Chapter 14

Circulation and Respiration

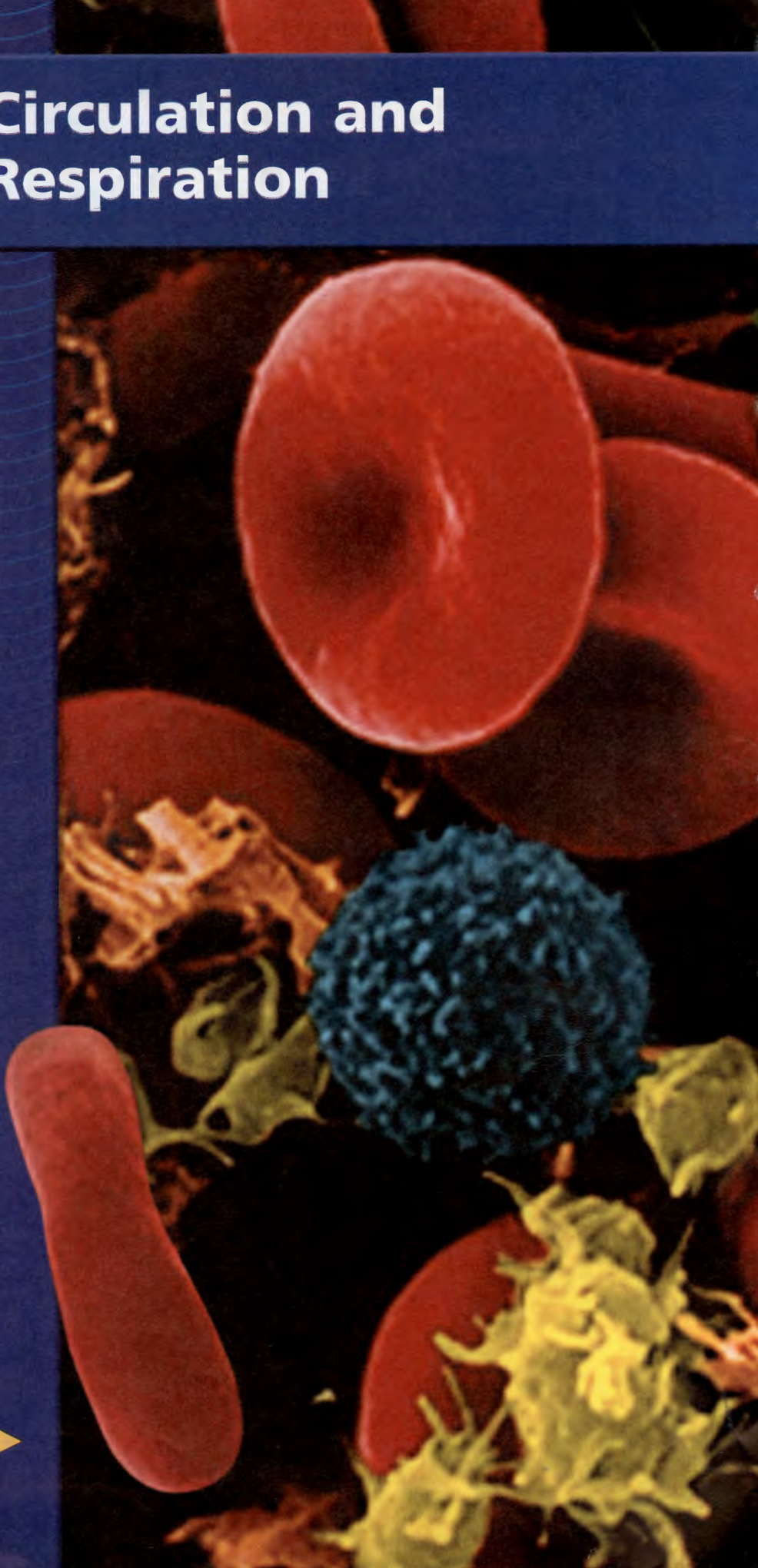
CALIFORNIA Standards Preview

S 7.5 The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. As a basis for understanding this concept:

- **a.** Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
- **b.** Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

S 7.6 Physical principles underlie biological structures and functions. As a basis for understanding this concept:

- **j.** Students know that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system.



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

Video Preview

Discovery Channel School

Circulation

S 7.5.b

Focus on the
BIG Idea

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

Check What You Know

Suppose you are blowing up balloons for a sports rally at school. How is the air you take into your lungs different from the air you blow into a balloon? Explain how this difference occurs.

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

High-Use Academic Words

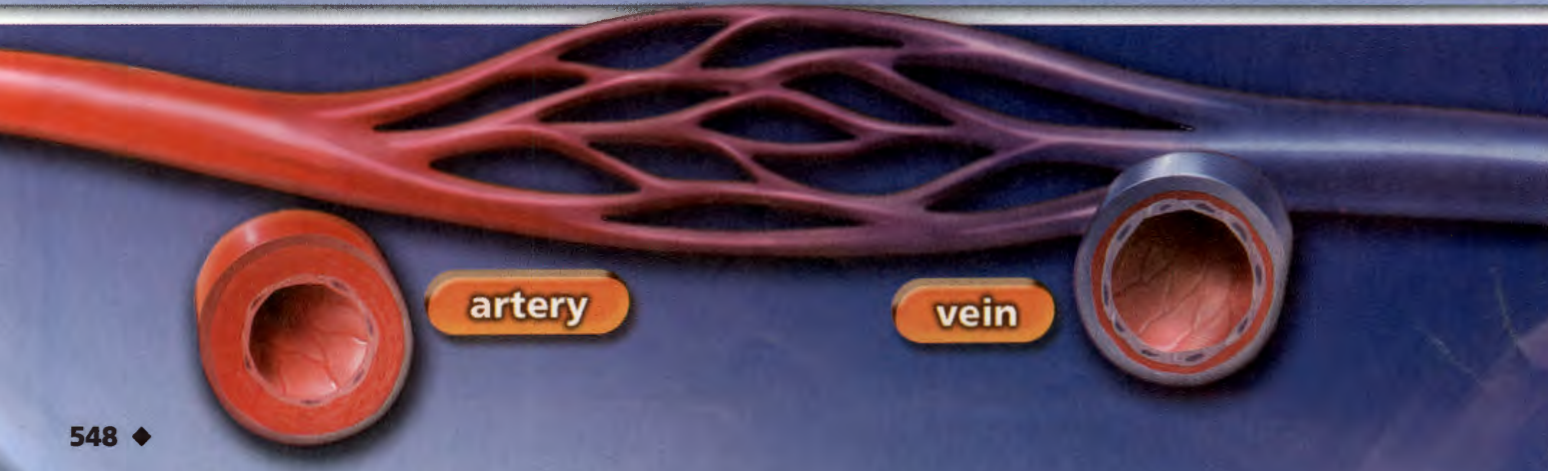
High-use academic words are words that are used frequently in classrooms. You and your teachers use these words when you discuss the subjects you study. Look for these words in this chapter.

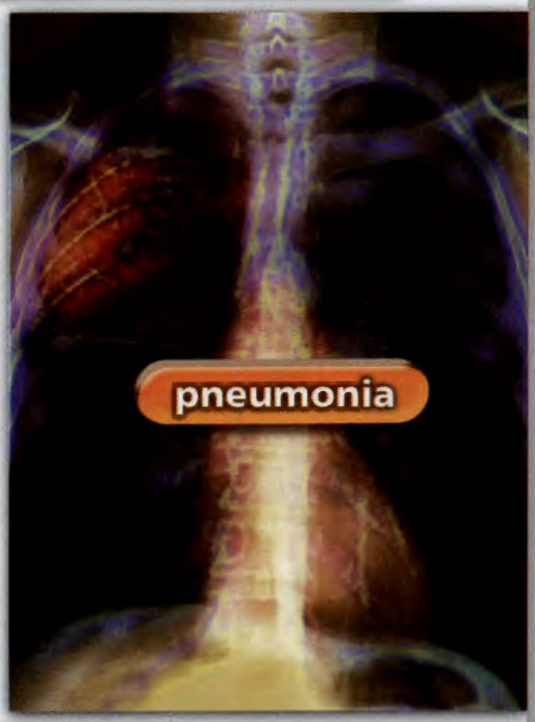
Word	Definition	Example Sentence
detect (dee TEKT) p. 553	*v.* To find out or discover	Lisa searched in the grass, trying to detect a four-leaf clover.
regulate (REG yuh layt) p. 563	*v.* To control, direct, or govern according to rule	A small device regulates the temperature in the building.
complex (Kahm PLEKS) p. 571	*adj.* Not simple; involved, complicated	The inside of a computer has a complex network of wires.
contribute (kun TRIB yoot) p. 584	*v.* To give or provide; to bring about a result	Physical activity can contribute to your good health.

Apply It!

Choose the word that best completes the sentence.

1. The doctor used several tests to _____ the disease.
2. One group of cells in the heart help _____ the rate at which the heart beats.
3. Blood is a _____ tissue that has several parts.
4. Air pollution can _____ to problems with breathing.





Chapter 14 Vocabulary

Section 1 (page 552)

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

Section 2 (page 563)

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

Section 3 (page 570)

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

Section 4 (page 580)

atherosclerosis
heart attack
hypertension
stroke
emphysema
bronchitis
asthma
suffocation
pneumonia

Interactive Textbook

Build Science Vocabulary Online
Visit: PHSchool.com
Web Code: cvj-4140

How to Read Science

Reading Skill

TARGET SKILL

Sequence

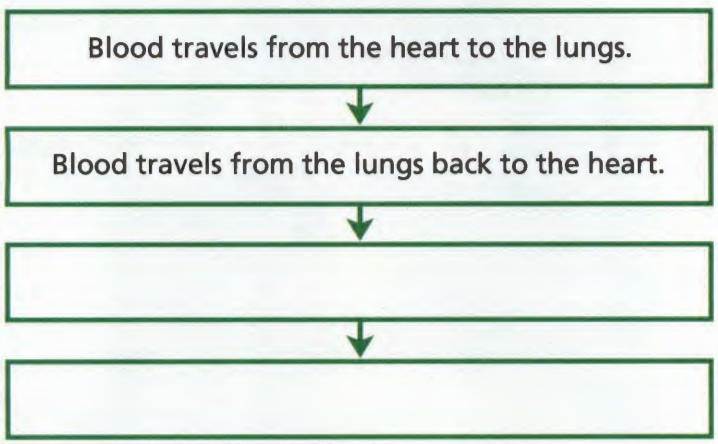
Sequence is the order in which events happen. Often science textbooks describe a sequence of events. Sometimes the text uses signal words like *first, second,* and *then* to show a sequence. Look for the sequence of events in the paragraph below.

> Blood flows through the body in something like a figure eight. 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 to the heart again.

Apply It!

In your notebook, complete the flowchart below by showing the sequence of the second loop.

Blood Flow



Lab zone

Standards Investigation

S 7.5.a, 7.5.b

Travels of a Red Blood Cell

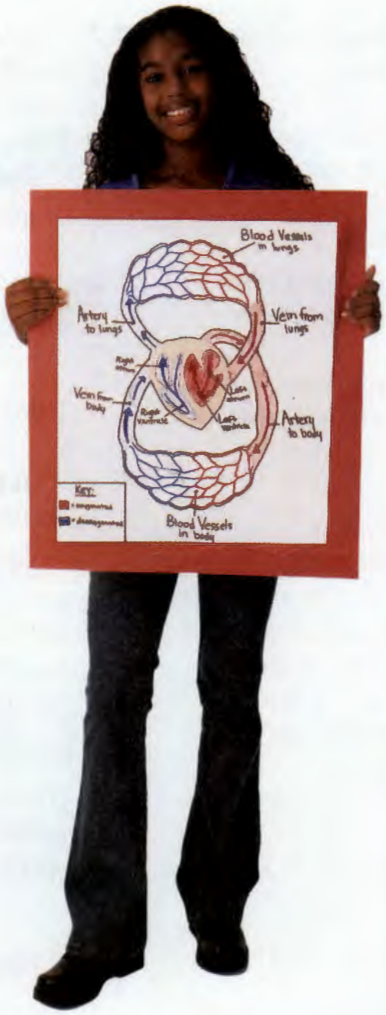
Every day, you travel from home to school and back home again. Your travel path makes a loop, or circuit, ending where it began. In this chapter, you'll learn how your blood also travels in circuits. In this investigation, you'll create a display to show how blood cells circulate and function throughout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

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

S 7.6.j Students know that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system.

- 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 • pressure
- blood pressure

Lab zone Standards Warm-Up

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 detect and kill the microorganisms and help you get well.

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

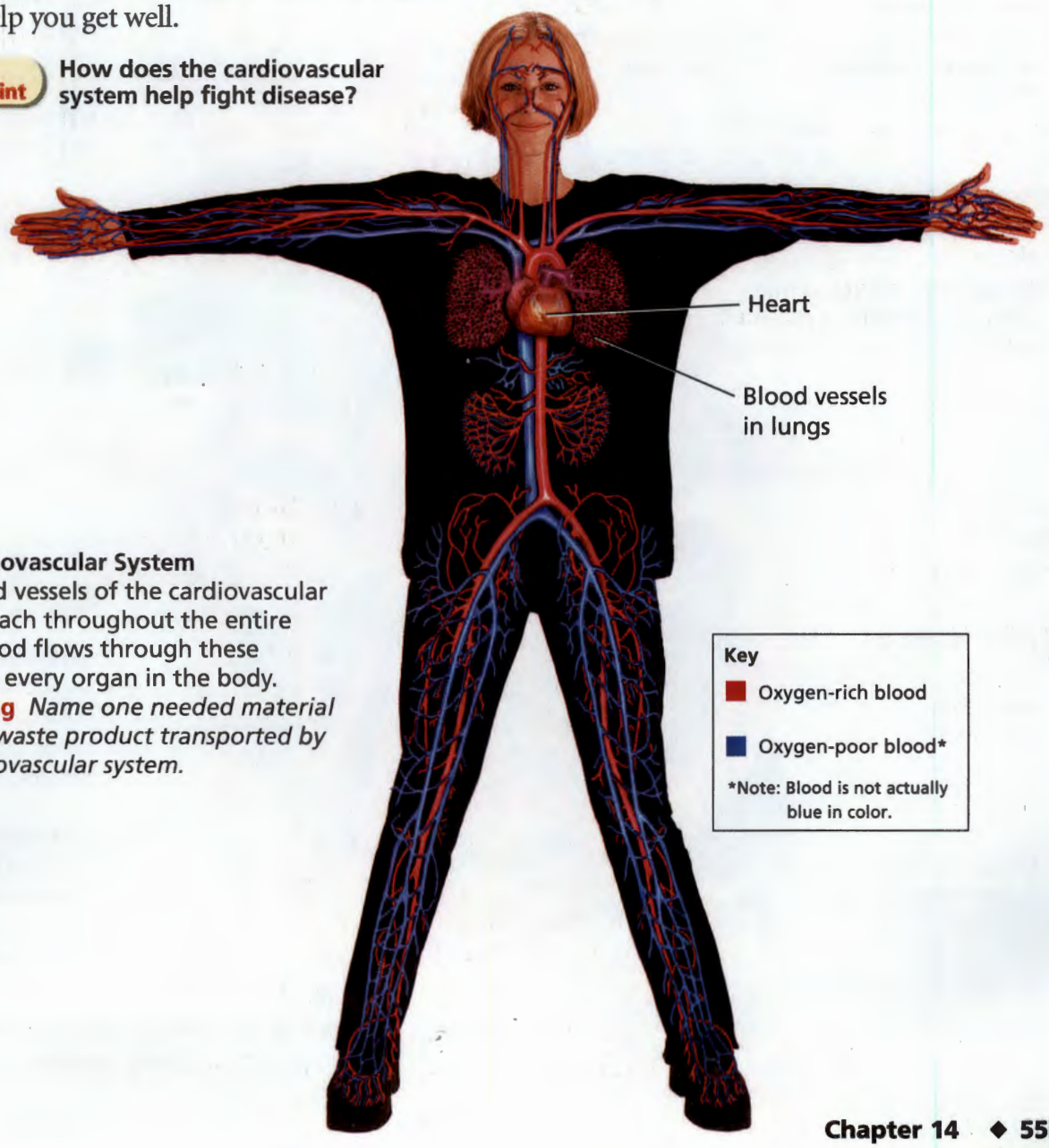


FIGURE 1
The Cardiovascular System
The blood vessels of the cardiovascular system reach throughout the entire body. Blood flows through these vessels to every organ in the body.
Classifying *Name one needed material and one waste product transported by the cardiovascular system.*

Go Online
active art

For: The Heart activity
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Web Code: cep-4031

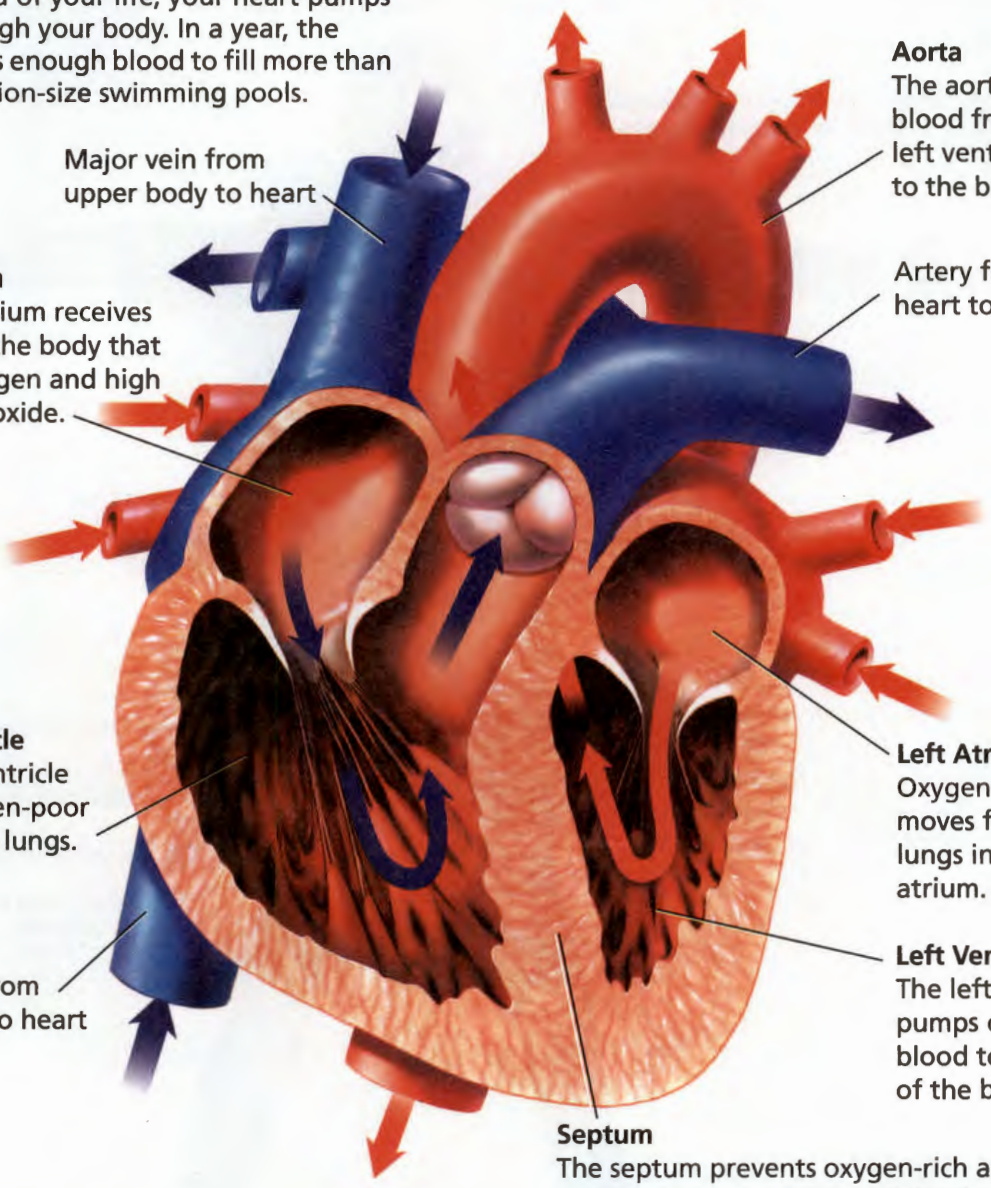
The Heart

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 tissue, which can contract over and over without getting tired.

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 blood vessels. 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?**

Video Field Trip
Discovery Channel School
Circulation

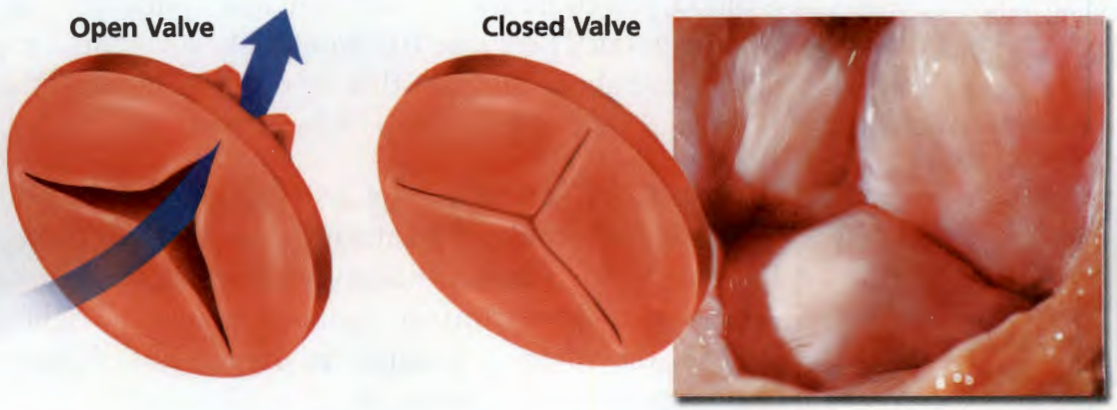


FIGURE 3
Open and Closed Heart Valves As blood flows out of the heart and toward the lungs, it passes through a valve like the one in the photograph. **Applying Concepts** *What is the function of a closed heart valve?*

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.

A Two-Loop System

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 infer 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.

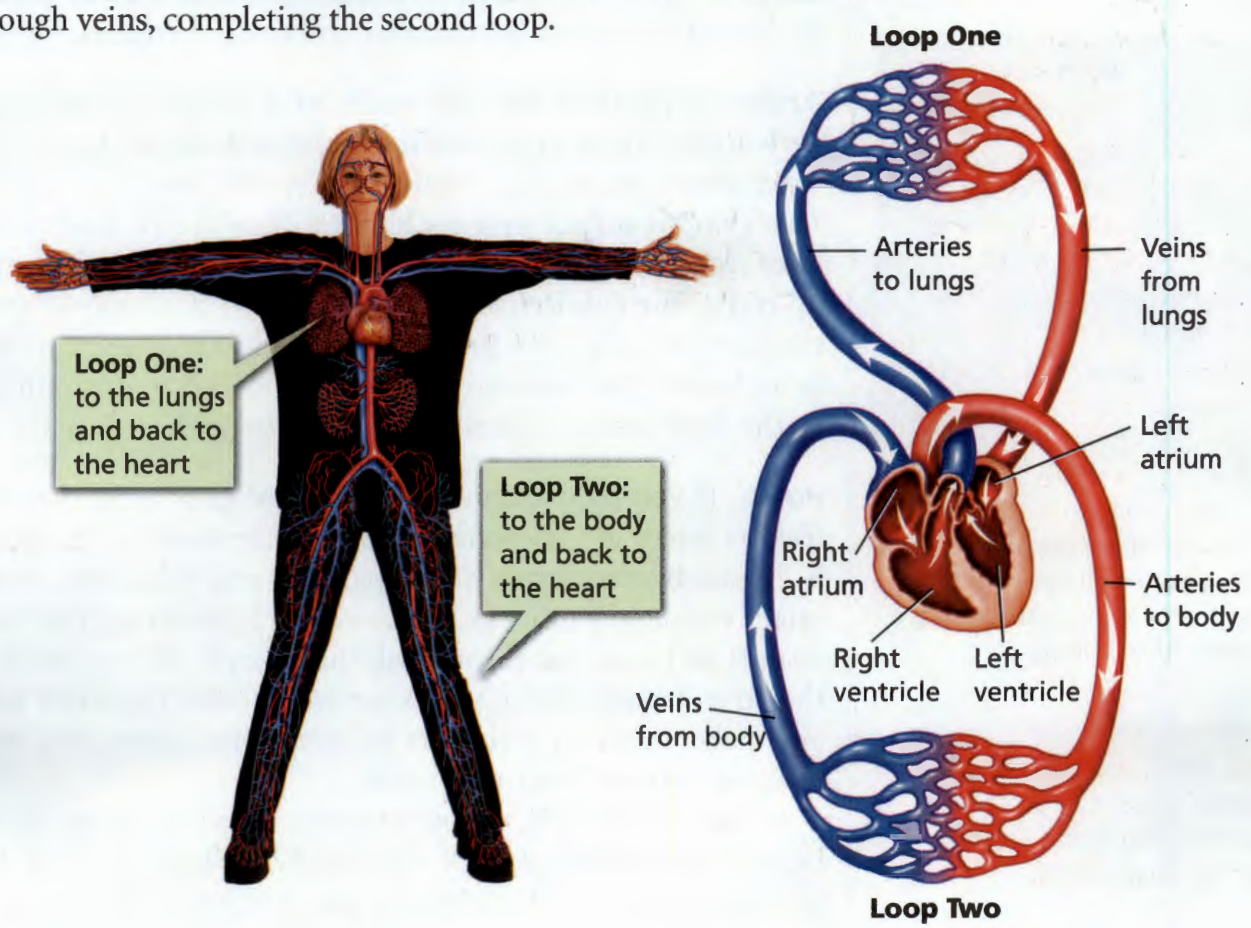


FIGURE 5
Direction of Blood Flow
Blood circulates through the body in two loops, with the heart at the center. Loop one goes from the heart to the lungs and back. Loop two circulates blood throughout the rest of the body.
Interpreting Diagrams *Where does the blood that enters the left atrium come from?*

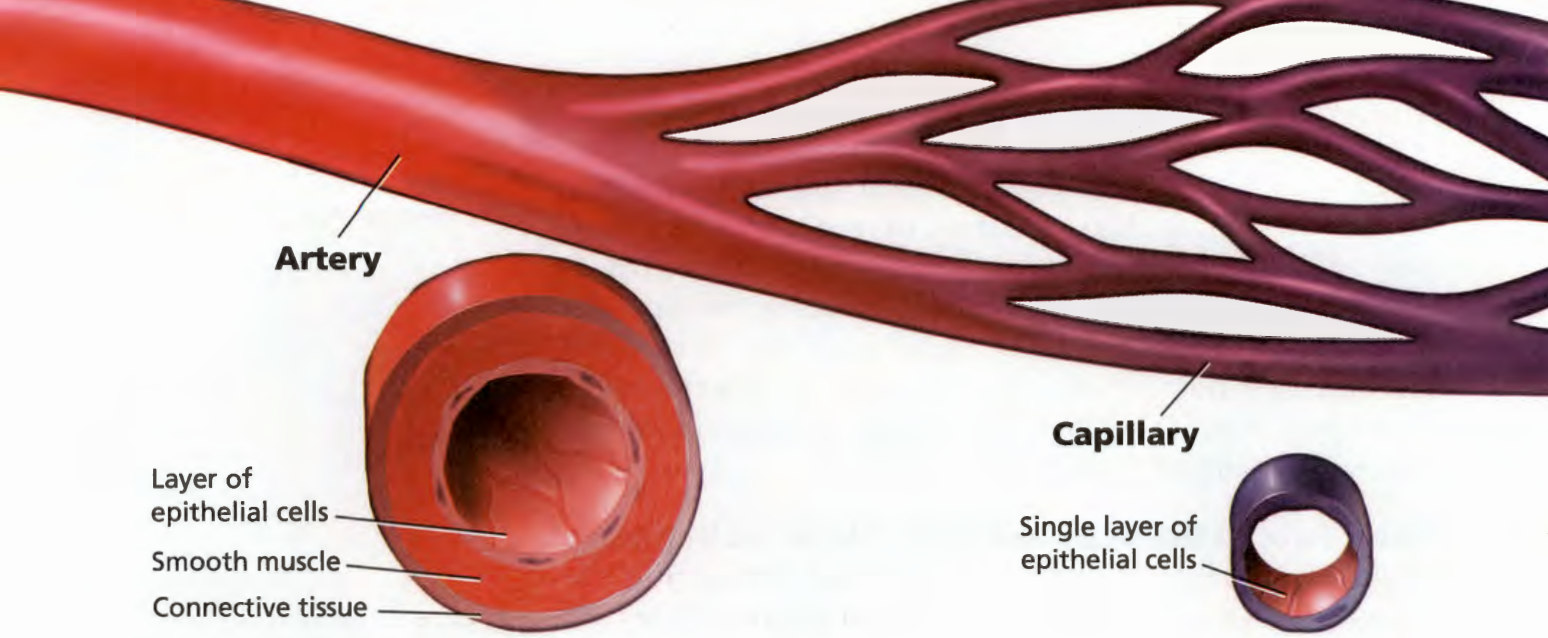
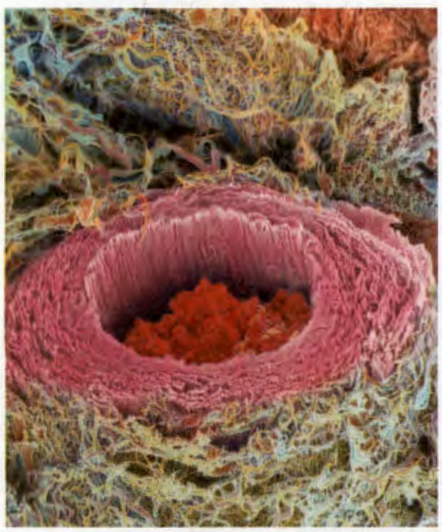


FIGURE 6
Artery, Capillary, and Vein
The walls of arteries and veins have three layers. The walls of capillaries are only one cell thick. **Relating Cause and Effect** *How does material get from inside capillaries to body cells?*



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

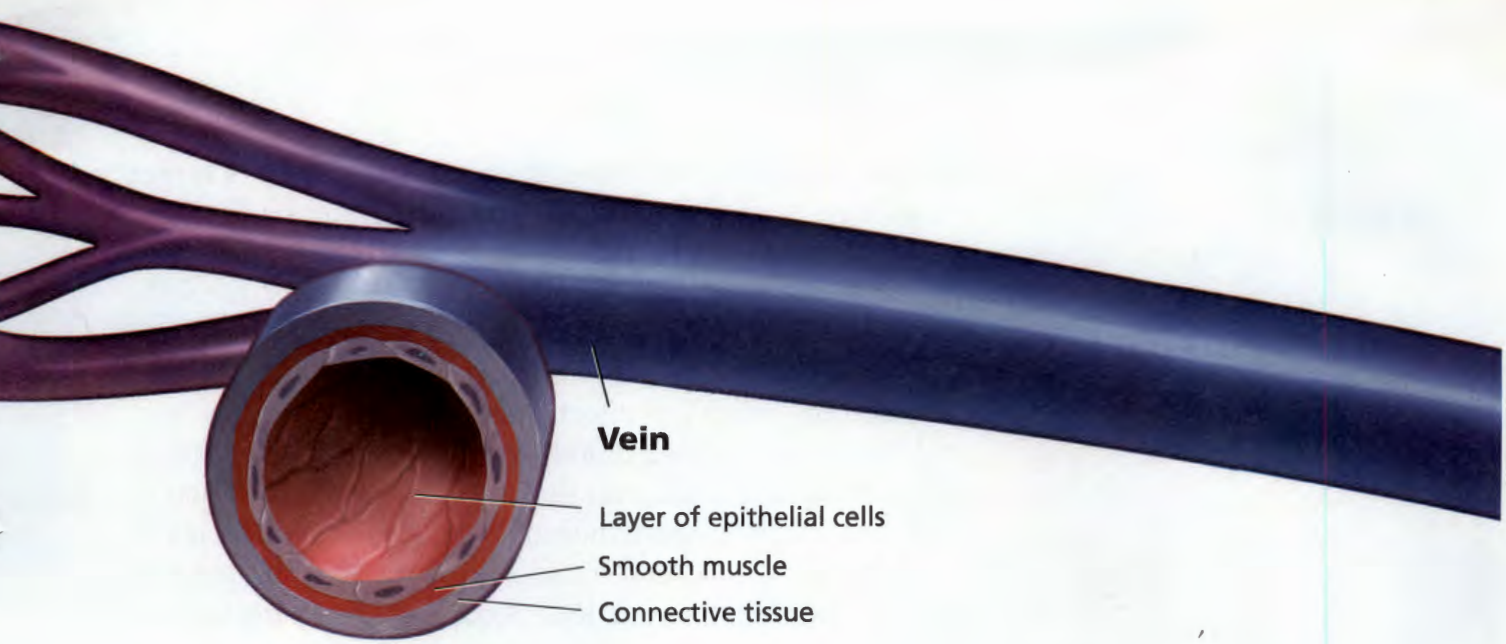
Arteries

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 heartbeats.

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 the backflow of blood. 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 its inner surface. **Pressure** is force per unit area. It can be measured in various units. 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 resembles water moving through a hose. Blood exerts a force, called **blood pressure**, against the walls of the blood vessels. Blood pressure is caused by the force with which the ventricles contract. This action increases the pressure on the blood and forces it through the vessels. In general, as blood moves away from the heart, blood pressure decreases. The blood flowing through your arteries exerts the highest pressure. Blood pressure in your capillaries and veins is much lower than in your arteries.

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 (mmHg). 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

S 7.5.a, 7.6.j, E-LA: Reading 7.2.0, Math: 7.1.3

Target Reading Skill **Sequence** Describe the path of blood from the lungs to the heart, through the heart, and then out of the heart to the rest of the body.

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

S 7.5.a, 7.7.c

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 heart function?
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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Web Code: ced-4032

Section 2

Blood and Lymph

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

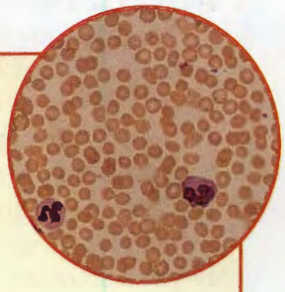
S 7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

- 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
- shock
- lymphatic system
- lymph
- lymph node

Lab zone Standards Warm-Up



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.

Lab zone Skills Activity

Writing a Hypothesis

Anemia is a condition in which the body does not have enough of either red blood cells or hemoglobin. Write a hypothesis that describes how a person who has anemia might be affected during everyday physical activities.

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.

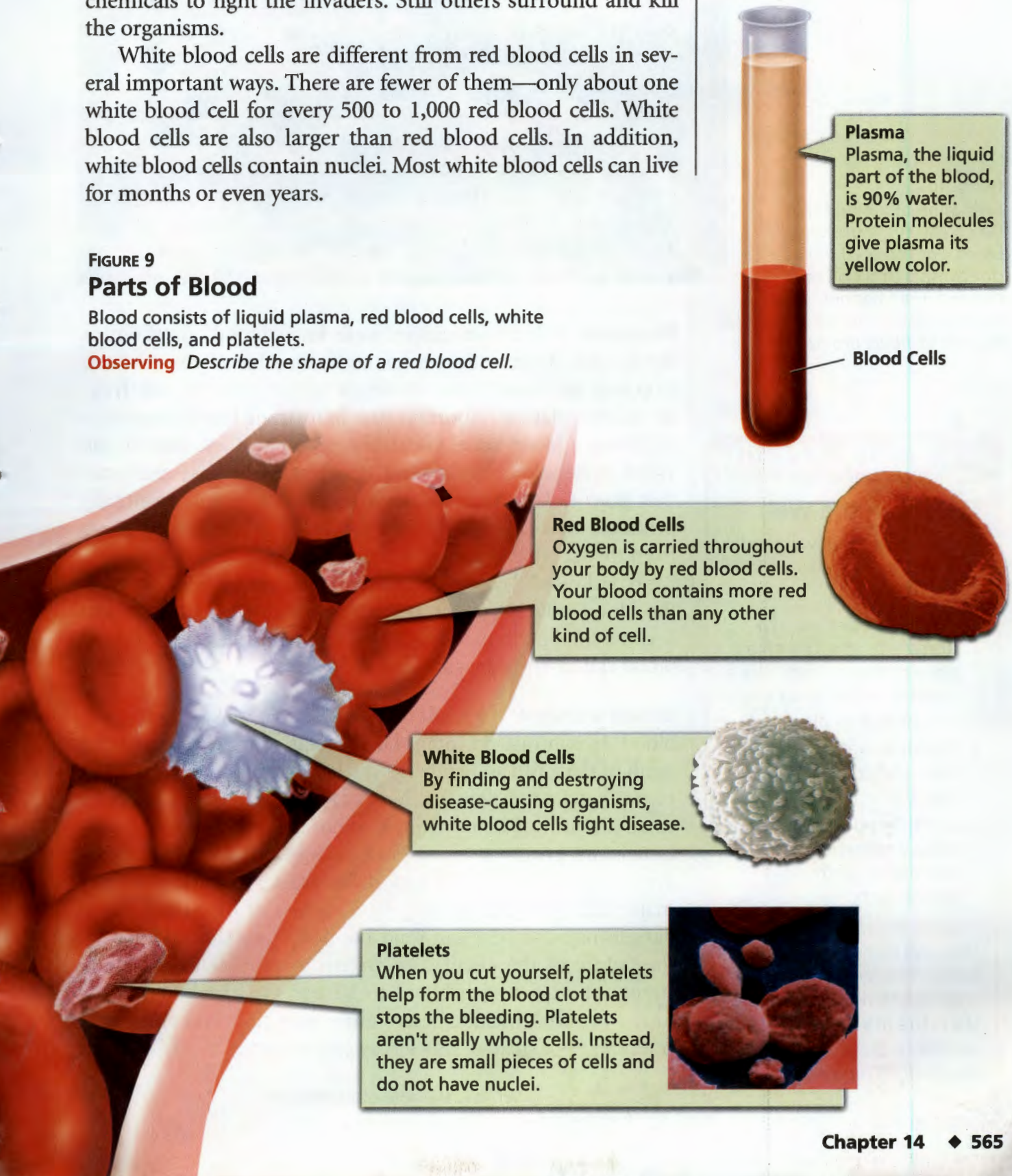
White blood cells are different from red blood cells in several important ways. There are fewer of them—only about one white blood cell for every 500 to 1,000 red blood cells. White blood cells are also larger than red blood cells. In addition, white blood cells contain nuclei. Most white blood cells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

FIGURE 9

Parts of Blood

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

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



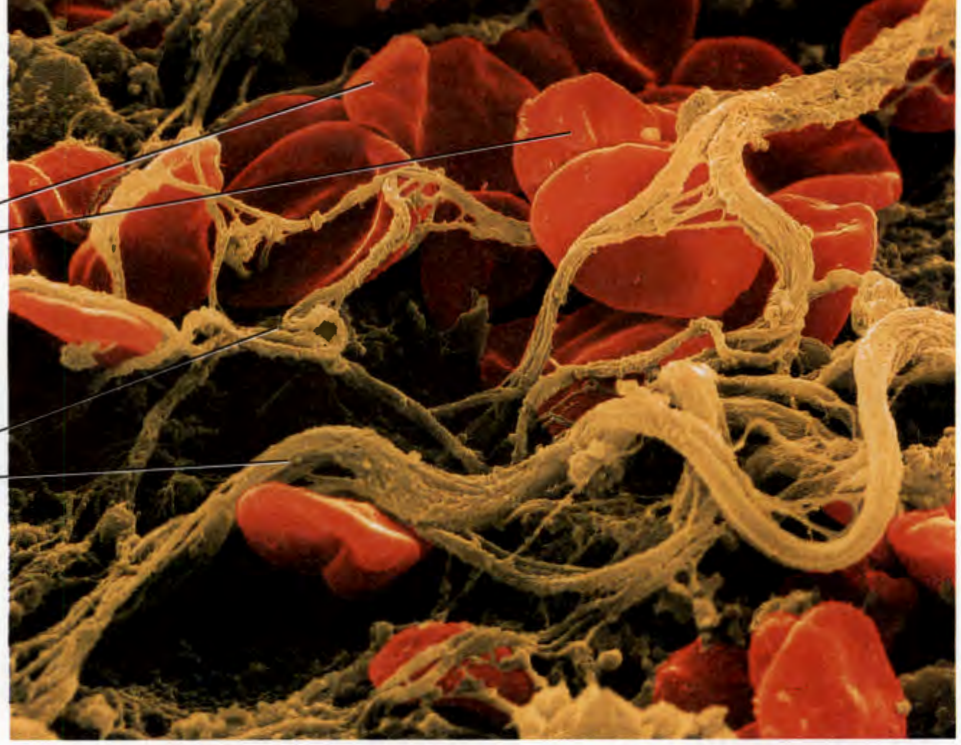


FIGURE 10
Formation of a Blood Clot
When you cut your skin, a blood clot forms. The blood clot consists of blood cells trapped in a fiber net.
Relating Cause and Effect *How is this net of fibers produced?*

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?

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.

Blood Volume An adult of average size has about 5 liters of blood. In contrast, an infant has a blood volume less than one tenth of that! You and your classmates have blood volumes that may range from below 2.5 liters to above 4 liters. If you lose a small amount of blood from a minor injury, your blood volume is not greatly affected. Your body recovers quickly. However, sometimes a person may suffer greater blood loss from a major injury or during surgery. This loss of blood volume is dangerous because it can send the body into shock. **Shock** is the failure of the circulatory system to provide an adequate supply of oxygen-rich blood to all parts of the body. Other causes of shock include heart failure, infection, and emotional trauma. If not treated, shock may cause death.

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

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.

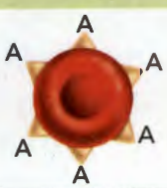
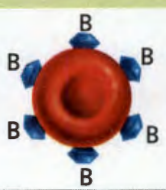
Marker Molecules Landsteiner went on to discover that there are four major types of blood—named A, B, AB, and O. Blood types are determined by proteins known as marker molecules that are on the red blood cells. If your blood type is A, you have the A marker. If your blood type is B, you have the B marker.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

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.** Figure 11 shows which transfusions are safe for each blood type.

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

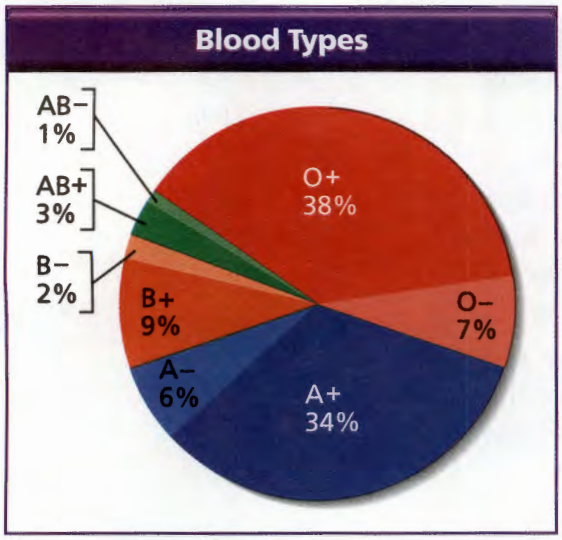


FIGURE 12
Blood Types in the Population This circle graph shows the percentage of each blood type found in the population of the United States.
Calculating *What percentage of the population is Rh negative?*

Safe 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 transfusions because type AB blood has no clumping proteins.

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.

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 cells. 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). See Figure 13 on the next page. **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 the 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?**

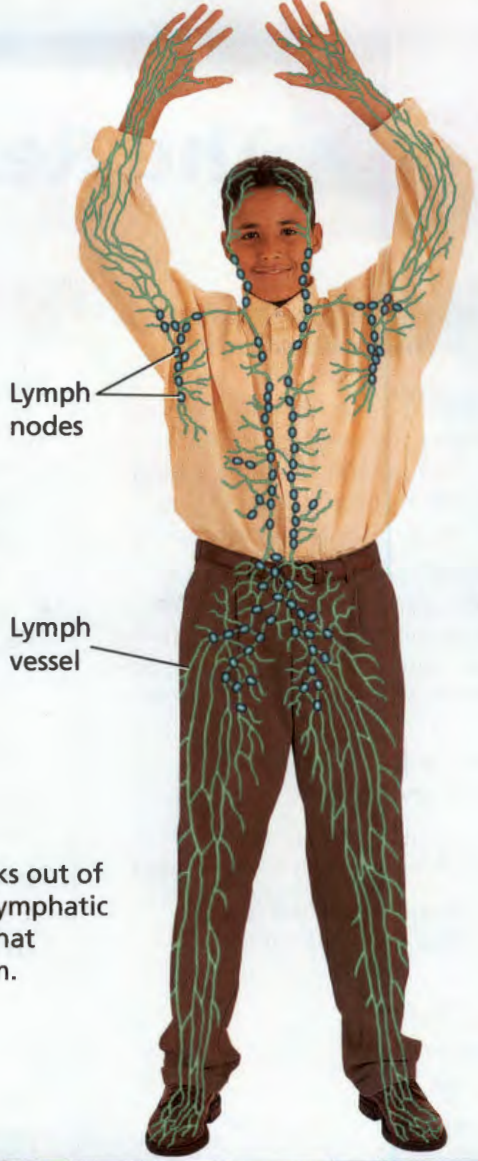


FIGURE 13
The Lymphatic System
Some of the liquid part of blood leaks out of blood vessels. This liquid enters the lymphatic system, a system of veinlike vessels that returns the liquid to the bloodstream.

Section 2 Assessment

S 7.5.a, 7.5.b, E-LA: Reading 7.1.0

Vocabulary Skill **High-Use Academic Words**
Explain why it is important for white blood cells to be able to *detect* disease-causing organisms.

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

The Respiratory System

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

S 7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

- 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
- mucus
- cilia
- pharynx
- trachea
- bronchi
- lungs
- alveoli
- diaphragm
- larynx
- vocal cords

Lab zone Standards Warm-Up

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.

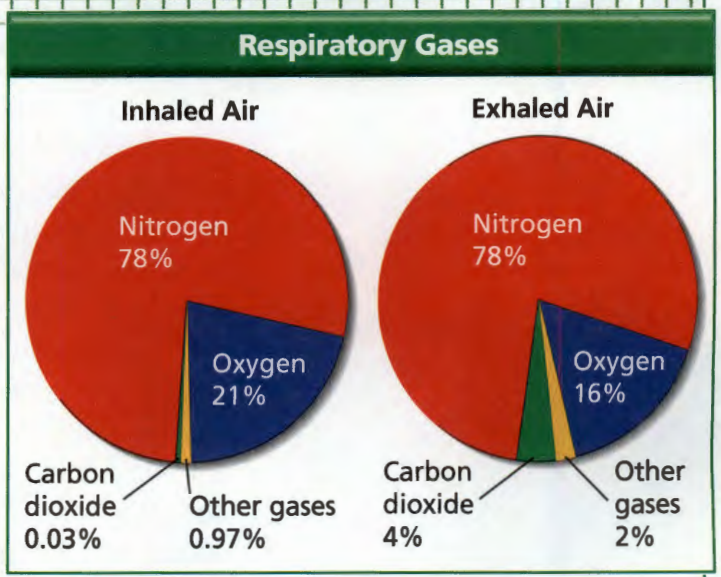
Math: Statistics, Data Analysis, and Probability 7.1.0

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. **Interpreting Data** Based on the data, which gas is used by the body? Explain.
2. **Drawing Conclusions** Compare the percentage of carbon dioxide in inhaled air with the percentage in exhaled air. How can you account for the difference?
3. **Inferring** Explain why the percentage of nitrogen is the same in both inhaled air and exhaled air.



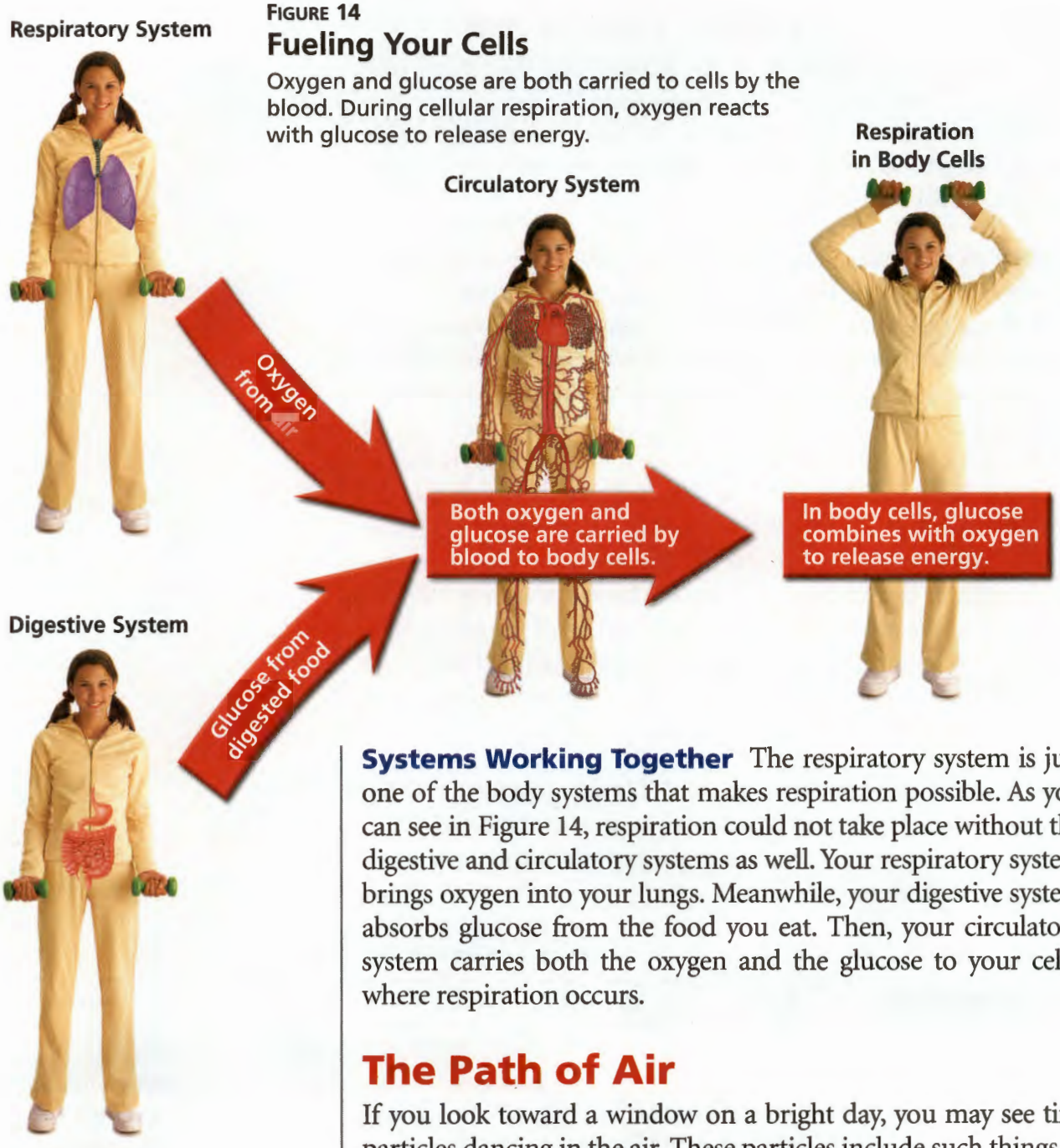


FIGURE 14

Fueling Your Cells

Oxygen and glucose are both carried to cells by the blood. During cellular 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 14, 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**—a thick, sticky liquid that moistens the air and keeps the lining from drying out. Mucus also traps particles such as dust.

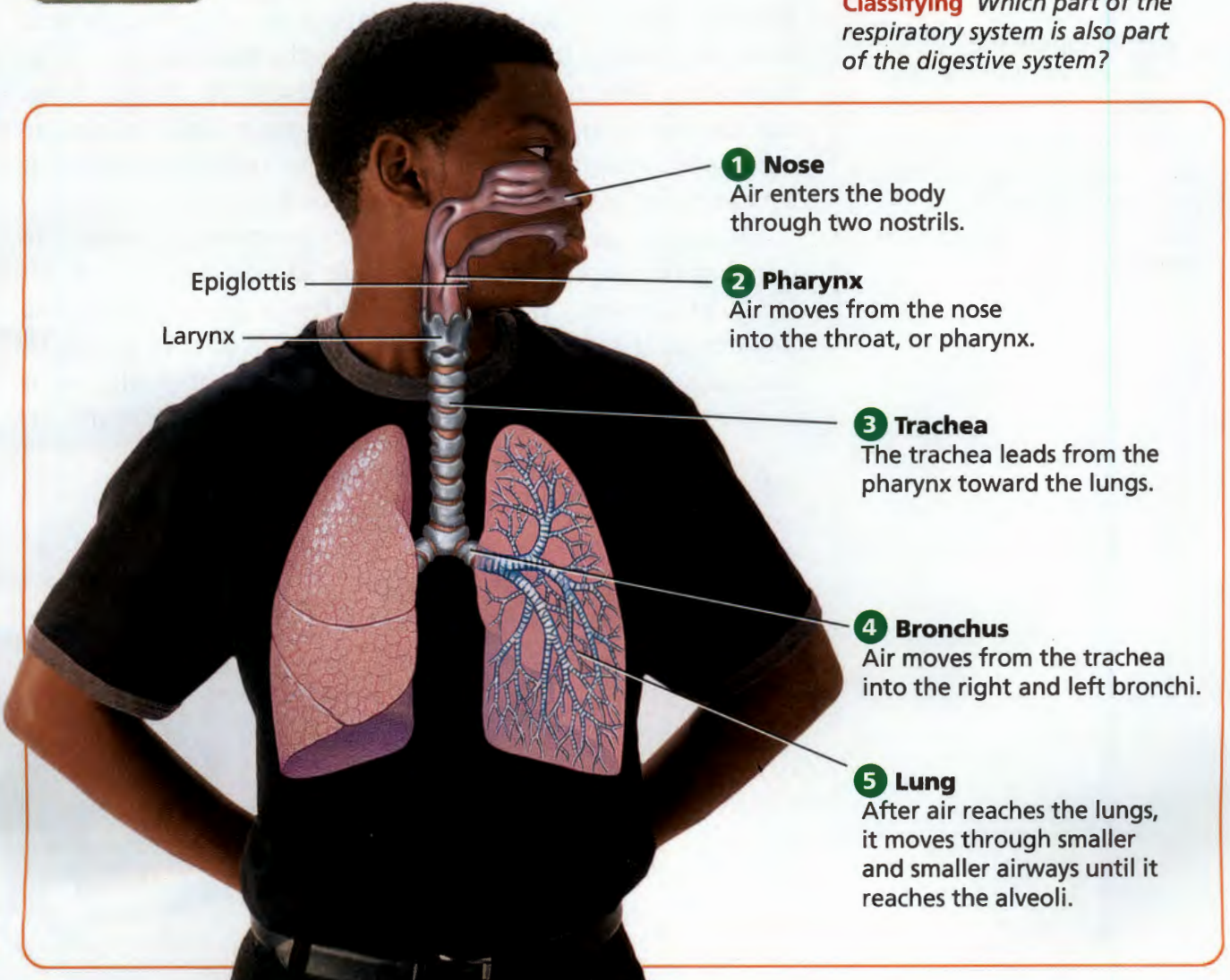
Cells that line the nasal cavities have **cilia** (SIL ee uh), tiny hairlike extensions that move together in a sweeping motion. Cilia sweep mucus into the throat, where you swallow it. Stomach acid destroys the mucus, and everything trapped in it.

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 15
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.

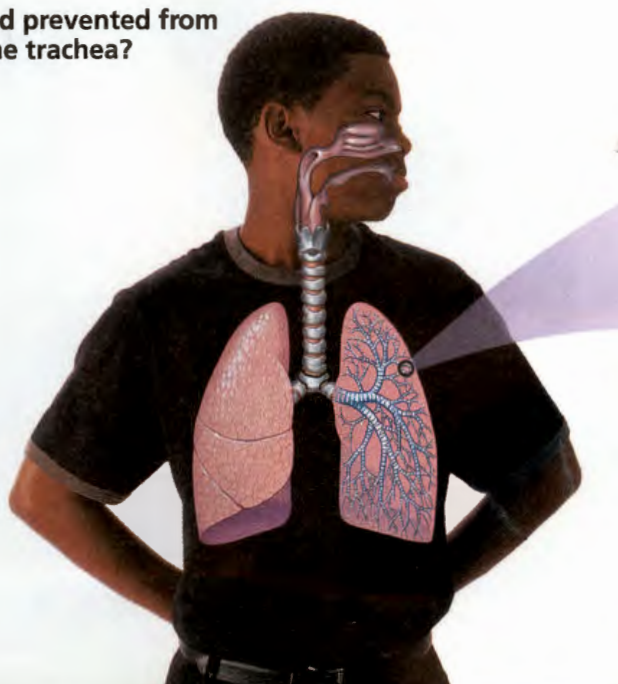
The trachea, like the nose, is lined with cilia and mucus. The cilia in the trachea sweep upward, moving mucus toward the pharynx, where it is swallowed. The trachea's cilia and mucus continue the cleaning and moistening of air that began in the nose. If particles irritate the lining of the trachea, 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 16 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 Gas exchange occurs as the circulatory and respiratory systems work together. *Pulmonary* means, "having to do with the lungs." Pulmonary circulation carries blood from the heart to the lungs and back. On the way to the lungs, blood has little oxygen. But it has a lot of carbon dioxide. In the capillaries around the alveoli, oxygen attaches to the hemoglobin in the red blood cells. At the same time, carbon dioxide moves from the blood and into the alveoli. As a result of pulmonary circulation, the blood that returns to the heart is rich in oxygen and poor in carbon dioxide.

FIGURE 16

Gas Exchange in the Alveoli

During gas exchange, oxygen moves from the alveoli into the blood and carbon dioxide moves from the blood into the alveoli.

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

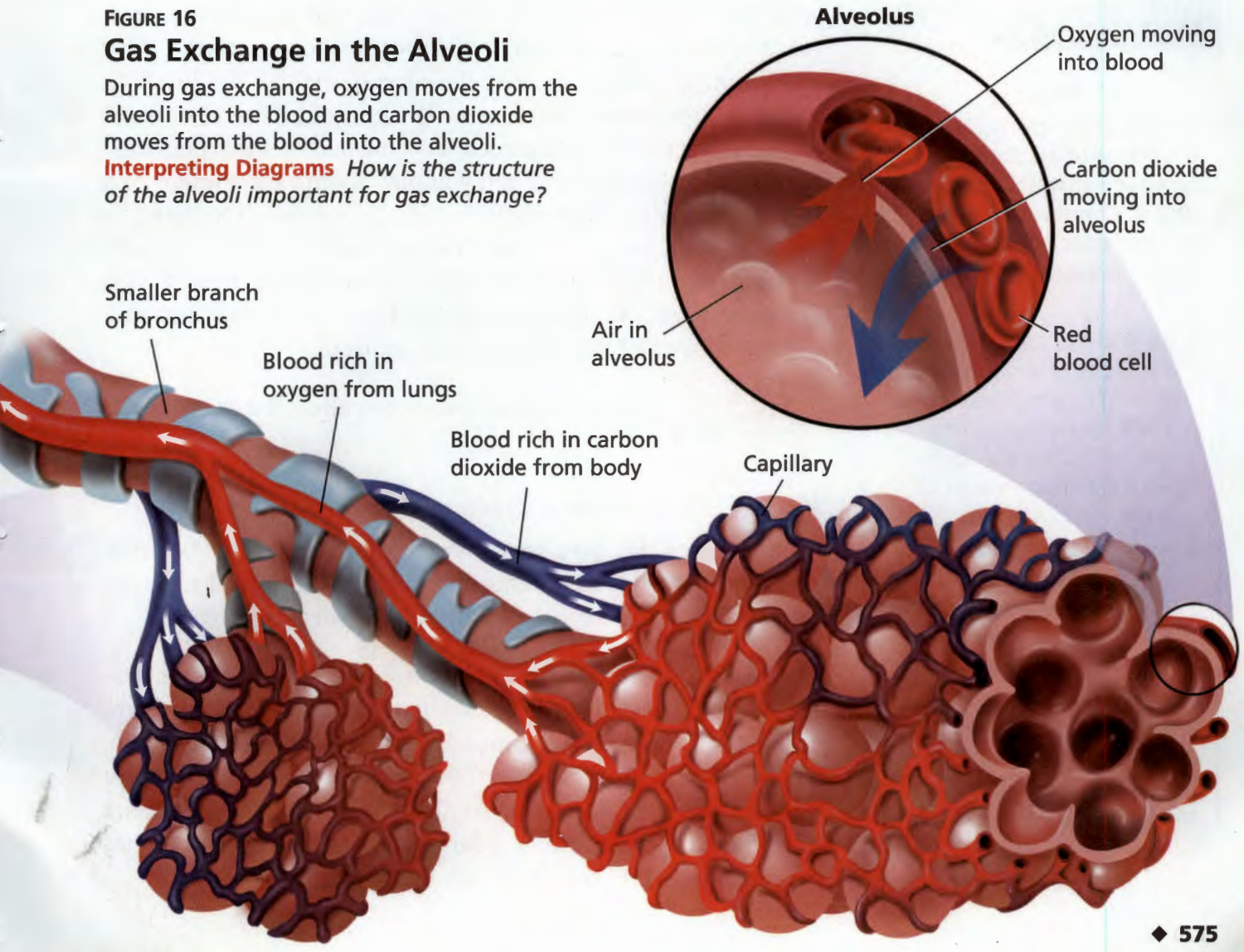


FIGURE 17
Oxygen for Activities
The huge surface area of the alveoli supplies the oxygen these trombone players need to march and play.

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. The small intestine of your digestive system contains specialized structures 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 18 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 × 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 cause your chest to expand or contract. 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 18
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?*

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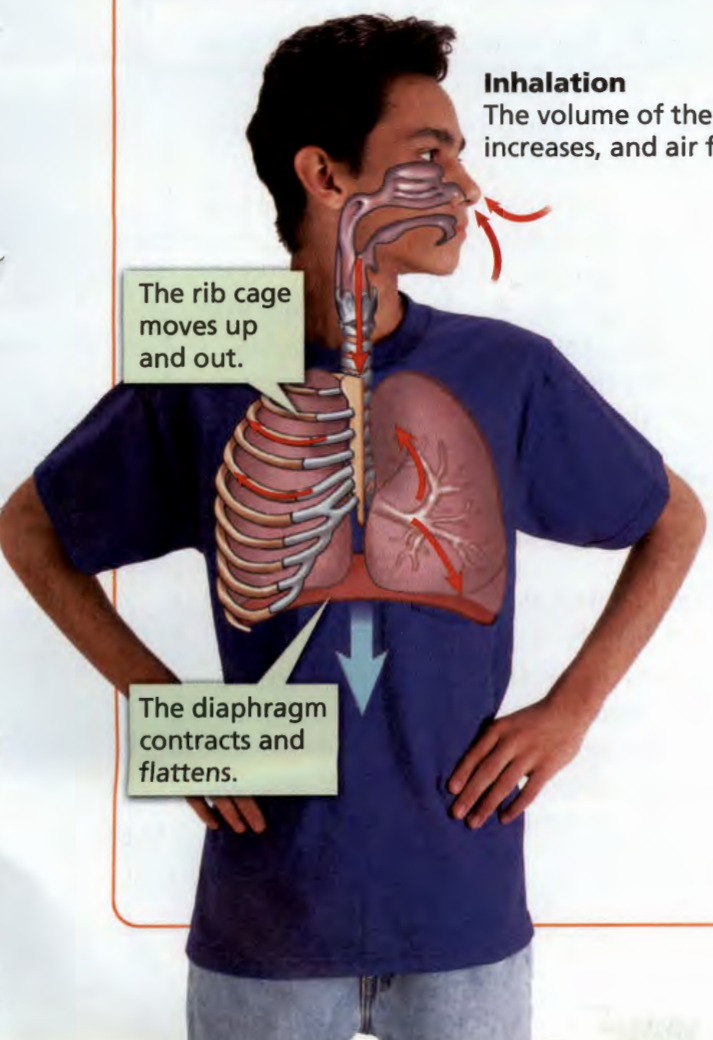
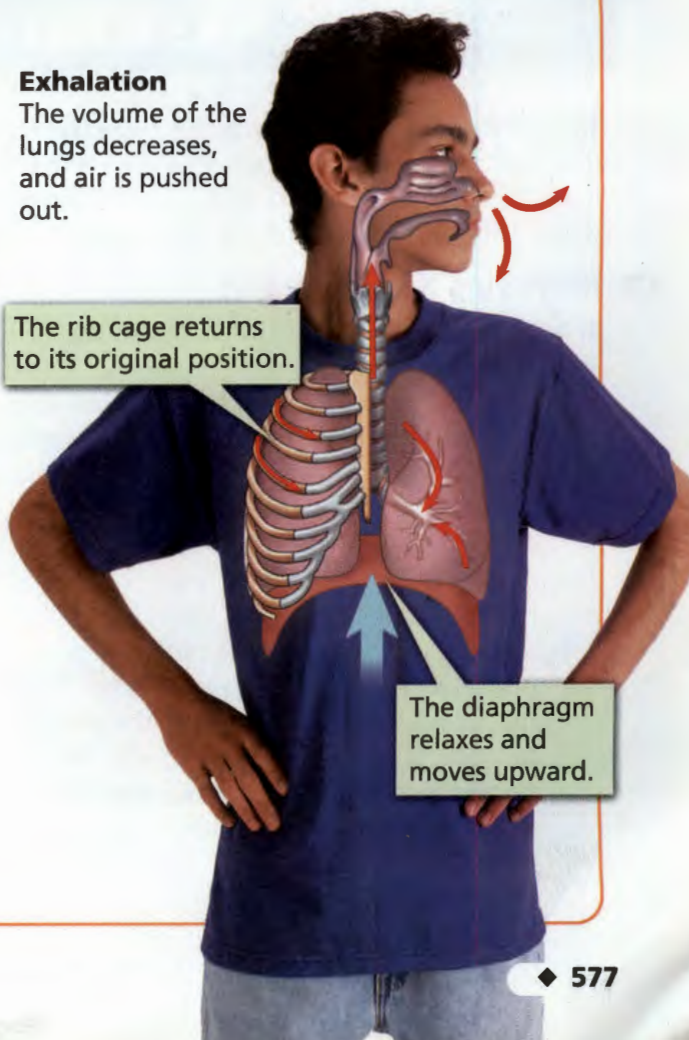




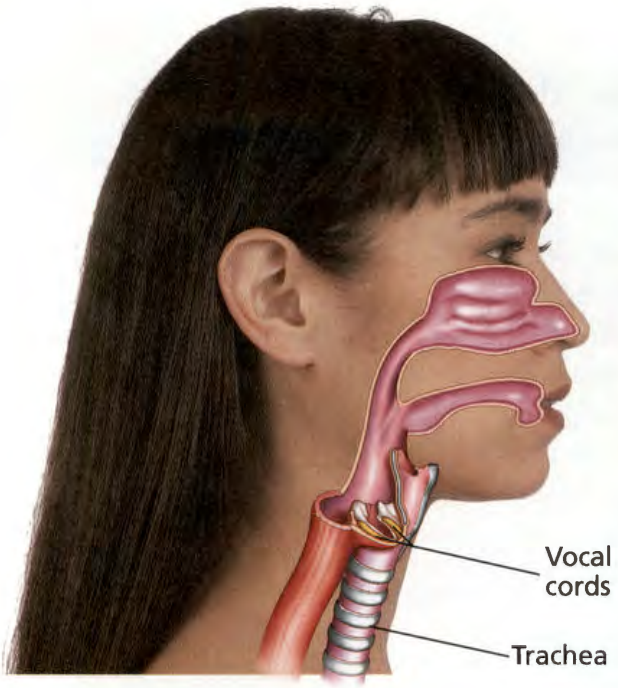


FIGURE 19
The Vocal Cords
Air moving over the vocal cords causes them to vibrate and produce sound.
Interpreting Diagrams *Where are the vocal cords located?*

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 19 you can see that the vocal cords have a slit-like 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 3 Assessment

S 7.5.a, 7.5.b, E-LA: Reading 7.2.0, Math: 7.2.4

Target Reading Skill **Sequence** Construct a flowchart showing the sequence of events that happens when you breathe in. In the first box write "Rib muscles and diaphragm contract."

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, so that each cube is 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?

A Breath of Fresh Air

S 7.5.b, 7.7.d

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.*

Cardiovascular and Respiratory Diseases

California Standards Focus

S 7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

- What are some diseases of the cardiovascular system?
- How may tobacco smoke affect the body?
- What are some respiratory diseases that result from infections or other physical conditions?

Key Terms

- atherosclerosis
- heart attack
- hypertension
- stroke
- emphysema
- bronchitis
- asthma
- suffocation
- pneumonia

Lab zone Standards Warm-Up

Which Foods Are "Heart Healthy"?

1. Your teacher will give you an assortment of foods. If they have nutrition labels, read the labels.
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 and their lungs are working hard. Oxygen-rich blood speeds to the arm and chest muscles that power the oars. Without healthy circulatory and respiratory systems, the rowers cannot do their best.

FIGURE 20
Exercising for Health
Strenuous exercise, such as rowing, requires a healthy cardiovascular system. In turn, exercise keeps the cardiovascular system healthy.

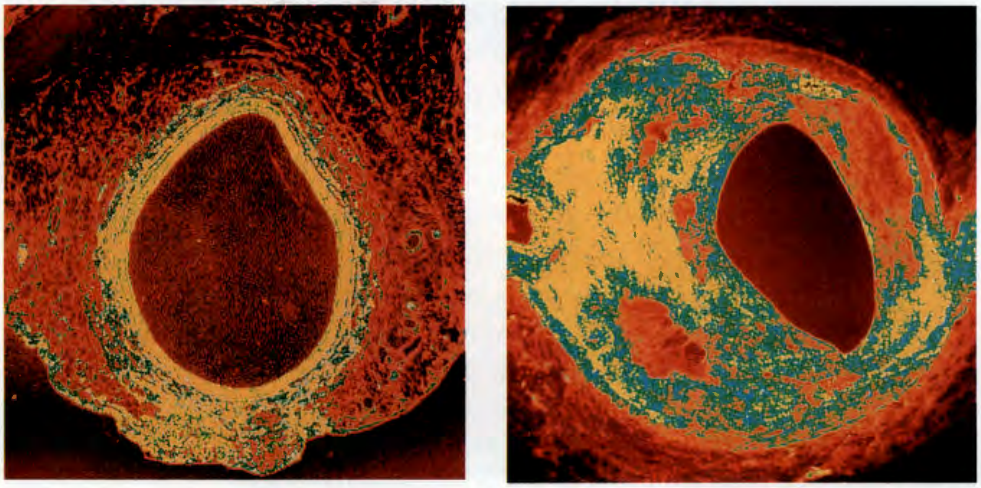


FIGURE 21
Effect of Atherosclerosis
The artery on the right shows atherosclerosis, which is caused by deposits of fat on the artery walls.
Relating Cause and Effect *What kind of diet can lead to atherosclerosis?*

Cardiovascular Diseases

Cardiovascular health is important for all people, not just for athletes. Cardiovascular disease ranks as 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 21. The healthy artery has a large space in the center through which blood can flow easily. The artery on the right, in contrast, has a much smaller space. 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 blood to the heart muscle. The muscle cells then receive 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 where the muscle does not receive sufficient blood and oxygen. This permanently damages the heart and may cause death. If a person who suffers a heart attack lives, the heart may remain badly weakened. The heart's ventricles may no longer contract normally, and the heart fails to pump enough blood to the body.

Treatment for atherosclerosis usually includes a low-fat diet, a moderate exercise program, and medications. Some people may need surgery to unclog blocked arteries.

Reading Checkpoint **How is cholesterol related to atherosclerosis?**

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. It also may damage the walls of blood vessels. Over time, the heart and arteries can be severely harmed by hypertension. People with hypertension often have no clear symptoms to warn them of the danger until damage is severe. For this reason, hypertension is sometimes called the "silent killer." Like atherosclerosis, treatment for hypertension includes regular exercise, careful food choices, and medications.

• 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.

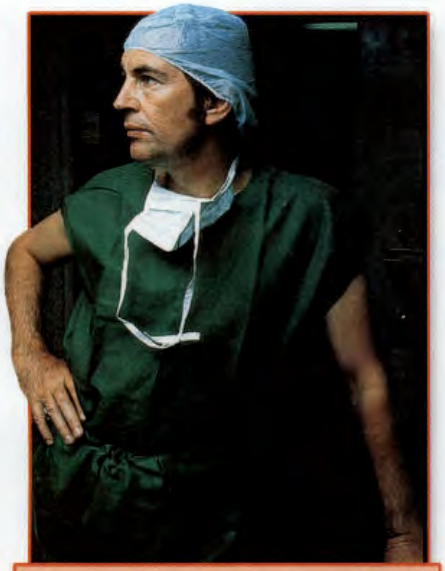
1961
Heart Valve Replacement
The first successful artificial heart valve was inserted into a patient's heart by surgeons Albert Starr and M. L. Edwards in Oregon. The valve was a rubberlike ball inside a stainless steel cage.

1930 1940 1950 1960

Stroke Sometimes atherosclerosis and hypertension may lead to a stroke. A **stroke** is the death of brain tissue that can result when a blood vessel in the brain is either blocked by a clot or bursts. For example, sometimes blood clots form in vessels that are affected by atherosclerosis. A clot that breaks free may travel to a blood vessel in the brain, blocking the flow of blood. Such a blockage prevents needed gas exchange between the blood and brain cells, which can result in paralysis or permanent brain damage. Sometimes a blood vessel in the brain can become weakened. If so, hypertension can cause the vessel to burst, flooding the brain with blood and damaging cells.

Writing in Science

Research and Write
Research one of the scientists in the timeline using print and electronic resources. 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 scientist's contributions.



1967
First Heart Transplant
Christiaan Barnard, a South African surgeon, performed the first transplant of a human heart. Louis Washkanksky, 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 Gruentizig 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

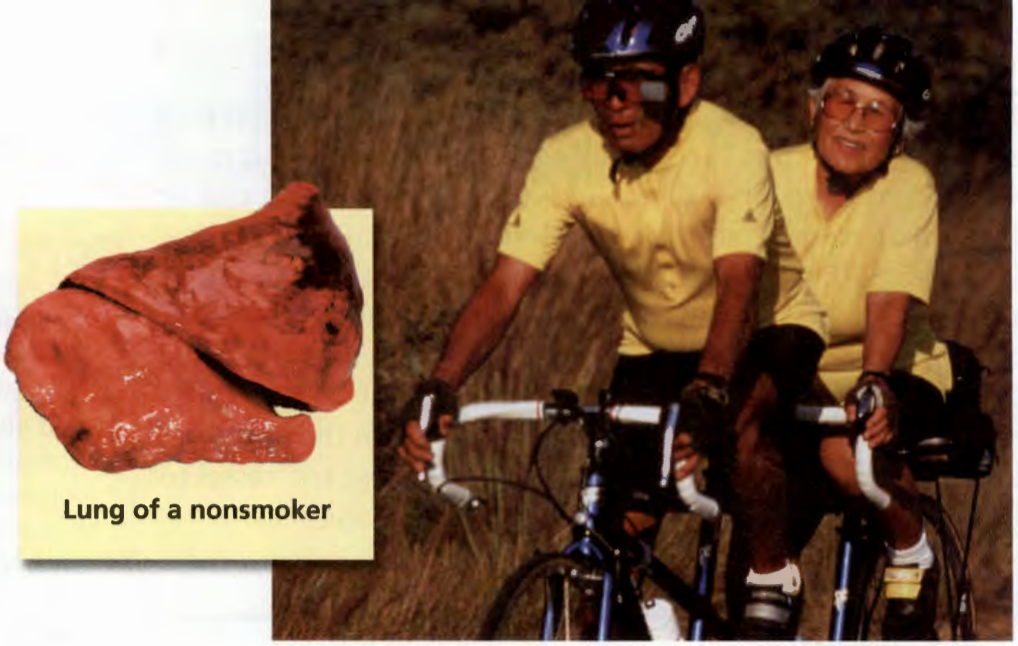


FIGURE 22
Staying Healthy by Not Smoking
People stay healthy by exercising and by choosing not to smoke.

Health Problems and Smoking

You may know that smoking tobacco is unhealthy. With each puff, a smoker inhales more than 4,000 chemicals. Three of the most deadly chemicals in tobacco smoke are listed in Figure 23. They are tar, carbon monoxide, and nicotine.

Tobacco smoke causes health problems in several ways. For example, tar-coated cilia can't sweep away mucus. Thus, many smokers have a frequent cough. The mucus buildup also limits space for airflow. As a result, oxygen intake decreases. Lack of oxygen may also cause long-term or heavy smokers to be short of breath during even light exercise.

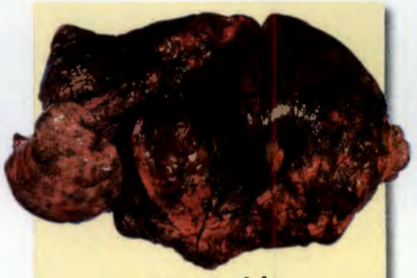
Tobacco smoke damages the respiratory system and strains the circulatory system, resulting in such diseases as emphysema, cancer, and chronic bronchitis. The respiratory and circulatory systems work together to get oxygen to body cells. A failure of any part of either system means other parts of both systems must work harder. Serious health problems can result from long-term smoking. 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.

You read earlier about atherosclerosis. This thickening of an artery wall from the buildup of fatty materials can lead to a heart attack. The chemicals from tobacco smoke cause added harm. Some of these chemicals get into the blood and are absorbed by the blood vessels. The chemicals irritate the walls of the vessels. This irritation contributes to the buildup of fatty material on the vessel walls. Compared to nonsmokers, smokers are more than twice as likely to have heart attacks.

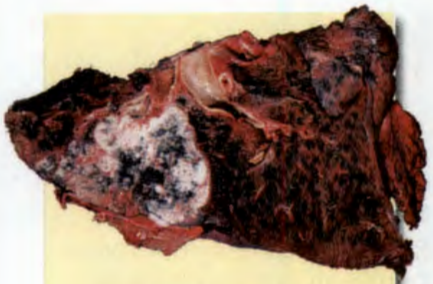
FIGURE 23
Deadly chemicals in tobacco smoke can damage body systems or interfere with their function.

Three Deadly Chemicals in Tobacco Smoke	
Tar	A dark, sticky substance that coats cilia making them clump together
Carbon Monoxide	A colorless, odorless gas that binds to hemoglobin in red blood cells taking the place of oxygen
Nicotine	An addictive drug that increases heart rate and blood pressure

FIGURE 24
Effects of Smoking on the Lungs Over time, smoking damages the lungs and leads to serious health problems. **Comparing and Contrasting** *Compare the diseased lungs below to the lung of a nonsmoker shown on the opposite page.*



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. About 90 percent of the people who suffer from emphysema are smokers. 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. Nonsmoking-related lung cancer is much less common. Cigarette smoke contains more than 50 different chemicals that cause cancer. 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.

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.

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

Respiratory Diseases

Respiratory diseases—also called pulmonary diseases—have causes other than smoking. **Diseases such as asthma, colds, influenza, and pneumonia are caused by infections or other physical conditions.** Like smoking-related diseases, other respiratory diseases can affect the function of the circulatory system. For example, a pulmonary infection may reduce the amount of oxygen that can be absorbed in the lungs. The heart must pump blood harder and faster. Breathing may become harder, too.

Asthma More than 20 million Americans suffer from a respiratory condition called asthma. **Asthma** (AZ muh) is a disorder in which the airways in the lungs narrow significantly. This narrowing causes wheezing, coughing, and shortness of breath.

Figure 25 compares the airways in a healthy person with the airways in a person who has asthma. During an asthma attack, the muscles around the airways tighten, making the airways narrower. At the same time, the inner walls of the airways become inflamed. That is, they become irritated, red, swollen, and warm. They also secrete mucus. The mucus clogs the airways and makes breathing even more difficult.

Asthma attacks may be triggered by many factors. These include tobacco smoke, air pollution, strong odors, heavy exercise, and respiratory infections. Other triggers are allergies to pollen, mold, dust and pets. People with asthma require medicines to open affected airways and reduce inflammation. Someone having a severe asthma attack may need emergency care to prevent suffocation. **Suffocation** occurs when there is insufficient gas exchange in the lungs. If this happens, not enough oxygen gets to vital organs and the person could die.

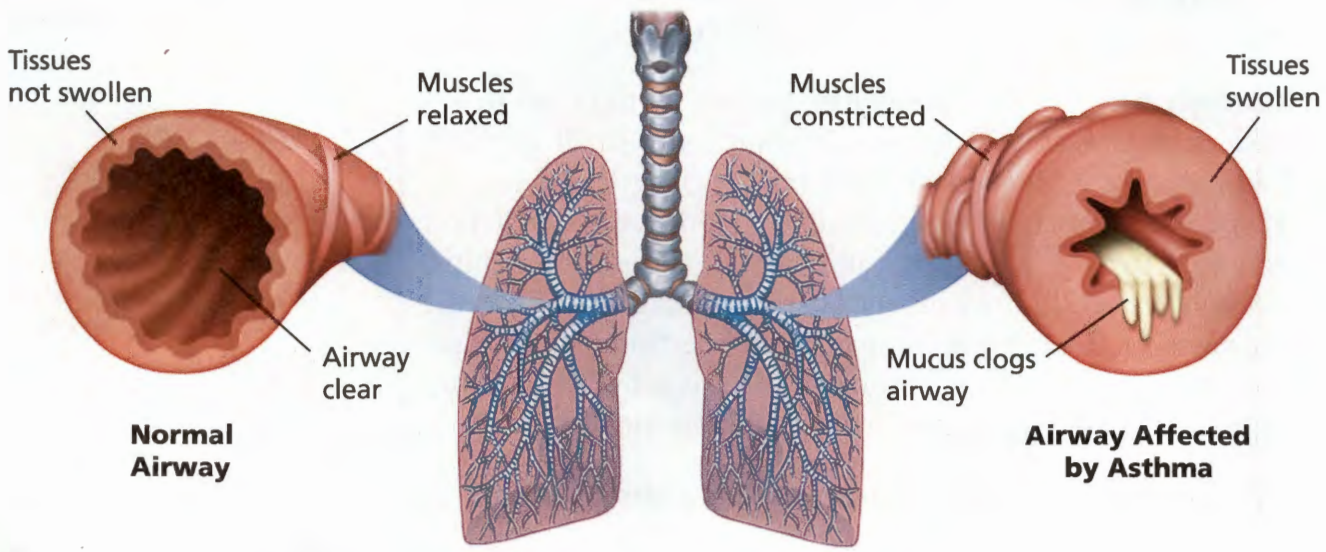


FIGURE 25
Effects of Asthma on Airways
During an asthma attack, air passages become narrow and breathing is more difficult.
Applying Concepts *What must happen to the muscles around the air passages for an asthma sufferer to begin to feel relief?*

Colds, Influenza, and Pneumonia Have you ever had a cold? Colds are the most common respiratory infection that people get. No doubt you know the symptoms of a typical cold. They include a sore throat, runny nose, cough, and stuffy head and chest. Most people recover quickly from colds.

Influenza, also known as "the flu," has symptoms like those of a cold, plus high fever and muscle aches. The flu usually feels worse than a cold. It can last longer, and it is more dangerous. In infants, the elderly, and people with heart and lung diseases, influenza can lead to pneumonia. **Pneumonia** (noo MOHN yuh) is an infection that causes fluid to collect in the alveoli, decreasing the lungs' ability to take in oxygen and remove carbon dioxide. If the infection is severe, breathing may be difficult. In the worst cases, insufficient gas exchange in the lungs can lead to suffocation and death.

Reading Checkpoint **What is suffocation?**

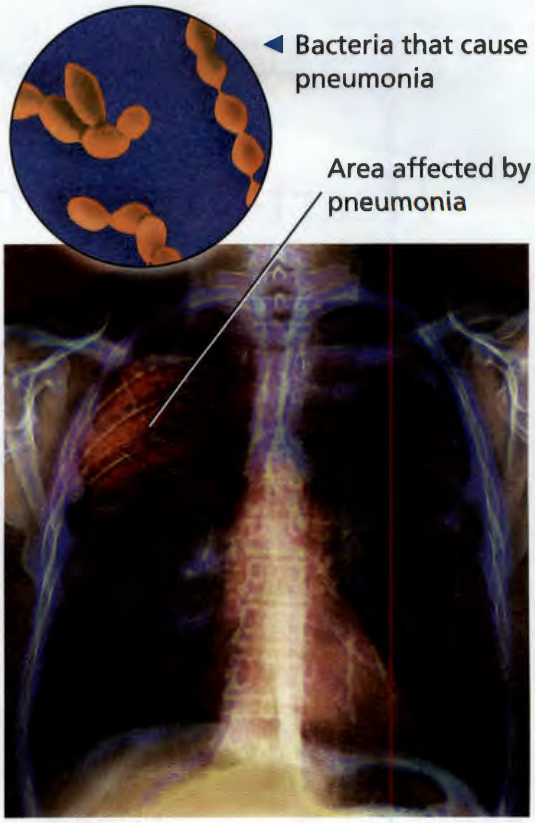


FIGURE 26
Pneumonia
Bacteria or viruses can cause pneumonia. Doctors may diagnose the disease by looking at an X-ray of the affected lung.

Section 4 Assessment

S 7.5.b, E-LA: Reading 7.1.0

Vocabulary Skill **High-Use Academic Words** Use what you know about the meaning of *contribute* to answer Question 2.b below.

Reviewing Key Concepts

1. a. **Defining** What is atherosclerosis? What is hypertension?
   b. **Relating Cause and Effect** How do atherosclerosis and hypertension affect the heart?
   c. **Sequencing** Describe the sequence of events in which atherosclerosis may lead to a stroke.
2. a. **Listing** What are three harmful substances in tobacco smoke?
   b. ***Describing*** How does smoking contribute to emphysema and atherosclerosis?
   c. **Inferring** What would be the effect on the circulatory system if a person were to quit smoking?
3. a. **Listing** Name three respiratory diseases that are caused by infections.
   b. **Making Generalizations** What do the effects of asthma and pneumonia have in common with those of emphysema and chronic bronchitis?

Lab zone **At-Home Activity**

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

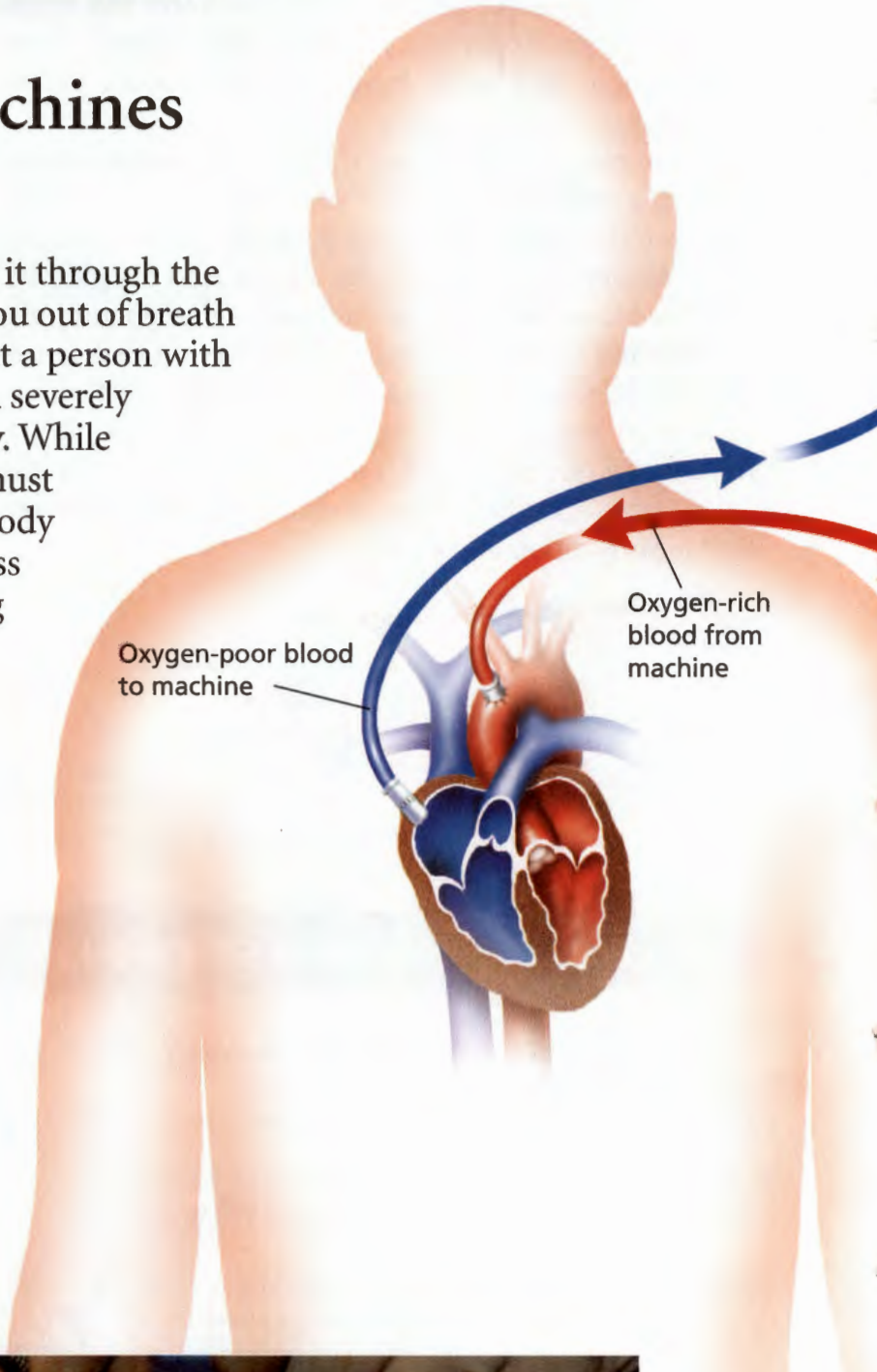
Heart-Lung Machines

S 7.5.b

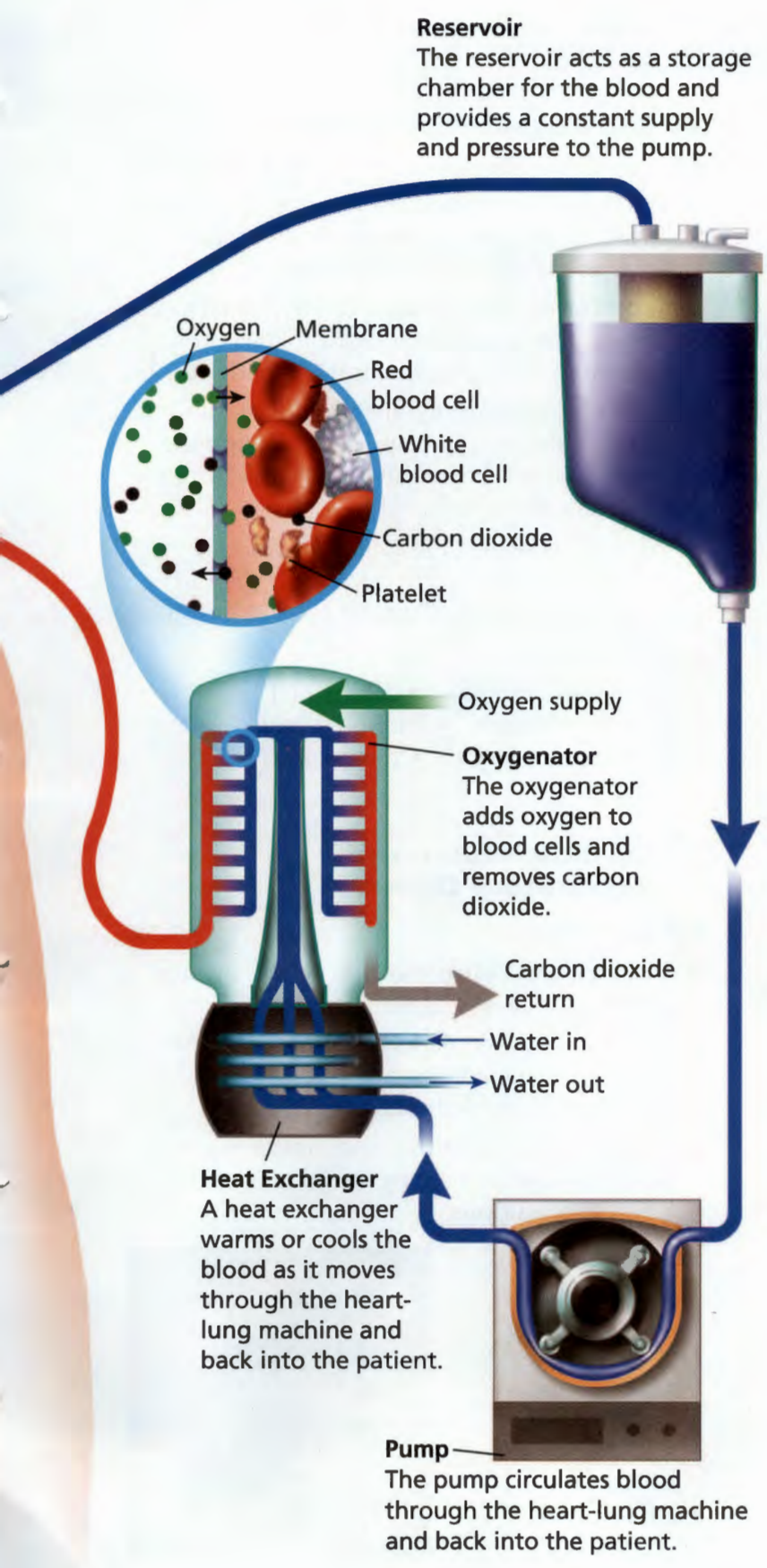
What if you were too tired to make it through the day? What if walking up stairs left you out of breath and dizzy? These are symptoms that a person with a damaged heart may experience. A severely damaged heart may require surgery. While the heart is being repaired, blood must continue to circulate through the body around the heart. One way to bypass the heart during surgery is by using a heart-lung machine.

Repairing a Damaged Heart

A heart-lung machine takes over the functions of the heart and the lungs when the heart is stopped during heart surgery. Surgeons insert one tube into the right atrium and a second tube into the aorta. Oxygen-poor blood flows into the heart-lung machine from the right atrium. Within the machine, carbon dioxide is removed, oxygen is added, the blood is filtered, and the blood's temperature is regulated. The filtered, oxygen-rich blood is then pumped through the second tube into the aorta, without flowing through the patient's heart. Once the surgical procedure is over, doctors disconnect the machine and restart the heart.



Heart-lung machine in use for open heart surgery ▶



Missing a Beat?

Heart valve repair and replacement, heart transplants, and coronary bypass surgery are a few of the surgeries that may use a heart-lung machine. Heart-lung machines have been credited with saving nearly one million lives around the world each year.

However, like all technologies, heart-lung machines pose certain risks. Use of the heart-lung machine has been associated with an increased risk of bleeding, stroke, kidney and lung problems, and memory loss. As with any surgical procedure, patients must consider the trade-offs.

Weigh the Impact

1. Identify the Need
What is the purpose of a heart-lung machine?

2. Research
Use print and electronic resources to research the success rate of bypass surgery using a heart-lung machine. Then research steps that patients might take to prevent the need for bypass surgery.

3. Write
Write a paragraph on steps patients might take to prevent the need for bypass surgery. Use your research and notes.

Go Online
PHSchool.com

For: More on heart-lung machines
Visit: PHSchool.com
Web Code: ceh-4030

Chapter 14 Study Guide

The BIG Idea The circulatory and respiratory systems move blood through the body and enable the exchange of gases.

1 The Body's Transport System

Key Concepts S 7.5.a, 7.6.j

- The cardiovascular system carries substances to cells and away from cells. In addition, blood contains cells that fight disease.
- The heart pushes blood through the cardiovascular system. The two sides of the heart are separated 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. Materials are exchanged between the blood and the body's cells in the capillaries. Veins carry blood back to the heart.

Key Terms

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

2 Blood and Lymph

Key Concepts S 7.5.a, 7.5.b

- Blood is made up of four components: plasma, red blood cells, white blood cells, and platelets.
- Marker molecules on red blood cells determine 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 • shock
• lymphatic system • lymph • lymph node

3 The Respiratory System

Key Concepts S 7.5.a, 7.5.b

- The respiratory system moves oxygen from the outside environment into the body. It also removes carbon dioxide and water.
- As air travels from the outside environment to the lungs, it passes through the following structures: nose, pharynx, trachea, and bronchi.
- Oxygen passes through the walls of the alveoli and then through the capillary walls into the blood. Carbon dioxide and water pass from the blood into the alveoli.
- When you breathe, the actions of your rib muscles and diaphragm cause your chest to expand or contract. Thus, air flows in or out.

Key Terms

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

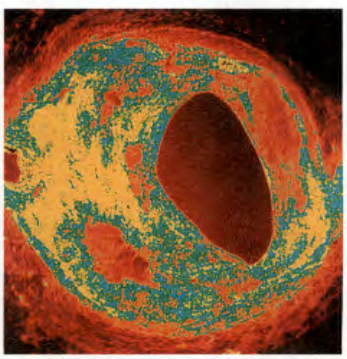
4 Cardiovascular and Respiratory Diseases

Key Concepts S 7.5.b

- Diseases of the cardiovascular system include atherosclerosis and hypertension.
- Tobacco smoke damages the respiratory system, resulting in such diseases as emphysema, cancer, and chronic bronchitis.
- Diseases such as asthma, colds, influenza, and pneumonia are caused by infections or other physical conditions.

Key Terms

• atherosclerosis
• heart attack
• hypertension
• stroke
• emphysema
• bronchitis
• asthma
• suffocation
• pneumonia



Review and Assessment

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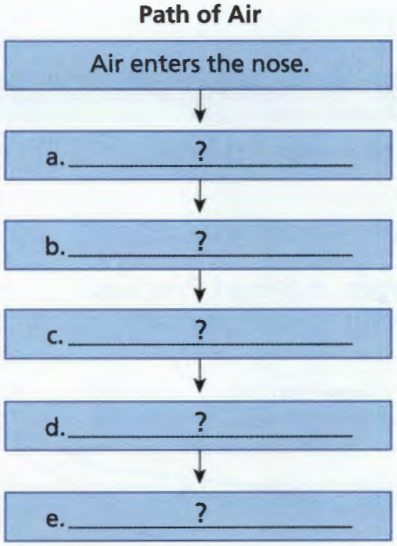
For: Self-Assessment
Visit: PHSchool.com
Web Code: cva-4140

Target Reading Skill

Sequence Copy the flowchart below. Use it to describe the path of air through the body. End with air entering the alveoli.



Reviewing Key Terms

Choose the letter of the best answer.

1. The heart's larger pumping chambers are called
   a. ventricles.
   b. atria.
   c. valves.
   d. arteries.
2. 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.
3. Blood components that transport oxygen in the body are
   a. platelets.
   b. red blood cells.
   c. white blood cells.
   d. plasmas.
4. The exchange of gases between the blood and the air takes place in the
   a. trachea.
   b. diaphragm.
   c. bronchi.
   d. alveoli.
5. Which of the following diseases causes less oxygen to be taken into the body from the air?
   a. emphysema
   b. stroke
   c. hypertension
   d. atherosclerosis

Complete the following sentences so that your answers clearly explain the key term.

6. **Blood pressure** is exerted by the blood on the walls of blood vessels as a result of _____.
7. The protein **hemoglobin** that is present in red blood cells enables the blood to carry oxygen because _____.
8. Air comes into the lungs as a result of the actions of the **diaphragm** and chest muscles, which _____.
9. Fluid that is carried by the lymphatic system is called **lymph**, which consists of _____.
10. A **heart attack** can result in the death of some heart muscle cells because_____.

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.

Video Assessment
Discovery Channel School
Circulation

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. Explain the difference between breathing and respiration.

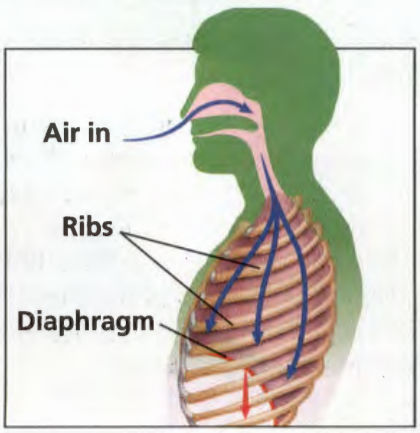
15. Explain how the alveoli provide a large surface area for gas exchange in the lungs.

16. How does a heart attack affect the body?

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. **Making Judgments** What process is shown in the diagram below? What role do changes in air pressure play in this process?



19. **Applying Concepts** Describe how the buildup of mucus in air passages affects breathing.

20. **Making Judgments** Do you think that drugstores, which sell medicines, should also sell cigarettes and other tobacco products? Why or why not?

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?

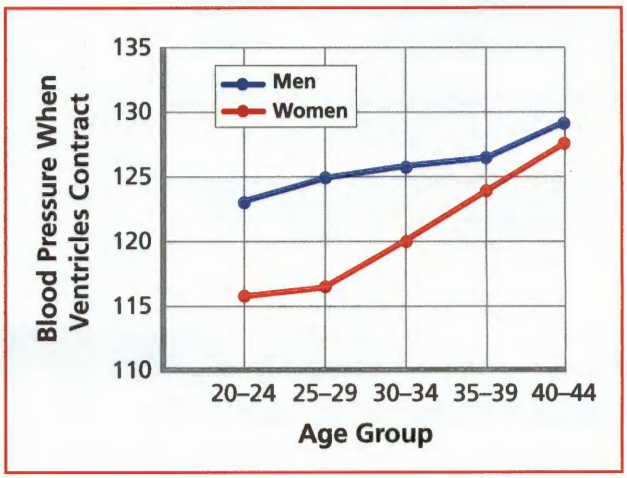
22. **Surface Area** Which has a greater surface area, a cube that is 2 cm × 2 cm on a side, or eight cubes that are each 1 cm × 1 cm on a side? Show your work.

Applying Skills

Use the graph to answer Questions 23–25.

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

Changes in Blood Pressure



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 Standards Investigation

Performance Assessment You should now be ready to present your display. Make sure it is clear and accurate, and be ready to answer questions from classmates.

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.

S 7.5.a

2. The correct sequence of organs through which air travels when it is breathed into the body is
- **A** pharynx, nose, trachea, bronchi.
- **B** nose, trachea, pharynx, bronchi.
- **C** nose, pharynx, bronchi, trachea.
- **D** nose, pharynx, trachea, bronchi.

S 7.5.a

3. When valves in the heart or blood vessels fail to function,
- **A** the pumping of blood stops.
- **B** a backflow of blood occurs.
- **C** the heart stops.
- **D** the blood pressure decreases.

S 7.5.b

4. Blood pressure results from the
- **A** contraction of the diaphragm.
- **B** exchange of gases between the blood and body cells.
- **C** build up of fatty materials in artery walls.
- **D** contraction of the ventricles in the heart that forces blood into blood vessels.

S 7.6.j

5. Which of the following conditions may result from insufficient gas exchange in the lungs?
- **A** suffocation
- **B** heart attack
- **C** stroke
- **D** atherosclerosis

S 7.5.b

6. Which of the following pairs of structures work together to control inhaling and exhaling?
- **A** lungs and rib muscles
- **B** diaphragm and rib muscles
- **C** diaphragm and bronchi
- **D** trachea and lungs

S 7.5.a

Use the table below and your knowledge of science to answer Questions 7 and 8.

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

7. A person who has type O blood can safely receive blood from a person with
- **A** type O blood.
- **B** type A blood.
- **C** type AB blood.
- **D** type B blood.

S 7.5.b

8. 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.

S 7.5.b

Apply the BIG Idea

9. The delivery of oxygen to body cells and the removal of carbon dioxide from body cells depend on the functions of both the circulatory system and the respiratory system. In a paragraph, explain how functions in both of these systems are affected when gas exchange in the lungs is reduced. Give specific details in describing changes that may occur.

S 7.5.b