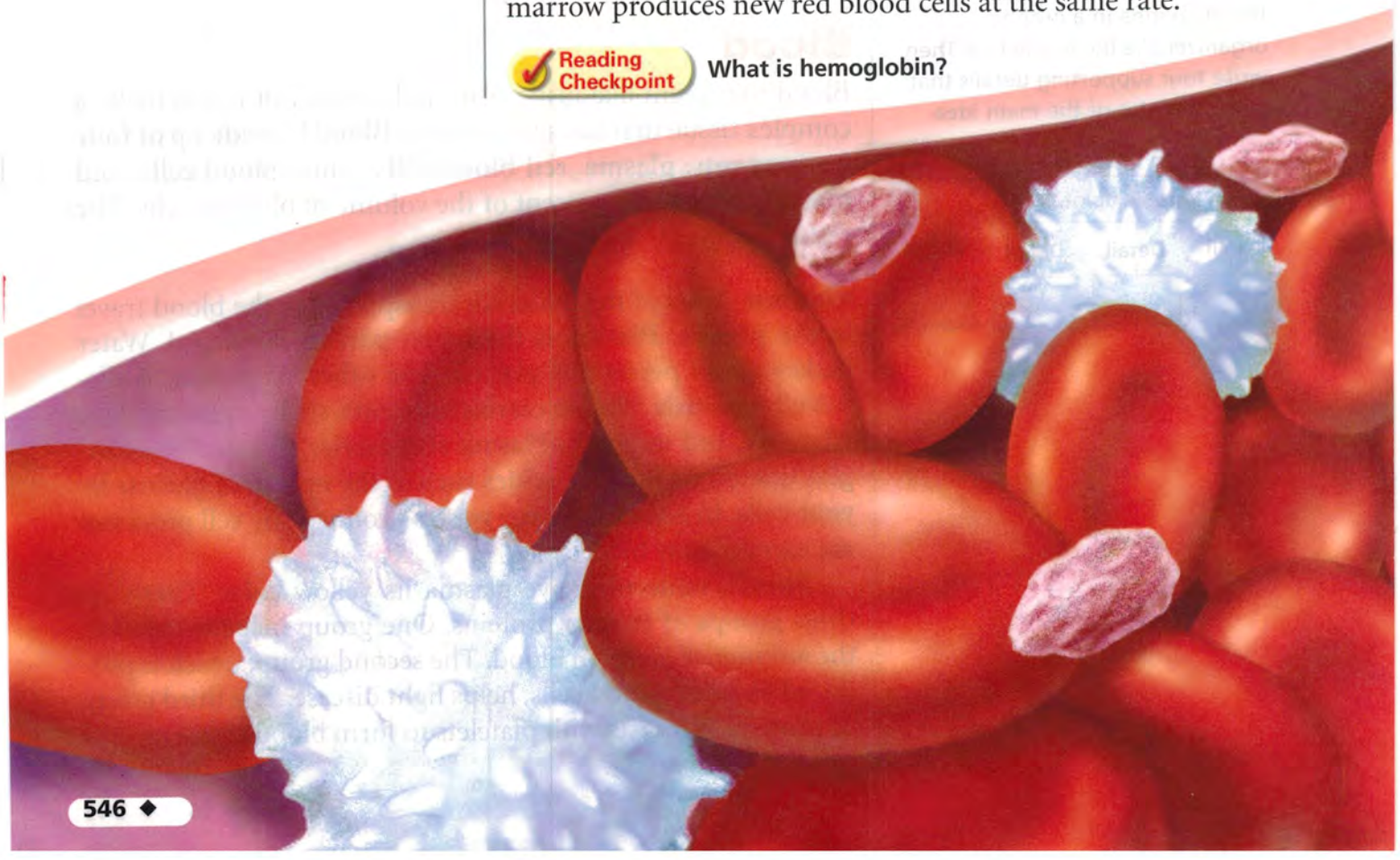
Protein molecules give plasma its yellow color. There are three groups of plasma proteins. One group helps to regulate the amount of water in blood. The second group, which is produced by white blood cells, helps fight disease. The third group of proteins interacts with platelets to form blood clots.

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. Under a microscope, these cells look like disks with pinched-in centers. Because of their pinched shape, red blood cells are thin in the middle and 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, the cells are dark red. Thus, blood leaving the heart through the aorta is bright red, whereas blood returning from the body to the heart through veins is 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.

Mature red blood cells have no nuclei. Without a nucleus, a red blood cell cannot reproduce or repair itself. Mature 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.

Reading Checkpoint **What is hemoglobin?**



White Blood Cells Like red blood cells, white blood cells are produced 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.

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 larger than red blood cells. In addition, white blood cells contain nuclei. Most white blood cells can live for months or even years.

FIGURE 9

Parts of Blood

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

Observing *Describe the shape of a red blood cell.*

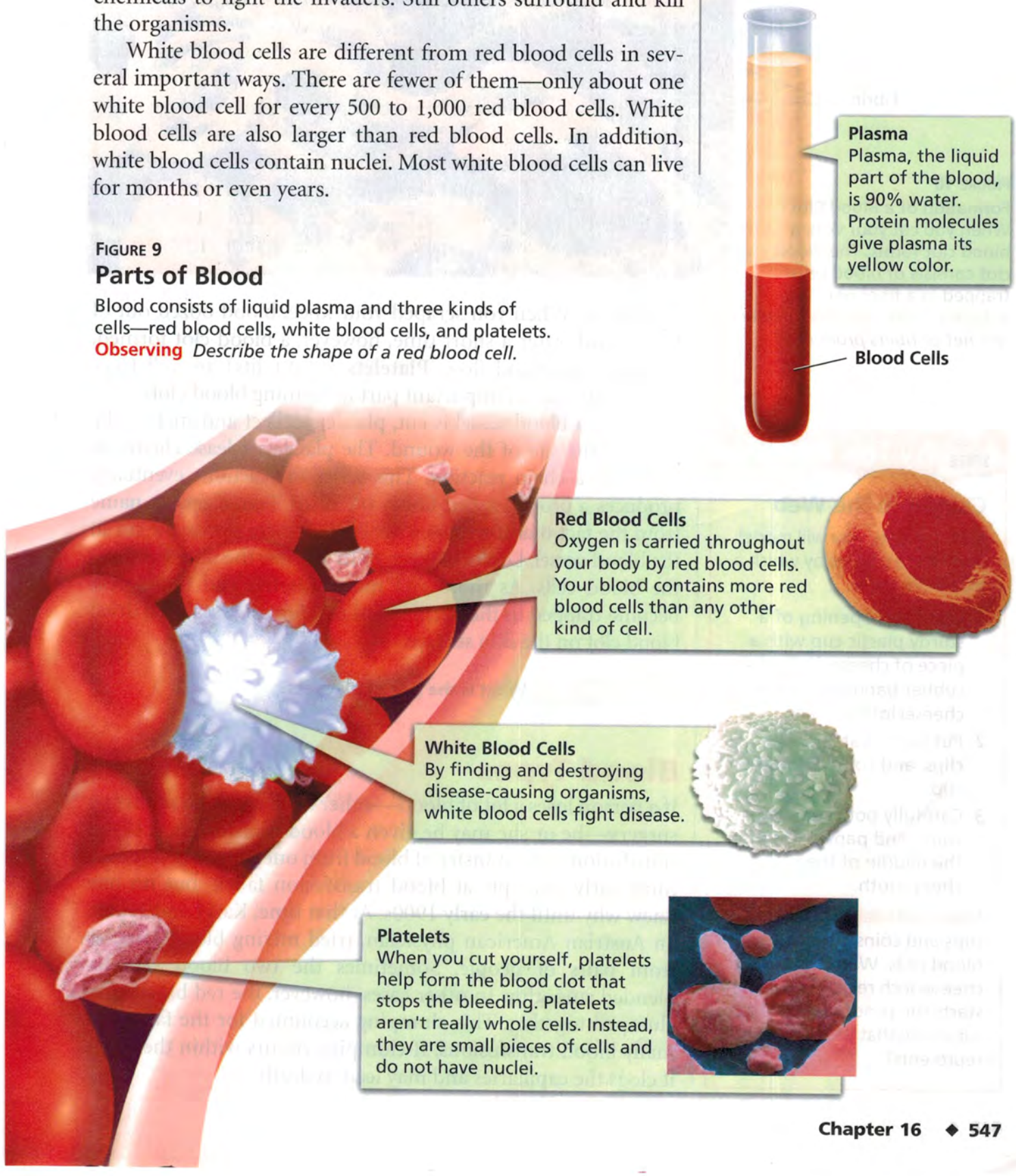


FIGURE 10
Formation of a Blood Clot
When you cut your skin, a blood clot forms. The blood clot consists of blood cells trapped in a fiber net.
Relating Cause and Effect *How is this net of fibers produced?*

Platelets When you scraped your knee, blood oozed out of the wound. After a short time, however, a blood clot formed, 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. Look at Figure 10 to see how the fiber net traps the 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.

Reading Checkpoint **What is the role of platelets?**

Lab zone Try This Activity

Caught in the Web

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?

Blood Types

If a person loses a lot of blood—either from a wound or during surgery—he or she may be given a blood transfusion. A blood transfusion is the transfer 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 lead to death.

Marker Molecules Landsteiner went on to discover that there are four major types of blood—A, B, AB, and O. Blood types are determined by proteins known as marker molecules that are on the 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. People with type O blood have neither A nor B markers.

Your plasma contains clumping proteins that recognize red blood cells with "foreign" markers (not yours) 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 11 shows which transfusions are safe for each blood type.

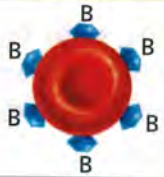
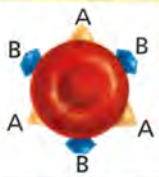
If you ever receive a transfusion, your blood type will be checked first. Then, donated blood that you can safely receive will be found. This process is called cross matching. You may have heard a doctor on a television show give the order to "type and cross." The doctor wants to find out what blood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

Go Online
NSTA SCILINKS

For: Links on blood
Visit: www.SciLinks.org
Web Code: scn-0433

FIGURE 11
Blood Types and Their Markers
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 Tables *What types of blood can be given safely to a person with blood type AB?*

Blood Types and Their Markers

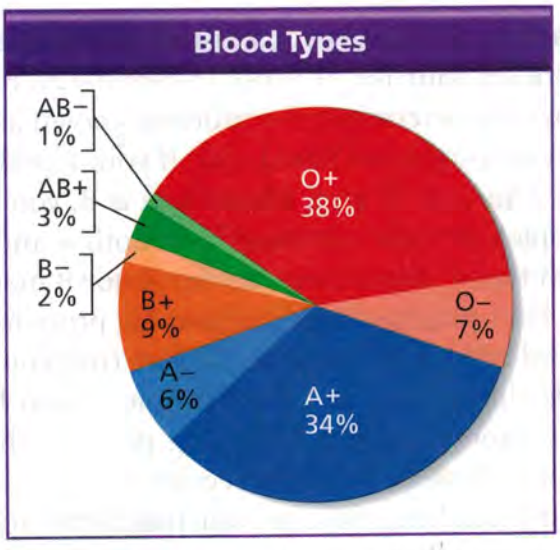
Blood Type Characteristic	Blood Type A	Blood Type B	Blood Type AB	Blood Type O
Marker Molecules on Red Blood Cells				
Clumping Proteins	anti-B	anti-A	no clumping proteins	anti-A and anti-B
Blood Types That Can Be Safely Received in a Transfusion	A and O	B and O	A, B, AB, and O	O

Math Analyzing Data

Blood Type Distribution

The circle graph shows the percentage of each blood type found in the U.S. population.

1. **Reading Graphs** What does each wedge of the graph represent?
2. **Interpreting Data** Rank the four major blood types—A, B, AB, and O—from least common to most common. What is the percentage of each type?
3. **Calculating** According to the graph, what percentage of the population is Rh positive? What percentage is Rh negative?
4. **Predicting** What type of blood can someone who is B negative (blood type B and Rh negative) receive? What percentage of the population does that represent?



5. **Creating Data Tables** Use the data to make a table of the eight possible blood types. Include columns for the A, B, AB, and O blood types and Rh factor (positive or negative), and a row for percentage of the population.

Rh Factor Landsteiner also discovered the presence of another protein on red blood cells, which he called Rh factor. About 85 percent of the people he tested had this protein, and about 15 percent lacked it. Like the A, B, AB, and O blood types, the presence of Rh factor is determined by a marker on the red blood cell. If your blood type is Rh positive, you have the Rh marker. If your blood type is Rh negative, you lack the marker on your cells. If you are Rh negative and ever received Rh positive blood, you would develop Rh clumping proteins in your plasma. This situation is potentially dangerous.

Reading Checkpoint **Where is the Rh marker found?**

The Lymphatic System

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 materials that the cells in the tissues need.

After bathing the cells, this fluid moves into your body's drainage system, called the **lymphatic system** (lim FAT ik). **The lymphatic system 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 excess 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 the fluid 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. The **lymph nodes** filter lymph, trapping bacteria and other disease-causing microorganisms in the fluid. When the body is fighting an infection, the lymph nodes enlarge. If you've ever had "swollen glands" when you've been sick, you've actually had swollen lymph nodes.

Reading Checkpoint **What is lymph?**

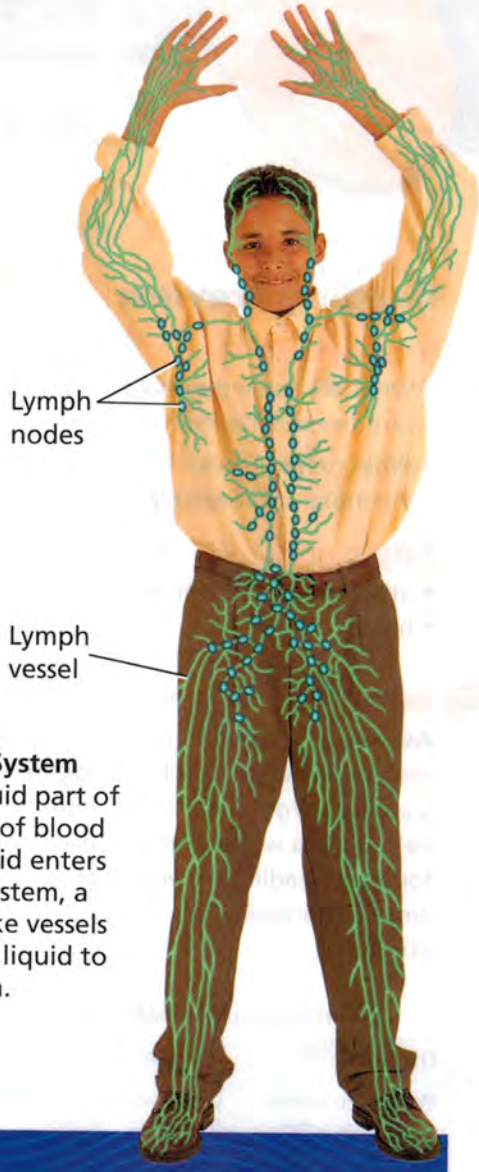


FIGURE 12
The Lymphatic System
Some of the liquid part of blood leaks out of blood vessels. This liquid enters the lymphatic system, a system of veinlike vessels that returns the liquid to the bloodstream.

Section 2 Assessment

Target Reading Skill **Identifying Main Ideas**
Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Listing** Name the four components of blood. Identify whether each is a cell, a part of a cell, or a liquid.
   b. **Summarizing** Briefly describe what happens to stop the bleeding when you cut yourself.
   c. **Relating Cause and Effect** People with the disorder hemophilia do not produce the protein fibrin. Explain why hemophilia is a serious disorder.
2. a. **Reviewing** What is a marker molecule?
   b. **Explaining** Explain why a person with type O blood cannot receive a transfusion of type A blood.
   c. **Predicting** Can a person with type AB, Rh negative blood safely receive a transfusion of type O, Rh negative blood? Explain.
3. a. **Identifying** Where does lymph come from?
   b. **Sequencing** What happens to lymph after it travels through the lymphatic system?

Lab zone At-Home Activity

What's Your Blood Type? If possible, find out your blood type. Explain to family members the types of blood you can receive and to whom you can donate blood. Create a chart to help with your explanation.

Section 3

Integrating Health

Cardiovascular Health

Reading Preview

Key Concepts

- What are some diseases of the cardiovascular system?
- What behaviors can help maintain cardiovascular health?

Key Terms

- atherosclerosis
- heart attack
- hypertension

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.

Cardiovascular Health

Question	Answer
What are some cardiovascular diseases?	Cardiovascular diseases include...

Lab zone 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?

Shortly after sunrise, when most people are just waking up, a team of rowers is 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. Inside their chests, their hearts are pounding, delivering blood to the arm and chest muscles that power the oars.

FIGURE 13
Exercising for Health
Strenuous exercise, such as rowing, requires a healthy cardiovascular system. In turn, exercise keeps the cardiovascular system healthy.

Healthy, unblocked artery

Partially blocked artery

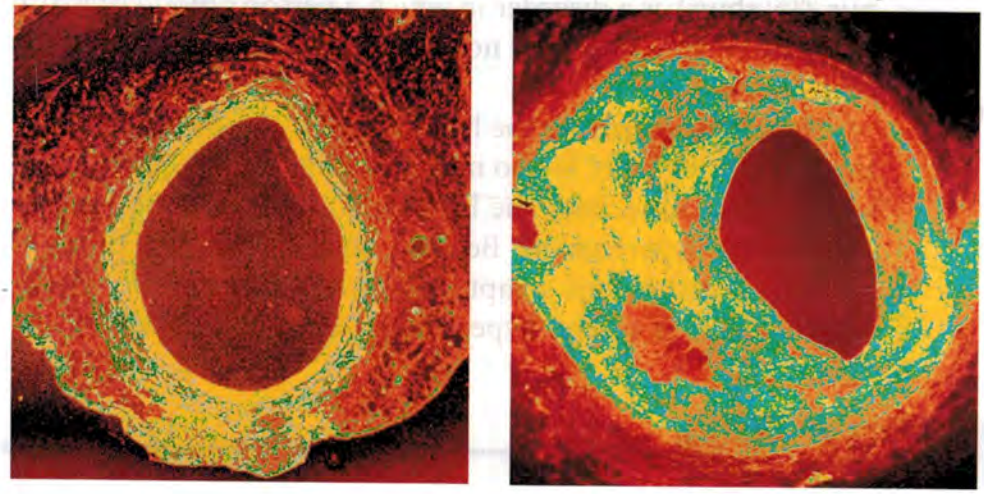


FIGURE 14
Effect of Atherosclerosis
The artery on the right shows atherosclerosis, which is caused by deposits of fat on the artery walls.
Relating Cause and Effect *What kind of diet can lead to atherosclerosis?*

Cardiovascular Diseases

Rowers cannot perform at their peaks unless their cardiovascular systems are in excellent condition. But cardiovascular health is important for all people, not just for athletes. Cardiovascular disease is the leading cause of death in the United States today. **Diseases of the cardiovascular system include atherosclerosis and hypertension.**

Atherosclerosis Compare the photos of the two arteries in Figure 14. 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 smaller 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 substance. Atherosclerosis results in a reduced flow of blood in the affected artery.

Atherosclerosis can develop in the coronary arteries, which supply the heart muscle. 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 and oxygen. 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 the blocked arteries.

Lab zone Try This Activity

Blocking the Flow

Use this activity to model 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. 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 paste along the bottom of the funnel's neck. Then, with a toothpick, carve out a hole in the paste 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.

Go Online
SCILINKS NSTA
For: Links on cardiovascular problems
Visit: www.SciLinks.org
Web Code: scn-0434

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—usually defined as greater than 140/90.

Hypertension makes the heart work harder to pump blood throughout the body. It also may damage the walls of the blood 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 of the danger until damage is severe, hypertension is sometimes called the "silent killer."

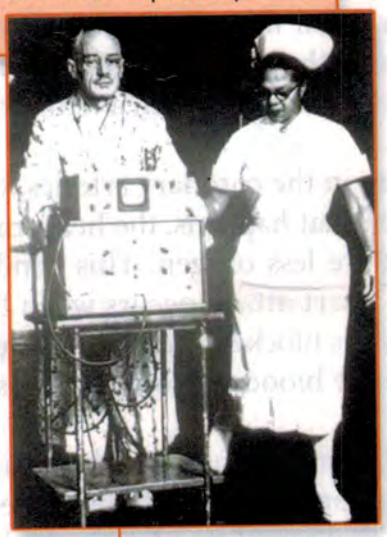
• Tech & Design in History •

Advances in Cardiovascular Medicine

Scientists today have an in-depth understanding of how the cardiovascular system works and how to treat cardiovascular problems. This timeline describes some of the advances in cardiovascular medicine.

1930s–1940s
Blood Banks
Charles Drew demonstrated that emergency blood transfusions could 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.

1958
Artificial Pacemaker
Electrical engineer Earl Baaken developed an external pacemaker to correct irregular heartbeats. A small electric generator connected to the pacemaker generated electric pulses that regulated heart rate. The first pacemakers had a fixed rate of 70 to 75 pulses per minute.



1961
Heart Valve Replacement
The first successful artificial heart valve was inserted into a patient's heart by surgeons Albert Starr and M. L. Edwards in Oregon. The valve was a rubberlike ball inside a stainless steel cage.

1930 1940 1950 1960

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

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

Writing in Science

Research and Write Choose one of the scientists whose work is described in the timeline. Imagine that you are on a committee that has chosen this scientist to receive an award. Write the speech you would give at the award ceremony, explaining the scientists 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.

1977
Angioplasty
The first coronary balloon angioplasty was performed by Andreas Gruentzig and a team of surgeons in San Francisco. A balloon is inserted into the coronary artery and inflated, thus opening the artery. In 2001, more than two million angioplasties were performed worldwide.

2001
Replacement Heart
The first replacement heart was implanted by a team of surgeons in Louisville, Kentucky. Unlike the first artificial heart, the Jarvik-7, the replacement heart has its own internal batteries. The patient does not have to be "plugged in" to an external power source. The first patient to receive the replacement heart lived for more than 500 days.

1970 1980 1990 2000

FIGURE 15
Eating for Health
Eating foods that are low in fat can help keep your cardiovascular system healthy.
Applying Concepts *What are some heart-healthy low-fat foods?*

Keeping Healthy

Few young people have heart attacks, but signs of atherosclerosis can be found in some people as young as 18 to 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 saturated fats and trans fats, cholesterol, and sodium; and avoid smoking.**

Exercise and Diet 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 strengthen your heart muscle and prevent atherosclerosis.

Foods that are high in cholesterol, saturated fats, and trans fats can lead to atherosclerosis. Foods such as red meats, eggs, and cheese are high in cholesterol. But because they also contain substances that your body needs, a smart approach might be to eat them only in small quantities. Foods that are high in saturated fat include butter, whole milk, and ice cream. Foods high in trans fat include margarine, potato chips, and doughnuts.

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

Reading Checkpoint **What are some foods that are high in cholesterol?**

Section 3 Assessment

Target Reading Skill **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. a. **Defining** What is atherosclerosis? What is hypertension?
   b. **Relating Cause and Effect** How do these two diseases affect the heart?
2. a. **Listing** List three things you can do to help your cardiovascular system stay healthy.
   b. **Explaining** Why it is important to exercise?
   c. **Inferring** Coronary heart disease is less common in some countries than in the United States. What factors might account for this difference?

Lab zone At-Home Activity

Heart-Healthy Activities With your family, discuss things you all can do to maintain heart health. Make a list of activities that you can enjoy together. You might also work with your family to cook and serve a "heart-healthy" meal. List the foods you would serve at the meal.

Lab zone Skills Lab

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

Problem

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

Skills Focus

interpreting data, drawing conclusions

Materials

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

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 four paper cups A, B, AB, and O. Fill each cup about one-third full with the model "blood" supplied by your teacher. Place 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 four petri dishes with a blood type: A, B, AB, or O. Place the petri dishes on a sheet of white paper.

Data Table

Donor: Type _____

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

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.
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. **Interpreting Data** Which blood types can safely receive a transfusion of type A blood? Type O blood?
2. **Inferring** Use what you know about marker molecules to explain why some transfusions of type A blood are safe while others are unsafe.
3. **Drawing Conclusions** If some blood types are not available, how might type O blood be useful?
4. **Communicating** Write a paragraph in which you discuss why it is important for hospitals to 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.

Chapter 16 Study Guide

The BIG Idea **Structure and Function** The circulatory system moves blood through the body, transports food, and enables the exchange of gases.

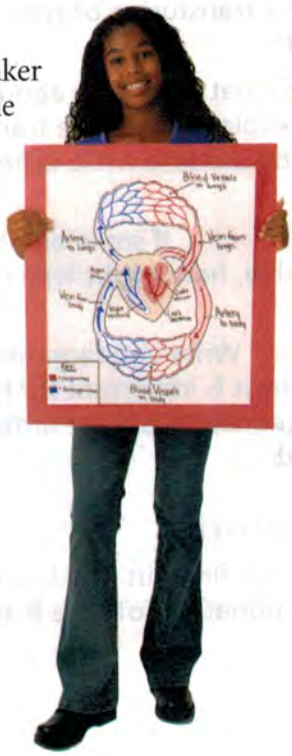
1 The Body's Transport System

Key Concepts

- The cardiovascular system carries needed substances to cells and carries waste products away from cells. In addition, blood contains cells that fight disease.
- The heart pushes blood through the cardiovascular system. The right side of the heart is separated from the left side by the septum. Each side has an upper chamber and a lower chamber.
- Blood circulates in two loops. First, it travels from the heart to the lungs and then back to the heart. Second, it is pumped from the heart to the body and then it returns to the heart.
- Blood leaves the heart through arteries. When it reaches the capillaries, materials are exchanged between the blood and the body's cells. Veins carry blood back to the heart. The walls of arteries and veins consist of three layers. Capillary walls are only one cell thick.

Key Terms

cardiovascular system
heart
atrium
pacemaker
ventricle
valve
artery
capillary
vein
aorta
coronary artery
pulse
diffusion
blood pressure



2 Blood and Lymph

Key Concepts

- Blood is made up of four components: plasma, red blood cells, white blood cells, and platelets.
- The marker molecules on your red blood cells determine your blood type and the type of blood that you can safely receive in transfusions.
- The lymphatic system is a network of vein-like vessels that returns the fluid to the bloodstream.

Key Terms

• plasma • red blood cell • hemoglobin
• white blood cell • platelet • lymphatic system
• lymph • lymph node

3 Cardiovascular Health

Key Concepts

- Diseases of the cardiovascular system include atherosclerosis and hypertension.
- To help maintain cardiovascular health, people should exercise regularly; eat a balanced diet that is low in saturated fats and trans fats, cholesterol, and sodium; and avoid smoking.

Key Terms

atherosclerosis
heart attack
hypertension

Review and Assessment

Go Online
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Visit: PHSchool.com
Web Code: cha-3160

Organizing Information

Comparing and Contrasting Copy the compare/contrast table about the two loops of the circulatory system onto a sheet of paper. Then complete it and add a title. (For more on Comparing and Contrasting, see the Skills Handbook.)

Loop	Side of heart where loop starts	Where blood flows to	Where blood returns to
Loop One	a. ?	Lungs	b. ?
Loop Two	Left side	c. ?	d. ?

Reviewing Key Terms

Choose the letter of the best answer.

1. The heart's upper chambers are called
   a. ventricles.
   b. atria.
   c. valves.
   d. arteries.
2. Nutrients are exchanged between the blood and body cells in the
   a. capillaries.
   b. veins.
   c. aorta.
   d. arteries.
3. The alternating expansion and relaxation of the artery that you feel in your wrist is your
   a. pulse.
   b. coronary artery.
   c. blood pressure.
   d. plasma.
4. Blood components that help the body to control bleeding are
   a. platelets.
   b. red blood cells.
   c. white blood cells.
   d. hemoglobin.
5. Cholesterol is a waxy substance associated with
   a. lymph nodes.
   b. white blood cells.
   c. atherosclerosis.
   d. plasma.

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 chambers of the heart are called <u>atria</u>.
7. The <u>veins</u> are the narrowest blood vessels in the body.
8. <u>White blood cells</u> contain hemoglobin.
9. The <u>lymphatic system</u> is involved in returning fluid to the bloodstream.
10. Elevated blood pressure is called <u>atherosclerosis</u>.

Writing in Science

Letter Write a letter to a friend describing what you do to stay active. For example, do you participate in team sports, jog, or take long walks with your dog? Include in your letter additional ways you can be even more active.

Discovery Channel School

Circulation
Video Preview
Video Field Trip
▶ Video Assessment

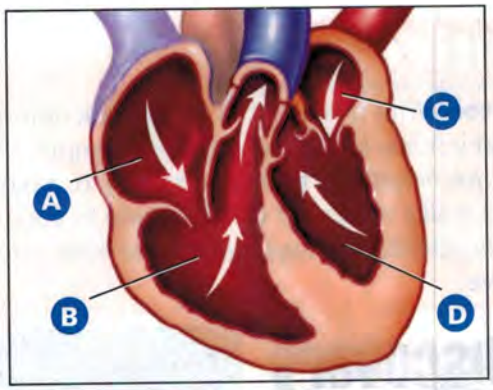
Review and Assessment

Checking Concepts

11. Contrast the forces with which the right and left ventricles contract. How does this relate to each ventricle's function?
12. A red blood cell is moving through an artery in your leg. Describe the path that the blood cell will follow back to your heart. Identify the chamber of the heart to which it will return.
13. How is a capillary's structure adapted to its function?
14. What is the function of hemoglobin?
15. What is lymph? How does lymph return to the cardiovascular system?
16. Give two reasons why food choices are important to cardiovascular health.

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. **Classifying** Which two chambers of the heart shown below are the ventricles? Through which chamber does oxygen-poor blood enter the heart from 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 is atherosclerosis sometimes called a "lifestyle disease"?

Math Practice

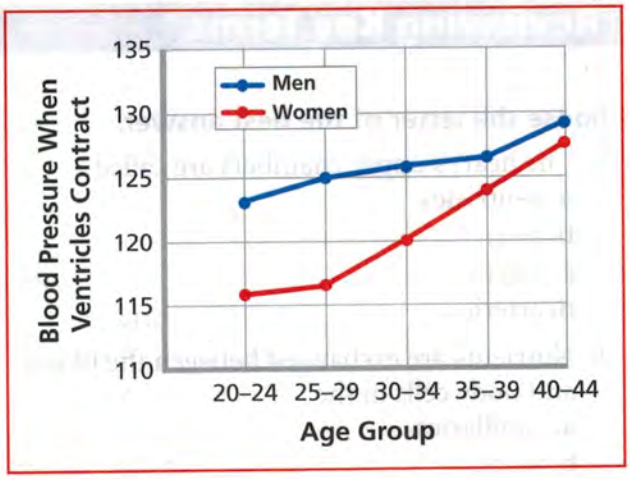
21. **Calculating a Rate** The veterinarian listens to your cat's heart and counts 30 beats in 15 seconds. What is your cat's heart rate?

Applying Skills

Use the graph to answer Questions 22–25.

The graph below shows how average blood pressure changes as men and women grow older.

Changes in Blood Pressure



22. **Reading Graphs** What is plotted on each axis?
23. **Interpreting Data** At age 20, who is likely to have higher blood pressure—men or women?
24. **Drawing Conclusions** In general, what happens to blood pressure as people age?
25. **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.

Lab zone Chapter Project

Performance Assessment 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.

Standardized Test Prep

Test-Taking Tip

Anticipating the Answer

You can sometimes figure out an answer to a question before you look at the answer choices. After you answer the question in your mind, compare your answer with the answer choices. Choose the answer that most closely matches your own answer. Try to answer the sample question below before you look at the answer choices.

Sample Question

The upper chambers of the heart are the

A ventricles.
B valves.
C atria.
D capillaries.

Answer

Choice **C** is correct because the blood that comes into the heart enters through the atria, the upper chambers of the heart. Choice **A** is incorrect because ventricles are the lower chambers of the heart. Choices **B** and **D** are incorrect because valves and capillaries are not heart chambers.

Choose the letter of the best answer.

1. The most important function of the cardiovascular system is to

A transport needed materials to body cells and remove wastes.
B provide structural support for the lungs.
C generate blood pressure so the arteries and veins do not collapse.
D produce blood and lymph.

2. The correct sequence for the path of blood through the body is

F heart—lungs—other body parts.
G heart—lungs—heart—other body parts.
H lungs—other body parts—heart.
J heart—other body parts—lungs—heart.

3. Which of the following is true about blood in the aorta?

A The blood is going to the lungs.
B The blood is oxygen-rich.
C The blood is dark red in color.
D The blood is going to the heart.

Use the table below and your knowledge of science to answer Questions 4 and 5.

Blood Types

Blood Type	Marker Molecules	Clumping Proteins
A	A	anti-B
B	B	anti-A
AB	A and B	none
O	none	anti-A and anti-B

4. A person who has type O blood can safely receive blood from a person with

F type O blood.
G type A blood.
H type AB blood.
J type B blood.

5. A person who has type O blood can safely donate blood to a person with

A type AB blood.
B type O blood.
C types A, B, AB, or O blood.
D type A or type B blood.

Constructed Response

6. Explain what blood pressure is and what causes it. How is blood pressure measured and what is the significance of the two numbers in a blood pressure reading? Why can high blood pressure be dangerous?

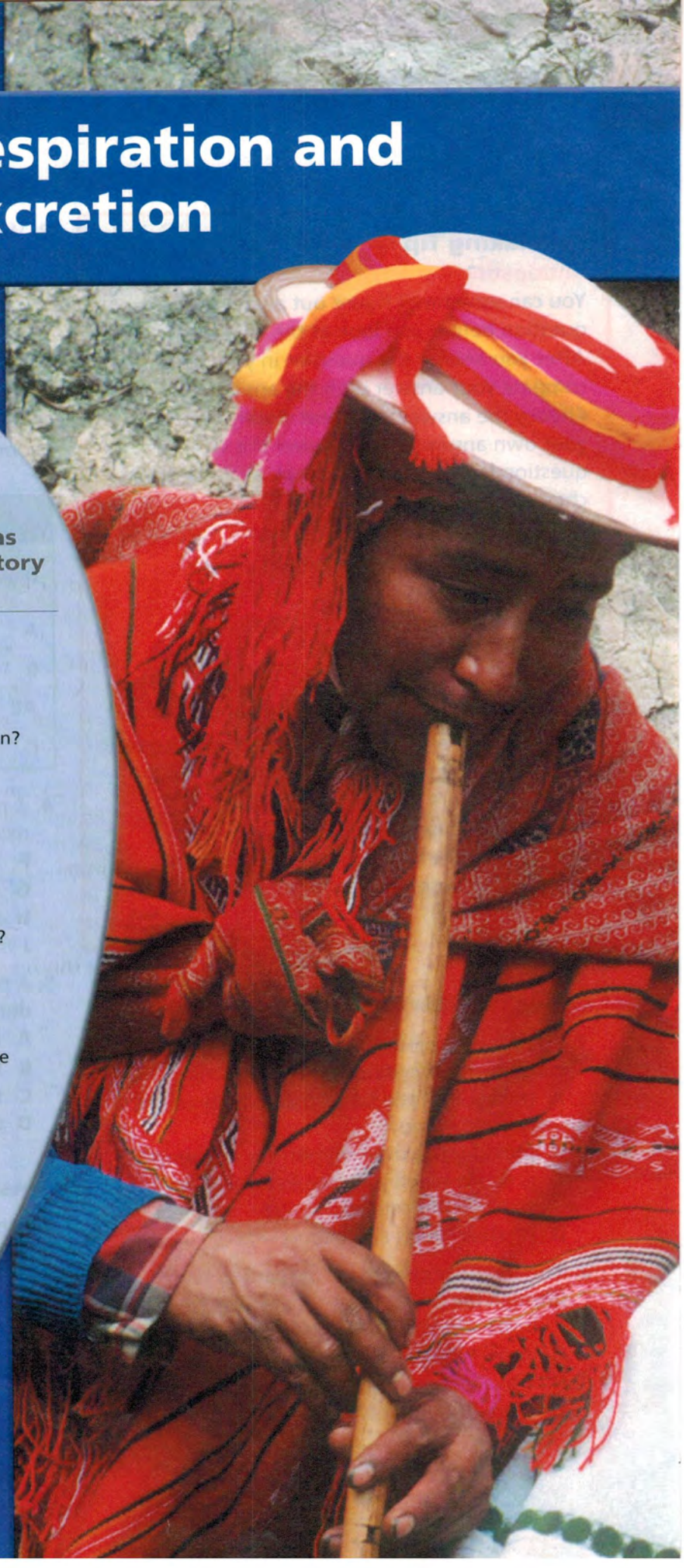
Chapter 17

Respiration and Excretion

The BIG Idea
Structure and Function

What are the major functions of the respiratory and excretory systems?

Chapter Preview



Playing the pan flute requires strong, healthy lungs.

Discovery CHANNEL SCHOOL

Respiration and Excretion

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

Get the Message Out

Imagine that you're part of a team of writers and designers who create advertisements. You've just been given the job of creating antismoking ads for different age groups. As you read this chapter and learn about the respiratory system, you can use your knowledge in your ad campaign.

Your Goal To design three different antismoking ads: one telling young children about the dangers of smoking, the second one discouraging teenagers from trying cigarettes, and the third encouraging adult smokers to quit

To complete this project successfully, each ad must

- accurately communicate at least three health risks associated with smoking
- address at least two pressures that influence people to start or continue smoking
- use images and words in convincing ways that gear your message to each audience

Plan It! Brainstorm a list of reasons why people smoke. Consider the possible influences of family and friends as well as that of ads, movies, videos, and television. Also, decide which types of ads you will produce, such as magazine ads or billboards. After your teacher approves your plan, begin to design your ads.

Section 1

The Respiratory System

Reading Preview

Key Concepts

- What are the functions of the respiratory system?
- What structures does air pass through as it travels to the lungs?
- What happens during gas exchange and breathing?

Key Terms

- respiration • cilia • pharynx
- trachea • bronchi • lungs
- alveoli • diaphragm • larynx
- vocal cords

Target Reading Skill

Sequencing As you read, make a flowchart that shows the path of air in the respiratory system. Write each step of the process in a separate box in the order in which it occurs.

Path of Air

Air enters the nose.

↓

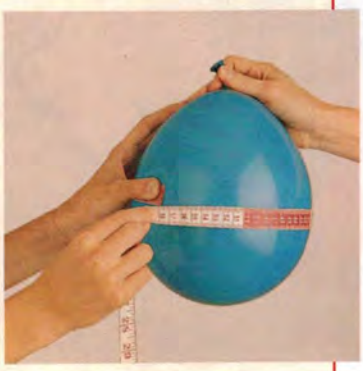
To the pharynx

↓

Lab zone Discover Activity

How Big Can You Blow Up a Balloon?

1. Take a normal breath, then blow as much air as possible into a balloon. Twist the end and hold it closed. Have your partner measure around the balloon at its widest point.
2. Let the air out of the balloon. Repeat Step 1 and calculate the average of the two measurements.
3. Compare your results with those of your classmates. The bigger the circumference, the greater the volume of air exhaled.



Think It Over

Inferring What factors might affect the volume of air a person can exhale?

Jerry, the main character in Doris Lessing's story "Through the Tunnel," is on vacation at the seaside. Day after day, he watches some older boys dive into deep water on one side of a huge rock. The boys mysteriously reappear on the other side. Jerry figures out that there must be an underwater tunnel in the rock. He finds the tunnel beneath the water and decides to swim through it. Once inside, though, he is terrified. The walls are slimy, and rocks scrape his body. He can barely see where he is going. But worst of all, Jerry has to hold his breath for far longer than ever before. The author describes Jerry this way: "His head was swelling, his lungs were cracking."

Hold your breath!

Respiratory System Functions

No one can go for very long without breathing. Your body cells need oxygen, and they get that oxygen from the air you breathe. **The respiratory system moves oxygen from the outside environment into the body. It also removes carbon dioxide and water from the body.**

Taking in Oxygen The oxygen your body needs comes from the atmosphere—the mixture of gases that blankets Earth. Your body doesn't use most of the other gases in the air you breathe in. When you exhale, most of the air goes back into the atmosphere.

Oxygen is needed for the energy-releasing chemical reactions that take place inside your cells. Like a fire, which cannot burn without oxygen, your cells cannot "burn" enough fuel to keep you alive without oxygen. The process in which oxygen and glucose undergo a complex series of chemical reactions inside cells is called **respiration.** Respiration, which is also called cellular respiration, is different from breathing. Breathing refers to the movement of air into and out of the lungs. Respiration, on the other hand, refers to the chemical reactions inside cells. As a result of respiration, your cells release the energy that fuels growth and other cell processes.

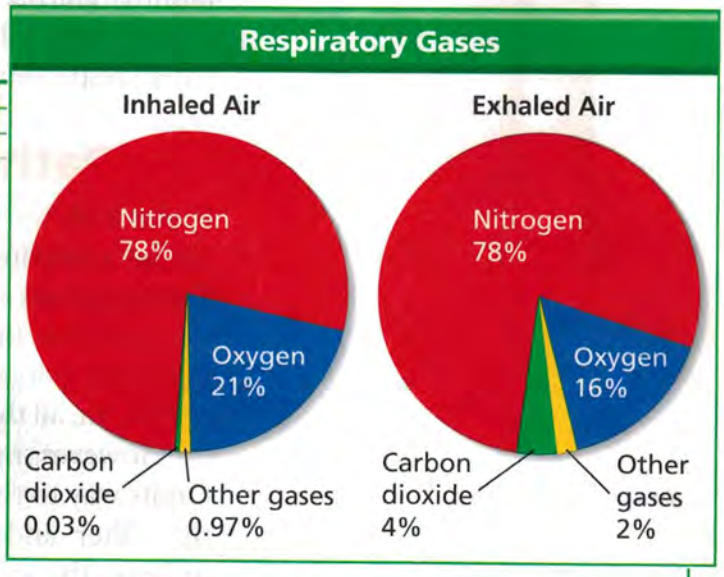
Removing Carbon Dioxide and Water In addition to the release of energy, respiration produces carbon dioxide and water. Your respiratory system eliminates the carbon dioxide and some of the water through your lungs.

Math Analyzing Data

The Air You Breathe

The air you breathe in contains several different gases, shown in the circle graph on the left. The air you breathe out contains the same gases, but in the amounts shown in the circle graph on the right.

1. **Reading Graphs** What does each wedge in the graphs represent?
2. **Interpreting Data** Based on the data, which gas is used by the body? Explain.
3. **Drawing Conclusions** Compare the percentage of carbon dioxide in inhaled air with the percentage in exhaled air. How can you account for the difference?

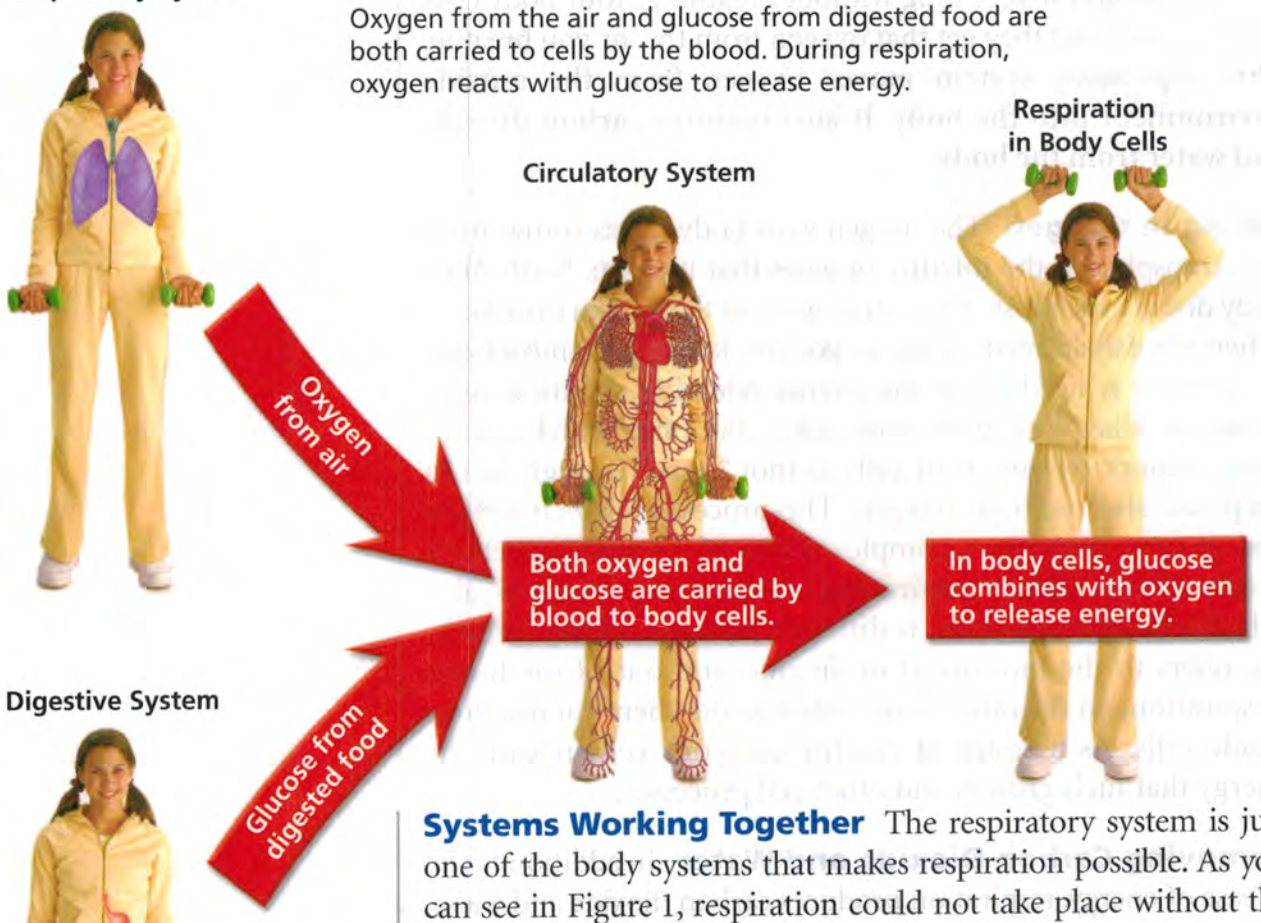


4. **Inferring** Explain why the percentage of nitrogen is the same in both inhaled air and exhaled air.

FIGURE 1

Fueling Your Cells

Oxygen from the air and glucose from digested food are both carried to cells by the blood. During respiration, oxygen reacts with glucose to release energy.



Systems Working Together The respiratory system is just one of the body systems that makes respiration possible. As you can see in Figure 1, respiration could not take place without the digestive and circulatory systems as well. Your respiratory system brings oxygen into your lungs. Meanwhile, your digestive system absorbs glucose from the food you eat. Then, your circulatory system carries both the oxygen and the glucose to your cells, where respiration occurs.

The Path of Air

If you look toward a window on a bright day, you may see tiny particles dancing in the air. These particles include such things as floating grains of dust, plant pollen, and ash from fires. Though you can't see them, air also contains microorganisms. Some of these microorganisms can cause diseases in humans. When you breathe in, all these materials enter your body along with the air.

However, most of these materials never reach your lungs. On its way to the lungs, air passes through a series of structures that filter and trap particles. These organs also warm and moisten the air. **As air travels from the outside environment to the lungs, it passes through the following structures: nose, pharynx, trachea, and bronchi.** It takes air only a few seconds to complete the route from the nose to the lungs.

The Nose Air enters the body through the nose and then moves into spaces called the nasal cavities. Some of the cells lining the nasal cavities produce mucus. This sticky material moistens the air and keeps the lining from drying out. Mucus also traps particles such as dust.

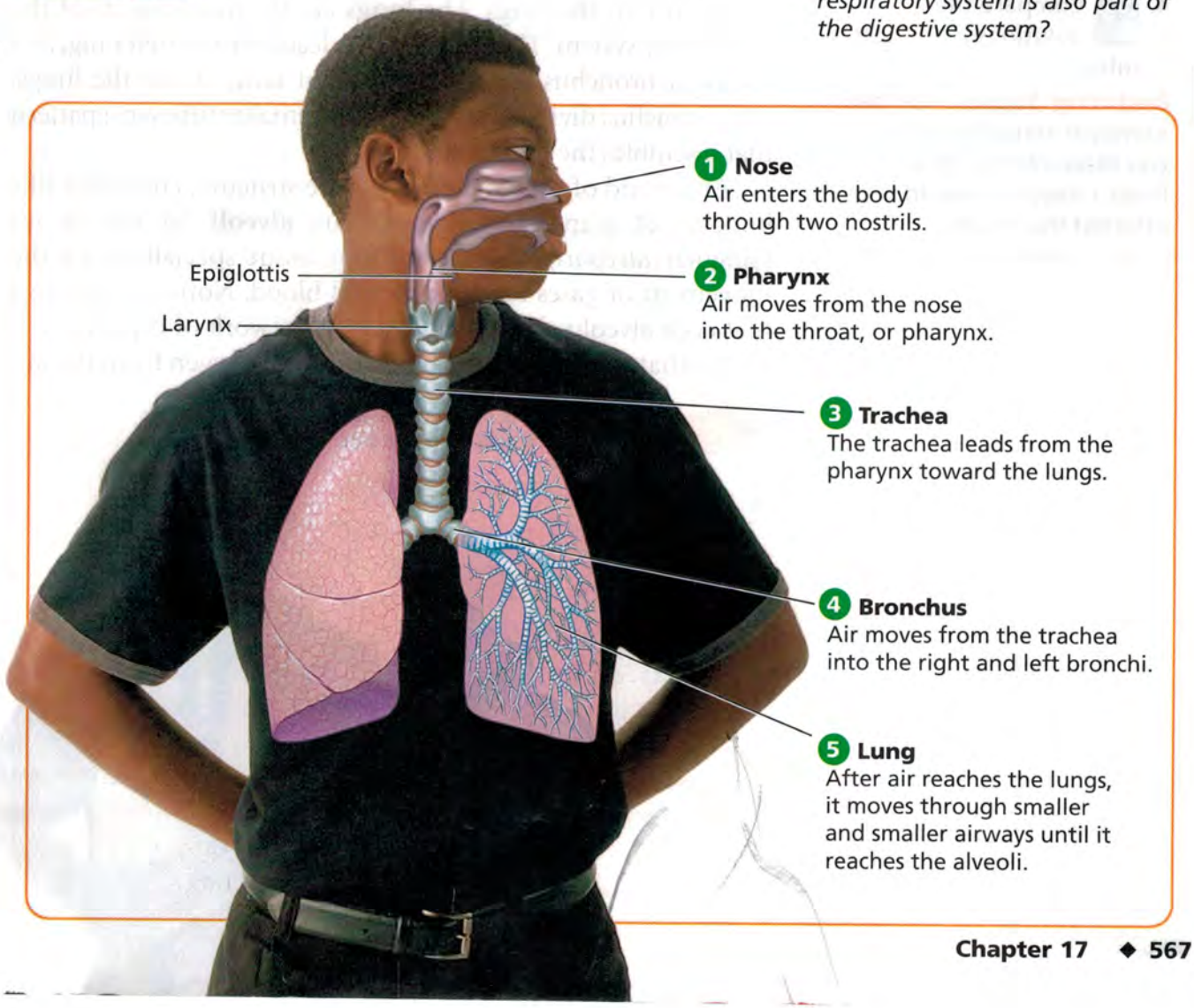
The cells that line the nasal cavities have **cilia** (SIL ee uh), tiny hairlike extensions that can move together in a sweeping motion. The cilia sweep the mucus into the throat, where you swallow it. Stomach acid destroys the mucus, along with everything trapped in it.

Some particles and bacteria can irritate the lining of your nose or throat, causing you to sneeze. The powerful force of a sneeze shoots the particles out of your nose and into the air.

The Pharynx Next, air enters the **pharynx** (FAR ingks), or throat. The pharynx is the only part of the respiratory system that is shared with another system—the digestive system. Both the nose and the mouth connect to the pharynx.

Reading Checkpoint **What is the role of cilia?**

FIGURE 2
The Respiratory System
On its path from outside the body into the lungs, air passes through several structures that clean, warm, and moisten it. Once in the lungs, the oxygen in the air can enter your bloodstream.
Classifying *Which part of the respiratory system is also part of the digestive system?*



Lab zone **Try This Activity**

What Do You Exhale?

Learn whether carbon dioxide is present in exhaled air.

1. Label two test tubes *A* and *B*.
2. Fill each test tube with 10 mL of water and a few drops of bromthymol blue solution. Bromthymol blue solution turns green or yellow in the presence of carbon dioxide.
3. Using a straw, gently blow air into the liquid in test tube A for a few seconds. **CAUTION:** *Do not suck the solution back through the straw.*
4. Compare the solutions in the test tubes.

Predicting Suppose you had exercised immediately before you blew into the straw. Predict how this would have affected the results.

The Trachea From the pharynx, air moves into the **trachea** (TRAY kee uh), or windpipe. You can feel your trachea if you gently run your fingers down the center of your neck. The trachea feels like a tube with a series of ridges. The firm ridges are rings of cartilage that strengthen the trachea and keep it open.

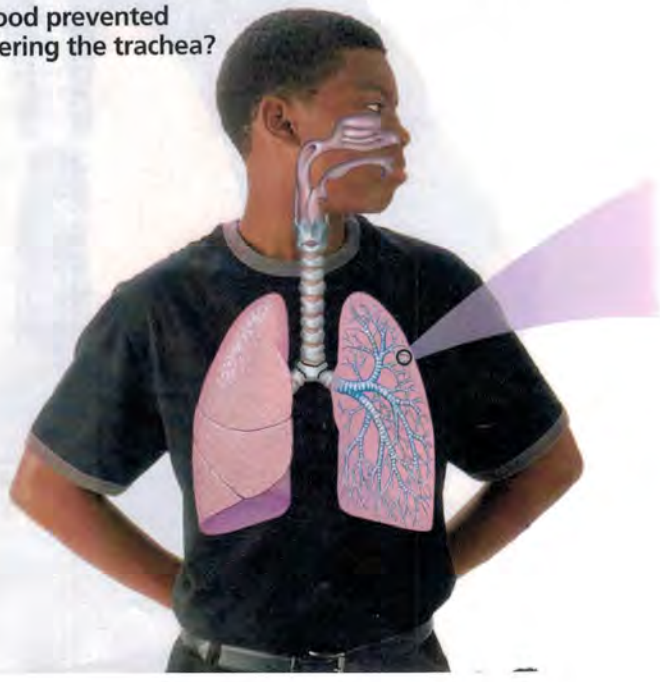
The trachea, like the nose, is lined with cilia and mucus. The cilia in the trachea sweep upward, moving mucus toward the pharynx, where it is swallowed. The trachea's cilia and mucus continue the cleaning and moistening of air that began in the nose. If particles irritate the lining of the trachea, you cough. A cough, like a sneeze, sends the particles into the air.

Normally, only air—not food—enters the trachea. If food does enter the trachea, the food can block the opening and prevent air from getting to the lungs. When that happens, a person chokes. Fortunately, food rarely gets into the trachea. The epiglottis, a small flap of tissue that folds over the trachea, seals off the trachea while you swallow.

The Bronchi and Lungs Air moves from the trachea to the **bronchi** (BRAHNG ky) (singular *bronchus*), the passages that direct air into the lungs. The **lungs** are the main organs of the respiratory system. The left bronchus leads into the left lung, and the right bronchus leads into the right lung. Inside the lungs, each bronchus divides into smaller and smaller tubes in a pattern that resembles the branches of a tree.

At the end of the smallest tubes are structures that look like bunches of grapes. The "grapes" are **alveoli** (al VEE uh ly) (singular *alveolus*), tiny sacs of lung tissue specialized for the movement of gases between air and blood. Notice in Figure 3 that each alveolus is surrounded by a network of capillaries. It is here that the blood picks up its cargo of oxygen from the air.

Reading Checkpoint **How is food prevented from entering the trachea?**



Gas Exchange

Because the walls of both the alveoli and the capillaries are very thin, certain materials can pass through them easily. **After air enters an alveolus, oxygen passes through the wall of the alveolus and then through the capillary wall into the blood. Carbon dioxide and water pass from the blood into the alveoli. This whole process is known as gas exchange.**

How Gas Exchange Occurs Imagine that you are a drop of blood beginning your journey through a capillary that wraps around an alveolus. When you begin that journey, you are carrying a lot of carbon dioxide and little oxygen. As you move through the capillary, oxygen gradually attaches to the hemoglobin in your red blood cells. At the same time, you are getting rid of carbon dioxide. At the end of your journey around the alveolus, you are rich in oxygen and poor in carbon dioxide.

FIGURE 3

Gas Exchange in the Alveoli

Alveoli are hollow air sacs surrounded by capillaries. As blood flows through the capillaries, oxygen moves from the alveoli into the blood. At the same time, carbon dioxide moves from the blood into the alveoli.

Interpreting Diagrams *How is the structure of the alveoli important for gas exchange?*

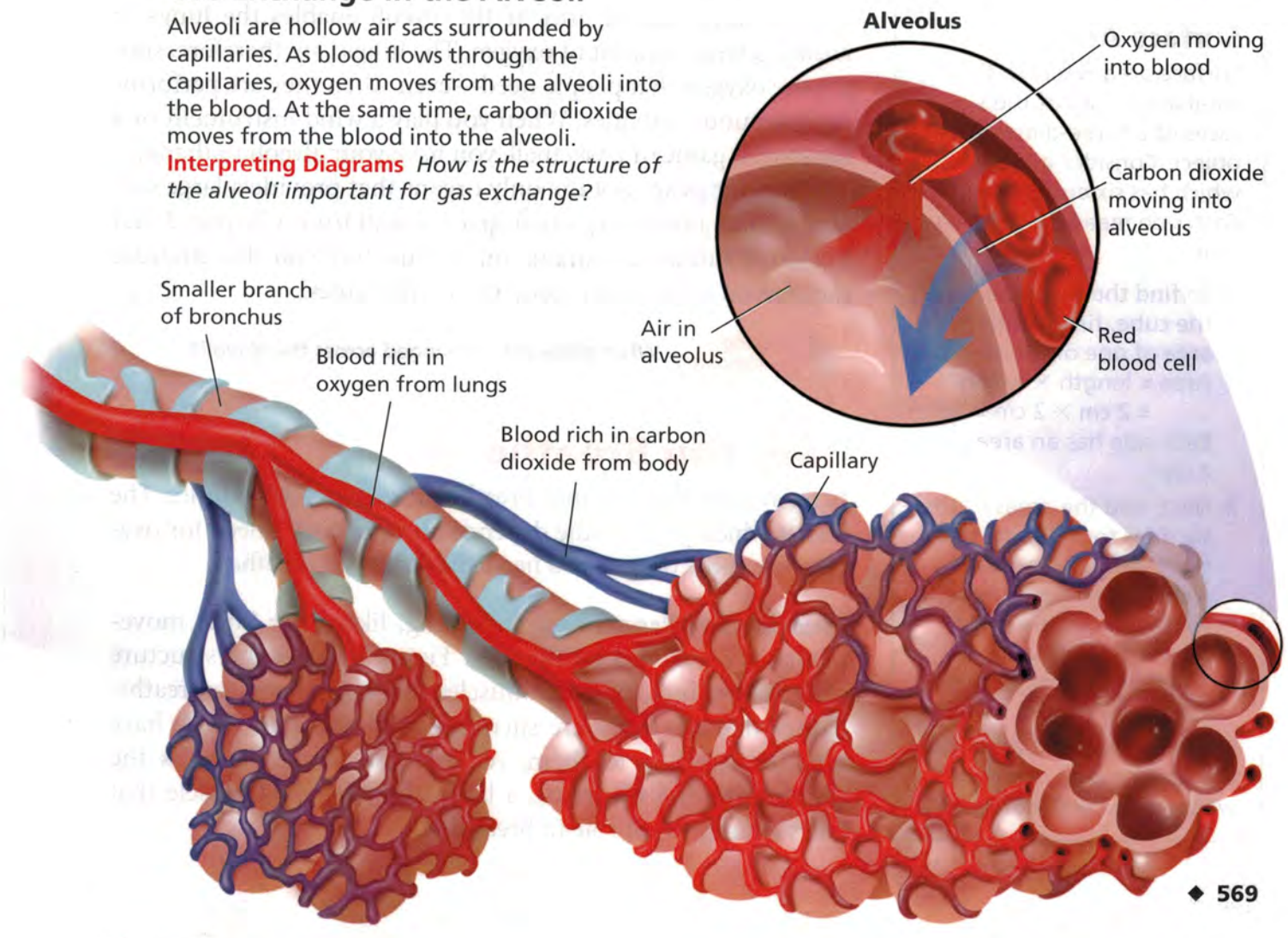


FIGURE 4
Oxygen for Activities
The huge surface area of the alveoli supplies the oxygen these trombone players need to march and play.

Surface Area for Gas Exchange Your lungs can absorb a large amount of oxygen because of the large surface area of the alveoli. An adult's lungs contain about 300 million alveoli. If you opened the alveoli and spread them out on a flat surface, you would have a surface area of about 70 square meters.

The huge surface area of the alveoli enables the lungs to absorb a large amount of oxygen. The lungs can, therefore, supply the oxygen that people need—even when they are performing strenuous activities. When you play a wind instrument or a fast-paced game of basketball, you have your alveoli to thank.

Your lungs are not the only organs that provide a large surface area in a relatively small space. Recall from Chapter 2 that the small intestine contains numerous, tiny villi that increase the surface available to absorb food molecules.

Reading Checkpoint **What gases are exchanged across the alveoli?**

How You Breathe

In an average day, you may breathe more than 20,000 times. The rate at which you breathe depends on your body's need for oxygen. The more oxygen you need, the faster you breathe.

Muscles for Breathing Breathing, like other body movements, is controlled by muscles. Figure 5 shows the structure of the chest, including the muscles that enable you to breathe. Notice that the lungs are surrounded by the ribs, which have muscles attached to them. At the base of the lungs is the **diaphragm** (DY uh fram), a large, dome-shaped muscle that plays an important role in breathing.

Math Skills

Surface Area

Surface area refers to the total area of all of the surfaces of a three-dimensional object. Consider a cube, which has six equal sides. Each side measures 2 cm by 2 cm.

1. To find the surface area of the cube, first calculate the area of one of the six sides:
   Area = length × width
   $= 2\ cm \times 2\ cm = 4\ cm^2$
   Each side has an area of $4\ cm^2$.
2. Next, add the areas of the six sides together to find the total surface area:
   $4\ cm^2 + 4\ cm^2 + 4\ cm^2 + 4\ cm^2 + 4\ cm^2 + 4\ cm^2 = 24\ cm^2$
   The surface area of the cube is $24\ cm^2$.

Practice Problem Calculate the surface area of a cube whose side measures 3 cm.

The Process of Breathing **When you breathe, the actions of your rib muscles and diaphragm expand or contract your chest. As a result, air flows in or out.**

Here's what happens when you inhale, or breathe in. The rib muscles contract, lifting the chest wall upward and outward. At the same time, the diaphragm contracts and moves downward. The combined action of these muscles makes the chest cavity larger. The same amount of air now occupies a larger space, causing the pressure of the air inside your lungs to decrease. This change means that the pressure of air inside the chest cavity is lower than the pressure of the atmosphere pushing on the body. Because of this difference in air pressure, air rushes into your chest, in the same way that air is sucked into a vacuum cleaner.

When you exhale, or breathe out, the rib muscles and diaphragm relax. This reduces the size of the chest cavity. This decrease in size squeezes air out of the lungs, the way squeezing a container of ketchup pushes ketchup out of the opening.

Reading Checkpoint **What muscles cause the chest to expand during breathing?**

FIGURE 5

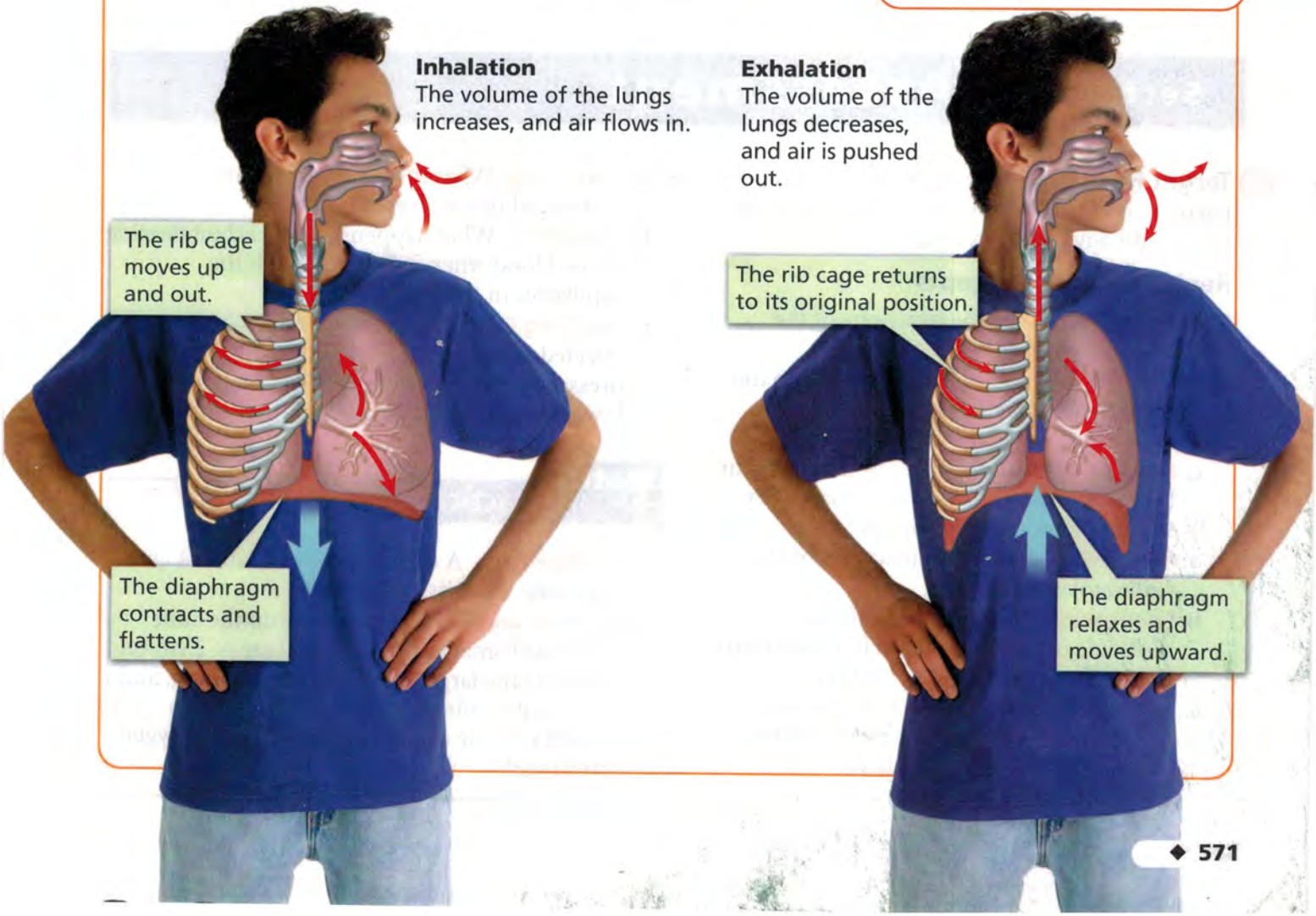
The Breathing Process

When you inhale, the diaphragm moves downward and pressure in the lungs decreases, causing air to flow in. When you exhale, the diaphragm moves upward and the pressure in the lungs increases, pushing the air out.

Interpreting Diagrams *How does the movement of the diaphragm affect the size of the chest cavity?*

Go Online active art

For: The Breathing Process activity
Visit: PHSchool.com
Web Code: cep-4041



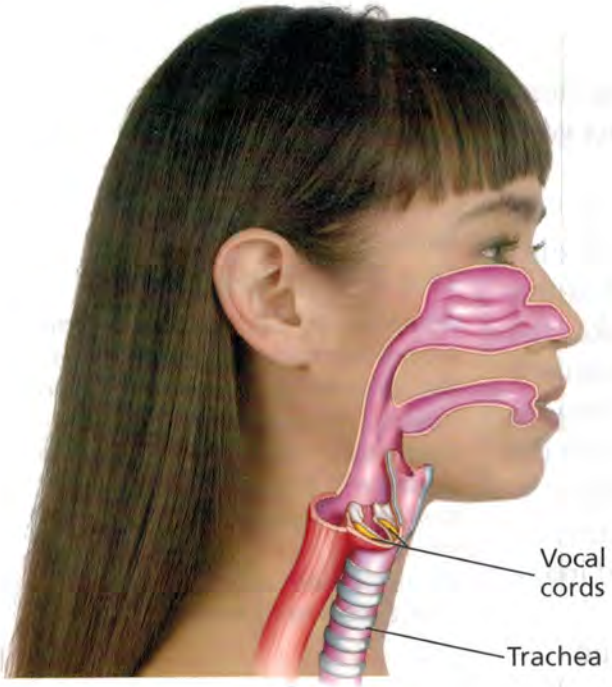


FIGURE 6
The Vocal Cords
Air moving over the vocal cords causes them to vibrate and produce sound.
Interpreting Diagrams *Where are the vocal cords located?*

Relating Breathing and Speaking The air that moves out of your lungs as you breathe also helps you speak. The **larynx** (LAR ingks), or voice box, is located in the top part of the trachea, underneath the epiglottis. Place your fingers on your Adam's apple, which sticks out from the front of your neck. You can feel some of the cartilage that makes up the larynx. Two **vocal cords,** folds of connective tissue that produce your voice, stretch across the opening of the larynx.

If you've ever let air out of a balloon while stretching its neck, you've heard the squeaking sound that the air makes. The neck of the balloon is something like your vocal cords. If you look at Figure 6 you can see that the vocal cords have a slitlike opening between them. When you speak, muscles make the vocal cords contract, narrowing the opening. Air from the lungs rushes through this opening. The movement of the vocal cords makes the air molecules vibrate, or move rapidly back and forth. This vibration creates a sound—your voice.

Section 1 Assessment

Target Reading Skill **Sequencing** With a partner, review your flowchart about the path of air. Add any necessary information.

Reviewing Key Concepts

1. a. **Listing** What are the functions of the respiratory system?
   b. **Comparing and Contrasting** Explain the difference between respiration and breathing.
   c. **Predicting** How might respiration in your body cells be affected if your respiratory system did not work properly?
2. a. **Identifying** Name the structures of the respiratory system.
   b. **Sequencing** Describe the path that a molecule of oxygen takes as it moves from the air outside your body into the alveoli.
   c. **Relating Cause and Effect** In a healthy person, how do coughing and sneezing protect the respiratory system?
3. a. **Reviewing** What three substances are exchanged in the alveoli?
   b. **Explaining** What happens to the carbon dioxide in the blood when it flows through the capillaries in the alveoli?
   c. **Applying Concepts** How would gas exchange be affected at the top of a tall mountain, where air pressure is lower and there is less oxygen than at lower elevations? Explain.

Math Practice

4. **Surface Area** A cube measures 4 cm × 4 cm on a side. Find its surface area.
5. **Surface Area** Suppose you cut up the cube into eight smaller cubes, each 2 cm × 2 cm on a side. If the larger cube represents a lung, and the smaller cubes represent alveoli, which would provide a larger surface area for oxygen exchange?

Lab zone **Skills Lab**

A Breath of Fresh Air

Problem

What causes your body to inhale and exhale air?

Skills Focus

making models, observing, drawing conclusions

Materials

- small balloon
- large balloon
- scissors
- transparent plastic bottle with narrow neck

Procedure

1. In your notebook, explain how you think air gets into the lungs during the breathing process.
2. Cut off and discard the bottom of a small plastic bottle. Trim the cut edge so there are no rough spots.
3. Stretch a small balloon; then blow it up a few times to stretch it further. Insert the round end of the balloon through the mouth of the bottle. Then, with a partner holding the bottle, stretch the neck of the balloon and pull it over the mouth of the bottle.
4. Stretch a large balloon; then blow it up a few times to stretch it further. Cut off and discard the balloon's neck.
5. Have a partner hold the bottle while you stretch the remaining part of the balloon over the bottom opening of the bottle, as shown in the photo.
6. Use one hand to hold the bottle firmly. With the knuckles of your other hand, push upward on the large balloon, causing it to form a dome. Remove your knuckles from the balloon, letting the balloon flatten. Repeat this procedure a few times. Observe what happens to the small balloon. Record your observations in your notebook.

Analyze and Conclude

1. **Making Models** Make a diagram of the completed model in your notebook. Add labels to show which parts of your model represent the chest cavity, diaphragm, lungs, and trachea.
2. **Observing** In this model, what is the position of the "diaphragm" just after you have made the model "exhale"? What do the lungs look like just after you have exhaled?
3. **Drawing Conclusions** In this model, how does the "diaphragm" move? How do these movements of the "diaphragm" affect the "lungs"?
4. **Communicating** Write a paragraph describing how this model shows that pressure changes are responsible for breathing.

More to Explore

How could you improve on this model to show more closely what happens in the chest cavity during the process of breathing? *Obtain your teacher's permission before carrying out your investigation.*

Section 2

Integrating Health

Smoking and Your Health

Reading Preview

Key Concepts

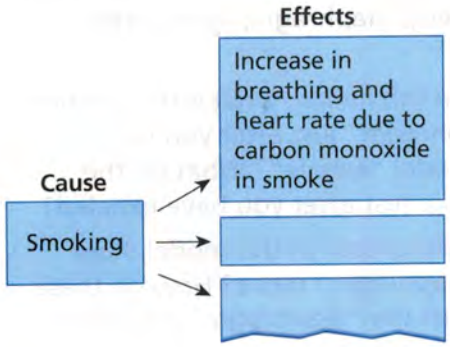
- What harmful chemicals are found in tobacco smoke?
- How can tobacco smoke affect a person's health over time?

Key Terms

- tar • carbon monoxide
- nicotine • addiction
- bronchitis • emphysema

Target Reading Skill

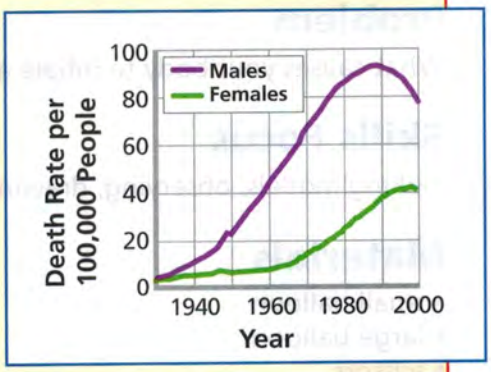
Relating Cause and Effect As you read, identify the effects of smoking on the body. Write the information in a graphic organizer like the one below.



Lab zone Discover Activity

What Are the Dangers of Smoking?

The graph shows the rate of lung cancer deaths in the United States from 1930 to 2000.



1. What was the rate of lung cancer deaths for males in 1930? For females?
2. What was the rate of lung cancer deaths for males in 1990? For females?
3. Did males or females show a faster rate of increase in the number of lung cancer deaths? How can you tell?
4. Cigarette smoking increased until 1965 but then decreased between 1965 and 1990. How does the trend in smoking compare with the rate of lung cancer deaths?

Think It Over

Predicting Do you think that the rate of lung cancer deaths is likely to increase, decrease, or remain the same by 2010? Explain.

Whoosh! Millions of tiny but dangerous aliens are invading the respiratory system. The aliens are pulled into the mouth with an inhaled breath. The cilia trap some aliens, and others get stuck in mucus. But thousands of the invaders get past these defenses and enter the lungs. The aliens then land on the surface of the alveoli!

The "aliens" are not tiny creatures from space. They are the substances found in cigarette smoke. In this section you will learn how tobacco smoke damages the respiratory system.

A heavy smoker may smoke two packs of cigarettes in a day.

Chemicals in Tobacco Smoke

With each puff, a smoker inhales more than 4,000 different chemicals. **Some of the most deadly chemicals in tobacco smoke are tar, carbon monoxide, and nicotine.**

Tar The dark, sticky substance that forms when tobacco burns is called **tar.** When someone inhales tobacco smoke, some tar settles on cilia that line the trachea, bronchi, and smaller airways. Tar makes cilia clump together so they can't function to prevent harmful materials from getting into the lungs. Tar also contains chemicals that have been shown to cause cancer.

Carbon Monoxide When substances—including tobacco—are burned, a colorless, odorless gas called **carbon monoxide** is produced. Carbon monoxide is dangerous because its molecules bind to hemoglobin in red blood cells. When carbon monoxide binds to hemoglobin, it takes the place of some of the oxygen that the red blood cells normally carry. The carbon monoxide molecules are something like cars that are parked in spaces reserved for other cars.

When carbon monoxide binds to hemoglobin, red blood cells carry less than their normal load of oxygen throughout the body. To make up for the decrease in oxygen, the breathing rate increases and the heart beats faster. Smokers' blood may contain too little oxygen to meet their bodies' needs.

Nicotine Another dangerous chemical found in tobacco is **nicotine.** Nicotine is a stimulant drug that increases the activities of the nervous system and heart. It makes the heart beat faster and increases blood pressure. Over time, nicotine produces an **addiction,** or physical dependence. Smokers feel an intense craving for a cigarette if they go without one. Addiction to nicotine is one reason why smokers have difficulty quitting.

Reading Checkpoint **How does the tar in cigarettes affect the body?**

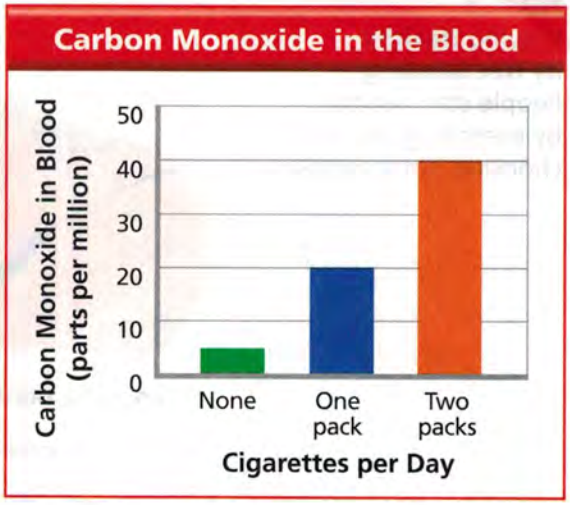


FIGURE 7
Carbon Monoxide in the Blood
The more cigarettes a person smokes, the more carbon monoxide he or she inhales.
Relating Cause and Effect *How does carbon monoxide deprive the body of oxygen?*

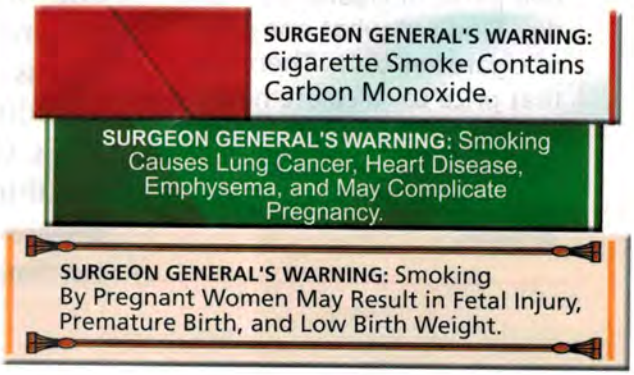


FIGURE 8
Staying Healthy by Not Smoking
People stay healthy by exercising and by choosing not to smoke.

Health Problems and Smoking

Tobacco smoke causes health problems in several ways. For example, because the cilia can't sweep away mucus, many smokers have a frequent cough. The mucus buildup also limits the space for airflow, thus decreasing oxygen intake. Because they are not getting enough oxygen, long-term or heavy smokers may be short of breath during even light exercise.

You probably know that smoking damages the respiratory system, but did you know that it strains the circulatory system as well? The respiratory and circulatory systems work together to get oxygen to body cells. If either system is damaged, the other one must work harder. Serious health problems can result from long-term smoking. **Over time, smokers can develop chronic bronchitis, emphysema, lung cancer, and atherosclerosis.** Every year in the United States, more than 400,000 people die from smoking-related illnesses. That's one out of every five deaths. Tobacco smoke is the most important preventable cause of major illness and death.

Chronic Bronchitis

Bronchitis (brahng KY tis) is an irritation of the breathing passages in which the small passages become narrower than normal and may be clogged with mucus. People with bronchitis have difficulty breathing. If the irritation continues over a long time, it is called chronic bronchitis. Chronic bronchitis can cause permanent damage to the breathing passages. It is often accompanied by infection with disease-causing microorganisms. Chronic bronchitis is five to ten times more common in heavy smokers than in nonsmokers.

Lab zone Skills Activity

Calculating

Heavy smokers may smoke two packs of cigarettes every day. Find out what one pack of cigarettes costs. Then, use that price to calculate how much a person would spend on cigarettes if he or she smoked two packs a day for 30 years.

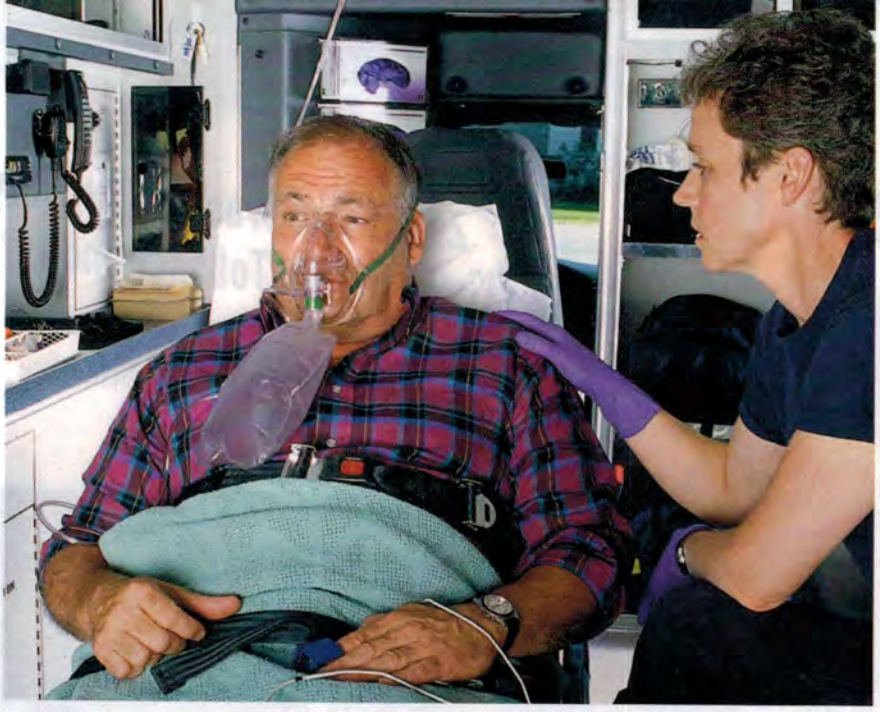
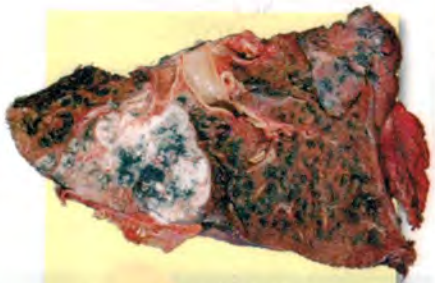


FIGURE 9
Effects of Smoking on the Lungs Over time, smoking damages the lungs and leads to serious health problems. **Comparing and Contrasting** *Compare the lungs of a person with emphysema and a person with lung cancer to the lung of a nonsmoker shown in Figure 8.*

Lung with emphysema



Lung with cancer

Emphysema The chemicals in tobacco smoke damage lung tissue as well as breathing passages. **Emphysema** (em fuh SEE muh) is a serious disease that destroys lung tissue and causes breathing difficulties. People with emphysema do not get enough oxygen and cannot adequately eliminate carbon dioxide. Therefore, they are always short of breath. Some people with emphysema even have trouble blowing out a match. Unfortunately, the damage caused by emphysema is permanent, even if a person stops smoking.

Lung Cancer About 140,000 Americans die each year from lung cancer caused by smoking. Cigarette smoke contains more than 50 different chemicals that cause cancer, including the chemicals in tar. Cancerous growths, or tumors, take away space in the lungs that are used for gas exchange. Unfortunately, lung cancer is rarely detected early, when treatment would be most effective.

Atherosclerosis The chemicals in tobacco smoke also harm the circulatory system. Some of the chemicals get into the blood and are absorbed by the blood vessels. The chemicals then irritate the walls of the blood vessels. This irritation contributes to the buildup of fatty material on the blood vessel walls that causes atherosclerosis. Atherosclerosis can lead to heart attacks. Compared to nonsmokers, smokers are more than twice as likely to have heart attacks.

Reading Checkpoint **How does emphysema affect a person's lungs?**

FIGURE 10
Passive Smoking
Billboards like this one increase people's awareness that nonsmokers can also suffer from the effects of tobacco smoke.

Go Online NSTA SCILINKS

For: Links on respiratory disorders
Visit: www.SciLinks.org
Web Code: scn-0442

Passive Smoking Smokers are not the only people to suffer from the effects of tobacco smoke. In passive smoking, people involuntarily inhale the smoke from other people's cigarettes, cigars, or pipes. This smoke contains the same harmful chemicals that smokers inhale. Each year, passive smoking is associated with the development of bronchitis and other respiratory problems, such as asthma, in about 300,000 young children in the United States.

Section 2 Assessment

Target Reading Skill **Relating Cause and Effect** Refer to your graphic organizer about the effects of smoking on the body to help you answer the questions below.

Reviewing Key Concepts

1. a. **Listing** What are three harmful substances in tobacco smoke?
   b. **Relating Cause and Effect** How does each of the harmful substances directly affect the body?
   c. **Developing Hypotheses** Why might nicotine-containing products, such as chewing gums or skin patches, help a person who is trying to quit smoking?
2. a. **Reviewing** Identify four health problems that can develop in smokers over time.
   b. **Describing** How does smoking contribute to atherosclerosis?
   c. **Inferring** What effect would it have on the circulatory system if a person quit smoking?

Lab zone At-Home Activity

Warning Labels With a family member, make a list of the warning statements found on cigarette labels. What chemicals found in tobacco smoke and health problems do the labels identify? Summarize the information you find to share with the class.

Section 3

The Excretory System

Reading Preview

Key Concepts

- What are the structures and functions of the excretory system?
- How do the kidneys filter wastes from the blood?
- How does excretion contribute to homeostasis?

Key Terms

- excretion • urea • kidney
- urine • ureter
- urinary bladder • urethra
- nephron

Target Reading Skill

Previewing Visuals Before you read, preview Figure 11. Then, write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

How the Kidneys Filter Wastes

Q. Where are nephrons located?
A.
Q.

Lab zone Discover Activity

How Does Filtering a Liquid Change the Liquid?

1. Your teacher will give you 50 mL of a liquid in a small container. Pour a small amount of sand into the liquid.
2. Use a glucose test strip to determine whether glucose is present in the liquid.
3. Put filter paper in a funnel. Then, put the funnel into the mouth of a second container. Slowly pour the liquid through the funnel into the second container.
4. Look for any solid material on the filter paper. Remove the funnel, and carefully examine the liquid that passed through the filter.
5. Test the liquid again to see whether it contains glucose.

Think It Over

Observing Which substances passed through the filter, and which did not? How might a filtering device be useful in the body?

The human body faces a challenge that is a bit like trying to keep your room clean. Magazines, notebook paper, and CD wrappers tend to pile up in your room. You use all of these things, but sooner or later you must clean your room if you don't want to be buried in trash. Something similar happens in your body. As your cells use nutrients in respiration and other processes, wastes are created. Different organs in the body have roles for the removal of these wastes. The removal process is known as **excretion.**

If wastes were not removed from your body, they would pile up and make you sick. Excretion helps keep the body's internal environment stable and free of harmful materials. **The excretory system is the system in the body that collects wastes produced by cells and removes the wastes from the body.**

The Excretory System

Two wastes that your body must eliminate are excess water and urea. **Urea** (yoo REE uh) is a chemical that comes from the breakdown of proteins. **The structures of the excretory system that eliminate urea, water, and other wastes include the kidneys, ureters, urinary bladder, and urethra.**

Your two **kidneys,** which are the major organs of the excretory system, remove urea and other wastes from the blood. The kidneys act like filters. They remove wastes but keep materials that the body needs. The wastes are eliminated in **urine,** a watery fluid that contains urea and other wastes. Urine flows from the kidneys through two narrow tubes called **ureters** (yoo REE turz). The ureters carry urine to the **urinary bladder,** a sacklike muscular organ that stores urine. Urine leaves the body through a small tube called the **urethra** (yoo REE thruh).

Reading Checkpoint **What is the role of the ureters?**

Filtration of Wastes

The kidneys are champion filters. Each of your kidneys contains about a million **nephrons,** tiny filtering factories that remove wastes from blood and produce urine. **The nephrons filter wastes in stages. First, both wastes and needed materials, such as glucose, are filtered out of the blood. Then, much of the needed material is returned to the blood, and the wastes are eliminated from the body.** Follow this process in Figure 11.

Filtering Out Wastes During the first stage of waste removal, blood enters the kidneys. Here, the blood flows through smaller and smaller arteries. Eventually it reaches a cluster of capillaries in a nephron. The capillaries are surrounded by a thin-walled, hollow capsule that is connected to a tube. In the capillary cluster, urea, glucose, and some water move out of the blood and into the capsule. Blood cells and most protein molecules do not move into the capsule. Instead, they remain in the capillaries.

Formation of Urine Urine forms from the filtered material in the capsule. This material flows through the long, twisting tube. As the liquid moves through the tube, many of the substances are returned to the blood. Normally, all the glucose, most of the water, and small amounts of other materials pass back into the blood in the capillaries that surround the tube. In contrast, urea and other wastes remain in the tube.

Lab zone Skills Activity

Classifying

A number of materials enter the kidney, where they are filtered by the nephrons.

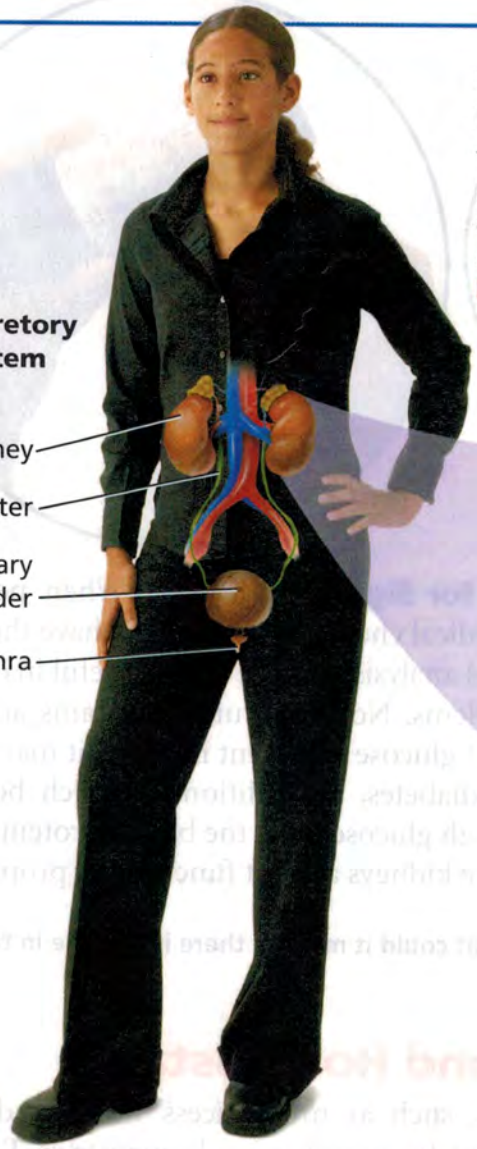
- What materials enter a nephron?
- What materials are returned to the blood?
- What materials leave the body in urine?

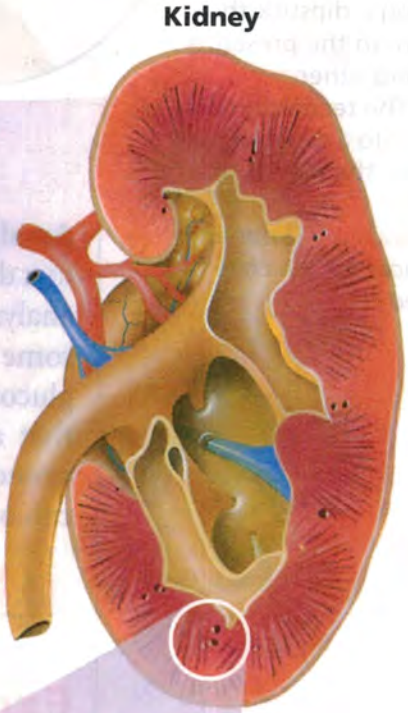
FIGURE 11

How the Kidneys Filter Wastes

The structures of the excretory system include the kidneys, urinary bladder, and urethra. Each kidney contains about a million tiny filtering units called nephrons. Urine is produced in the nephrons.

Interpreting Diagrams *Where are the kidneys located?*





1. Blood flows from an artery into a nephron in the kidney.
2. Blood reaches a cluster of capillaries. There, urea, water, glucose, and other materials are filtered out of the blood. These materials pass into a capsule that surrounds the capillaries.
3. The materials that were removed from the blood pass into a long, twisting tube. The tube is surrounded by capillaries.
4. As the filtered material flows through the tube, most of the water and glucose are reabsorbed into the blood. Most of the urea stays in the tube.
5. After the reabsorbing process is complete, the liquid that remains in the tube is called urine.

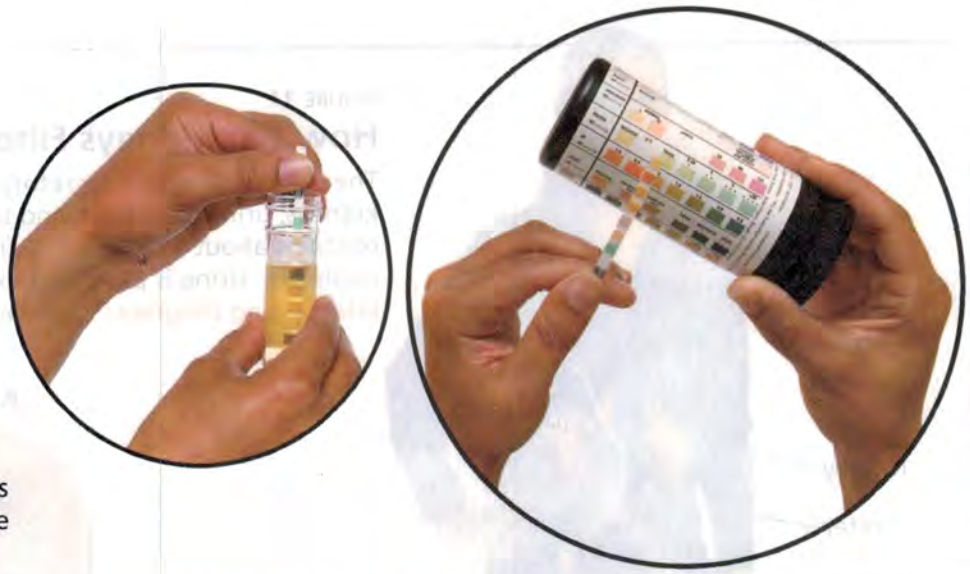


FIGURE 12
Analyzing Urine
Lab technicians can analyze urine by using a dipstick that changes color in the presence of glucose and other substances. The technician dips the dipstick into a urine sample and compares the results to a color chart.
Applying Concepts *What are two substances for which urine can be tested?*

Analyzing Urine for Signs of Disease When people go to a doctor for a medical checkup, they usually have their urine analyzed. A chemical analysis of urine can be useful in detecting some medical problems. Normally, urine contains almost no glucose or protein. If glucose is present in urine, it may indicate that a person has diabetes, a condition in which body cells cannot absorb enough glucose from the blood. Protein in urine can be a sign that the kidneys are not functioning properly.

Reading Checkpoint **What could it mean if there is glucose in the urine?**

Excretion and Homeostasis

Eliminating wastes, such as urea, excess water, and carbon dioxide, is important for maintaining homeostasis. **Excretion maintains homeostasis by keeping the body's internal environment stable and free of harmful levels of chemicals. In addition to the kidneys, organs of excretion that maintain homeostasis include the lungs, skin, and liver.**

Kidneys As the kidneys filter blood, they help to maintain homeostasis by regulating the amount of water in your body. Remember that as urine is being formed, water passes from the tube back into the bloodstream. The exact amount of water that is reabsorbed depends on conditions both outside and within the body. For example, suppose that it's a hot day. You've been sweating a lot, and you haven't had much to drink. In that situation, almost all of the water in the tube will be reabsorbed, and you will excrete only a small amount of urine. If, however, the day is cool and you've drunk a lot of water, less water will be reabsorbed. Your body will produce a larger volume of urine.

Go Online NSTA SCILINKS
For: Links on organs of excretion
Visit: www.SciLinks.org
Web Code: scn-0443

Lungs and Skin Most of the wastes produced by the body are removed through the kidneys. However, the lungs and skin remove some wastes from the body as well. When you exhale, carbon dioxide and some water are removed from the body by the lungs. Sweat glands in the skin also serve an excretory function because water and urea are excreted in perspiration.

Liver Have you ever torn apart a large pizza box so that it could fit into a wastebasket? If so, then you understand that some wastes need to be broken down before they can be excreted. The liver performs this function. For example, urea, which comes from the breakdown of proteins, is produced by the liver. The liver also converts part of the hemoglobin molecule from old red blood cells into substances such as bile. Because the liver produces a usable material from old red blood cells, you can think of the liver as a recycling facility.

FIGURE 13
Excretion Through the Lungs
Your lungs function as excretory organs. When you exhale on a cold morning, you can see the water in your breath.

Reading Checkpoint **What substances are excreted in perspiration?**

Section 3 Assessment

Target Reading Skill **Previewing Visuals** Compare your questions and answers about Figure 11 with those of a partner.

Reviewing Key Concepts

1. a. **Reviewing** What is the role of the excretory system in the body?
   b. **Sequencing** Name the structures of the excretory system in order of their roles in producing and eliminating urine. Describe the function of each structure.
2. a. **Reviewing** What are the two main stages of waste removal by the kidneys?
   b. **Describing** What happens as wastes are filtered in a nephron?
   c. **Relating Cause and Effect** Why is protein in the urine a sign that something could be wrong with the kidneys?
3. a. **Identifying** What is the role of excretion in maintaining homeostasis?
   b. **Explaining** How do the kidneys help maintain homeostasis?
   c. **Predicting** On a long bus trip, a traveler does not drink any water for several hours. How will the volume of urine she produces that day compare to the volume on a day when she drinks several glasses of water? Explain.

Writing in Science

Explanation Write a paragraph explaining how wastes are filtered in the kidneys. To help you with your writing, first make two lists—one that includes materials removed from the blood in the kidneys and one that includes materials returned to the blood.

Lab zone **Skills Lab**

Clues About Health

Problem

How can you test urine for the presence of glucose and protein?

Skills Focus

observing, interpreting data, drawing conclusions

Materials

- 6 test tubes
- test-tube rack
- 6 plastic droppers
- water
- glucose solution
- protein solution
- marking pencil
- white paper towels
- 6 glucose test strips
- Biuret solution
- 3 simulated urine samples

Procedure

PART 1 Testing for Glucose

1. Label six test tubes as follows: *W* for water, *G* for glucose, *P* for protein, and *A*, *B*, and *C* for three patients' "urine samples." Place the test tubes in a test-tube rack.
2. Label six glucose test strips with the same letters: *W*, *G*, *P*, *A*, *B*, and *C*.
3. Copy the data table into your notebook.
4. Fill each test tube about $\frac{3}{4}$ full with the solution that corresponds to its label.
5. Place glucose test strip W on a clean, dry section of a paper towel. Then, use a clean plastic dropper to place 2 drops of the water from test tube W on the test strip. Record the resulting color of the test strip in your data table. If no color change occurs, write "no reaction."
6. Use the procedure in Step 5 to test each of the other five solutions with the correctly labeled glucose test strip. Record the color of each test strip in the data table.

PART 2 Testing for Protein

7. Obtain a dropper bottle containing Biuret solution. Record the original color of the solution in your notebook.
8. Carefully add 30 drops of Biuret solution to test tube W. **CAUTION:** *Biuret solution can harm skin and damage clothing. Handle it with care.* Gently swirl the test tube to mix the two solutions together. Hold the test tube against a white paper towel to help you detect any color change. Observe the color of the final mixture, and record that color in your data table.
9. Repeat Step 8 for each of the other test tubes.

Data Table

	Test Tube					
Test for	W (water)	G (glucose)	P (protein)	A (Patient A)	B (Patient B)	C (Patient C)
Glucose						
Protein						

Analyze and Conclude

1. **Observing** What color reaction occurred when you used the glucose test strip on sample W? On sample G?
2. **Interpreting Data** What do the changes in color you observed in Part 1 indicate? Explain.
3. **Observing** What happened when you added Biuret solution to test tube W? To test tube P?
4. **Interpreting Data** What do the changes in color of the Biuret solution you observed in Part II indicate? Explain.
5. **Drawing Conclusions** Which of the three patients' urine samples tested normal? How do you know?
6. **Drawing Conclusions** Which urine sample(s) indicated that diabetes might be present? How do you know?
7. **Drawing Conclusions** Which urine sample(s) indicated that kidney disease might be present? How do you know?
8. **Communicating** Do you think a doctor should draw conclusions about the presence of a disease based on a single urine sample? Write a paragraph in which you discuss this question based on what you know about gathering data in experiments.

More to Explore

Propose a way to determine whether a patient with glucose in the urine could reduce the level through changes in diet.

Chapter 17 Study Guide

The BIG Idea **Structure and Function** The respiratory system enables the exchange of gases. The excretory system removes wastes from the body.

1 The Respiratory System

Key Concepts

- The respiratory system moves oxygen from the outside environment into the body. It also removes carbon dioxide and water from the body.
- As air travels from the outside environment to the lungs, it passes through the following structures: nose, pharynx, trachea, and bronchi.
- After air enters an alveolus, oxygen passes through the wall of the alveolus and then through the capillary wall into the blood. Carbon dioxide and water pass from the blood into the alveoli. This whole process is known as gas exchange.
- When you breathe, the actions of your rib muscles and diaphragm expand or contract your chest, causing air to flow in or out.

Key Terms

• respiration • cilia • pharynx • trachea
• bronchi • lungs • alveoli • diaphragm
• larynx • vocal cords

2 Smoking and Your Health

Key Concepts

- Some of the most deadly chemicals in tobacco smoke are tar, carbon monoxide, and nicotine.
- Over time, smokers can develop chronic bronchitis, emphysema, lung cancer, and atherosclerosis.

Key Terms

• tar • carbon monoxide • nicotine
• addiction • bronchitis • emphysema

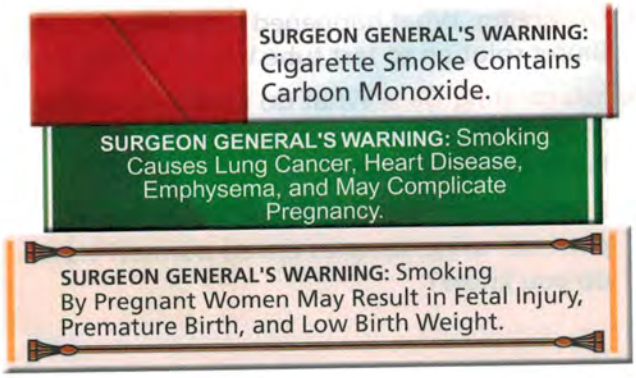
3 The Excretory System

Key Concepts

- The excretory system is the system in the body that collects wastes produced by cells and removes the wastes from the body.
- The structures of the excretory system that eliminate urea, water, and other wastes include the kidneys, ureters, the urinary bladder, and the urethra.
- The nephrons filter wastes in stages. First, both wastes and needed materials, such as glucose, are filtered from the blood into a nephron. Then, much of the needed material is returned to the blood, and the wastes are eliminated from the body.
- Excretion maintains homeostasis by keeping the body's internal environment stable and free of harmful levels of chemicals. In addition to the kidneys, organs of excretion that maintain homeostasis include the lungs, skin, and liver.

Key Terms

excretion
urea
kidney
urine
ureter
urinary bladder
urethra
nephron

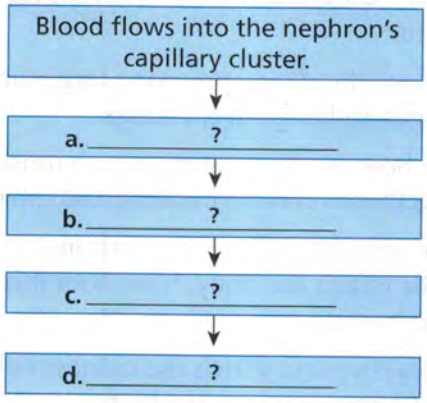


Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cea-4040

Organizing Information

Sequencing Copy the flowchart about excretion onto a separate sheet of paper. Then, fill in the empty spaces and add a title. (For more on Sequencing, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. The process in which glucose and oxygen react in cells to release energy is called
   a. excretion.
   b. respiration.
   c. bronchitis.
   d. emphysema.
2. The trachea divides into two tubes called
   a. bronchi.
   b. alveoli.
   c. ureters.
   d. vocal cords.
3. Your voice is produced by the
   a. pharynx. **b.** larynx.
   c. trachea. **d.** alveoli.
4. A colorless, odorless gas produced by burning tobacco is
   a. carbon monoxide.
   b. tar.
   c. nicotine.
   d. urea.
5. The filtration of wastes takes place inside the kidneys in the
   a. ureters.
   b. urethra.
   c. urinary bladder.
   d. nephrons.

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

6. Dust particles trapped in mucus are swept away by tiny, hairlike <u>alveoli</u>.
7. Clusters of air sacs in the lungs are <u>bronchi</u>.
8. <u>Tar</u> is a chemical in tobacco smoke that makes the heart beat faster.
9. Urine leaves the body through the <u>ureter</u>.
10. Urine is stored in the <u>urethra</u>.

Writing in Science

Informational Brochure Pretend you are a doctor advising high-altitude climbers. Develop an informational brochure that focuses on the effects that high altitude has on the human body. Be sure to include one method climbers can use to become used to the higher altitudes.

Discovery CHANNEL SCHOOL

Respiration and Excretion
Video Preview
Video Field Trip
▶ Video Assessment

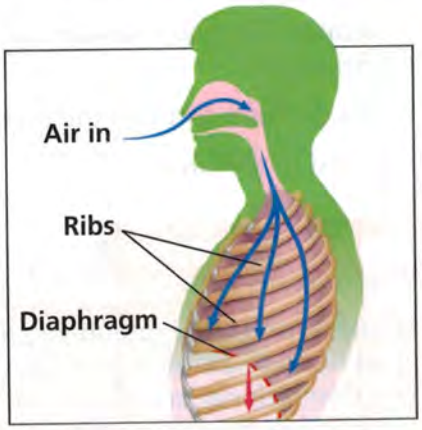
Review and Assessment

Checking Concepts

11. Explain the difference between breathing and respiration.
12. Explain how the alveoli provide a large surface area for gas exchange in the lungs.
13. Describe how the diaphragm and rib muscles work together to control inhaling and exhaling.
14. Describe what happens when carbon monoxide enters the body. How does this affect the body?
15. Explain two ways in which the kidneys help to maintain homeostasis in the body.

Thinking Critically

16. **Comparing and Contrasting** How is respiration similar to the burning of fuel? How is it different?
17. **Relating Cause and Effect** What process is shown in the diagram below? What role do changes in pressure play in this process?



18. **Applying Concepts** Explain how babies can develop smoking-related respiratory problems.
19. **Making Judgments** Do you think that drugstores, which sell medicines, should also sell cigarettes and other tobacco products? Why or why not?
20. **Predicting** If the walls of the capillary cluster in a nephron were damaged or broken, what substance might you expect to find in urine that is not normally present? Explain.

Math Practice

21. **Surface Area** Which has a greater surface area, a cube that is 2 cm × 2 cm on a side, or eight cubes that are each 1 cm × 1 cm on a side? Show your work.

Applying Skills

Use your knowledge of the excretory system and the information in the data table below to answer Questions 22–25.

Average Daily Water Loss in Humans (mL)

Source	Normal Weather	Hot Weather	Extended Heavy Exercise
Lungs	350	250	650
Urine	1,400	1,200	500
Sweat	450	1,750	5,350
Digestive waste	200	200	200

22. **Interpreting Data** Identify the major source of water loss during normal weather and the major source of water loss during hot weather.
23. **Drawing Conclusions** How do the data for normal weather and hot weather show that the body is maintaining homeostasis?
24. **Calculating** What is the total amount of water lost on a hot-weather day? What is the total amount of water lost during extended heavy exercise?
25. **Inferring** Use the data to explain why it is important to drink a lot of water when you are exercising heavily.

Lab zone Chapter Project

Performance Assessment Your three anti-smoking ads should be ready for display. Be prepared to explain why you chose the message you did for each group of viewers. What health risks do each of your ads identify? Why do you think your ads would be effective?