Chapter

10 Circulation

Standard Course of Study

1.02 Develop appropriate experimental procedures.

1.03 Apply safety procedures.

1.04 Analyze variables.

1.05 Analyze evidence.

1.06 Use mathematics to gather, organize, and present data.

1.07 Prepare models and/or computer simulations.

1.08 Use oral and written language.

1.09 Use technologies and information systems.

2.01 Explore definitions of "technology."

4.01 Analyze how human body systems interact.

4.02 Describe functions of human body systems.

4.03 Explain how the structure of an organ is adapted to perform specific functions.

4.04 Evaluate how human body systems regulate the internal environment.

4.07 Explain how environmental effects influence human embryo development and health.

4.08 Explain how understanding the human body helps to make informed health decisions.

Interactive Textbook

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

End-of-Grade Test Practice

Test-Taking Tip

Watching for Qualifiers

You may be asked to answer a question that uses a qualifying word such as *most, least, best,* or *except for.* For example, you may be asked what the *best* conclusion is according to experimental data. When you see this type of question, read the answer choices very carefully. More than one choice may be partially correct. Look for the answer choice that offers the best or most complete answer.

Sample Question

According to the Food Guide Pyramid, the *most* healthful diet includes limiting one's intake of

A sugar and fats.
B water.
C grains.
D fruits and vegetables.

Answer

Choice **A** is correct because sugars and fats should be eaten sparingly, as recommended by the Food Guide Pyramid. Choice **B** is incorrect because the body cannot function without water. Choices **C** and **D** are incorrect because the Food Guide Pyramid recommends several servings of these foods.

Choose the letter of the best answer.

1. Which of the following parts of the digestive system is *best* paired with its function?

A esophagus—digests carbohydrates
B stomach—digests fats
C small intestine—absorbs water
D liver—produces bile

2. A food label on a cereal box gives you the following information: a serving size equals one cup and there are 110 Calories per serving. You measure the amount of cereal you plan to eat and find that it measures 1 1/2 cups. How many Calories will you consume?

A 110 Calories
B 165 Calories
C 220 Calories
D 1,100 Calories

Use the table below and your knowledge of science to answer Questions 3 and 4.

Length of Time Food Stays in Organ

Organ	Time
Mouth	Less than 1 minute
Esophagus	Less than 1 minute
Stomach	1–3 hours
Small Intestine	1–6 hours
Large Intestine	12–36 hours

3. If a meal is eaten at noon, what is happening to the food at 1 P.M.?

A Saliva is breaking down starch into sugar.
B Proteins are being digested into short chains of amino acids.
C Fats are being digested.
D Digested food is being absorbed into the blood.

4. For food eaten at noon, absorption cannot have begun by

A 1 P.M.
B 7 P.M.
C 9 P.M.
D noon the next day.

5. Which of the following organs is *not* just a digestive organ?

A stomach
B liver
C small intestine
D large intestine

Constructed Response

6. Compare the processes of mechanical and chemical digestion. How are they similar? How are they different? In what parts of the digestive system do the two processes take place? How do the processes occur?

Discovery CHANNEL SCHOOL

Circulation
- Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ Chapter Project

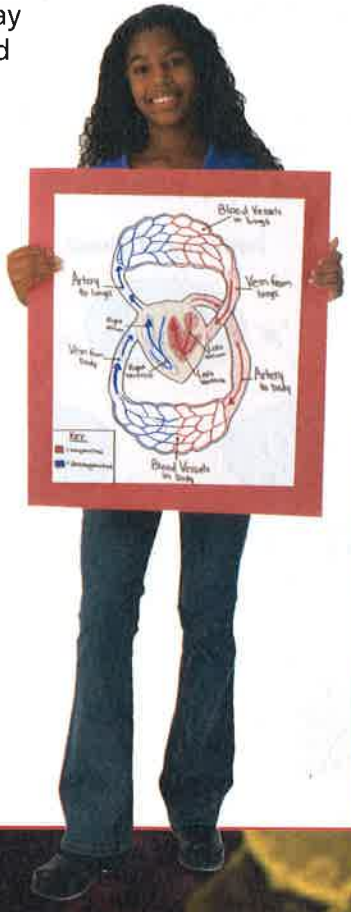
Travels of a Red Blood Cell

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

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

Your display must

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



Plan It! Preview the chapter and find diagrams that show the heart, red blood cells, and the pathway of blood throughout the body. Then discuss the kinds of displays you could use, including a three-dimensional model, posters, a series of drawings, a flip book, or a video animation. Write down any content questions you'll need to answer.

Section 1

The Body's Transport System

Reading Preview

Key Concepts

- What are the functions of the cardiovascular system?
- What is the structure and function of the heart?
- What path does blood take through the cardiovascular system?

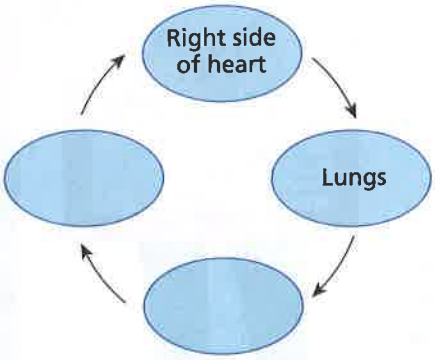
Key Terms

- cardiovascular system • heart
- atrium • ventricle • valve
- pacemaker • artery
- capillary • vein • aorta

Target Reading Skill

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

Pathway of Blood



Lab zone **Discover Activity**

How Hard Does Your Heart Work?

1. Every minute, your heart beats about 75 to 85 times. With each beat, it pumps about 60 milliliters of blood. Can you work as hard and fast as your heart does?
2. Cover a table or desk with newspapers. Place two large plastic containers side by side on the newspapers. Fill one with 2.5 liters of water, which is about the volume of blood that your heart pumps in 30 seconds. Leave the other container empty.
3. With a plastic cup that holds about 60 milliliters, transfer water as quickly as possible into the empty container, trying not to spill any. **CAUTION:** *Wipe up spills on the floor immediately.* Have a partner time you for 30 seconds. As you work, count how many transfers you make in 30 seconds.
4. Multiply your results by 2 to find the number of transfers in 1 minute.

Think It Over

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

Late at night, a truck rolls through the darkness. Loaded with fresh fruits and vegetables, the truck is headed for a city supermarket. The driver steers off the interstate and onto a smaller highway. Finally, after driving through narrow city streets, the truck reaches its destination. As dawn breaks, store workers unload the cargo. At the same time, a garbage truck removes yesterday's trash and drives off down the road.

The Cardiovascular System

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

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

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

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

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

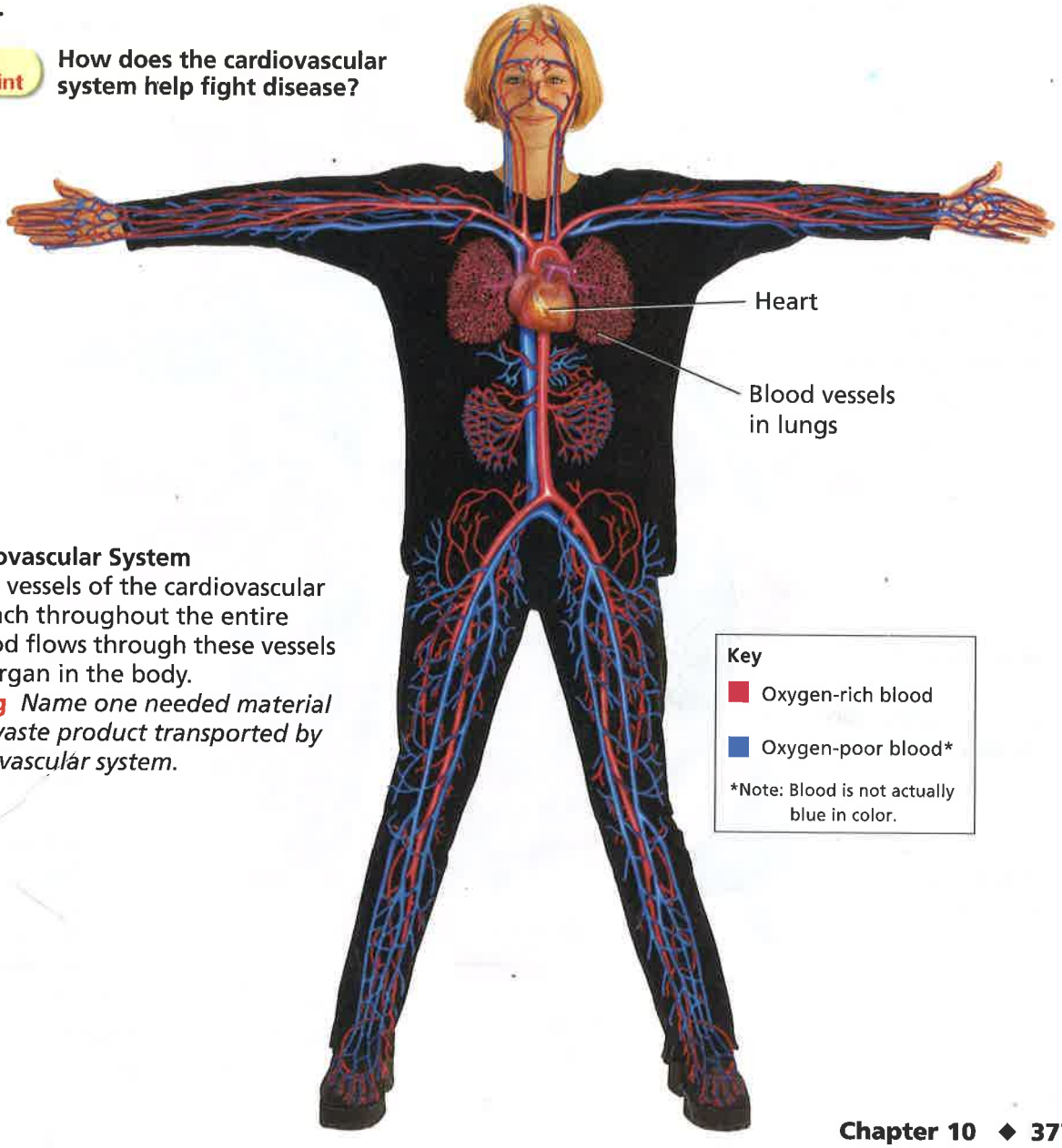


FIGURE 1
The Cardiovascular System
The blood vessels of the cardiovascular system reach throughout the entire body. Blood flows through these vessels to every organ in the body.
Classifying *Name one needed material and one waste product transported by the cardiovascular system.*

The Heart

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

Each time the heart beats, it pushes blood through the blood vessels of the cardiovascular system. The heart is made of cardiac muscle, which can contract over and over without getting tired. Figure 2 shows the structure of the heart.

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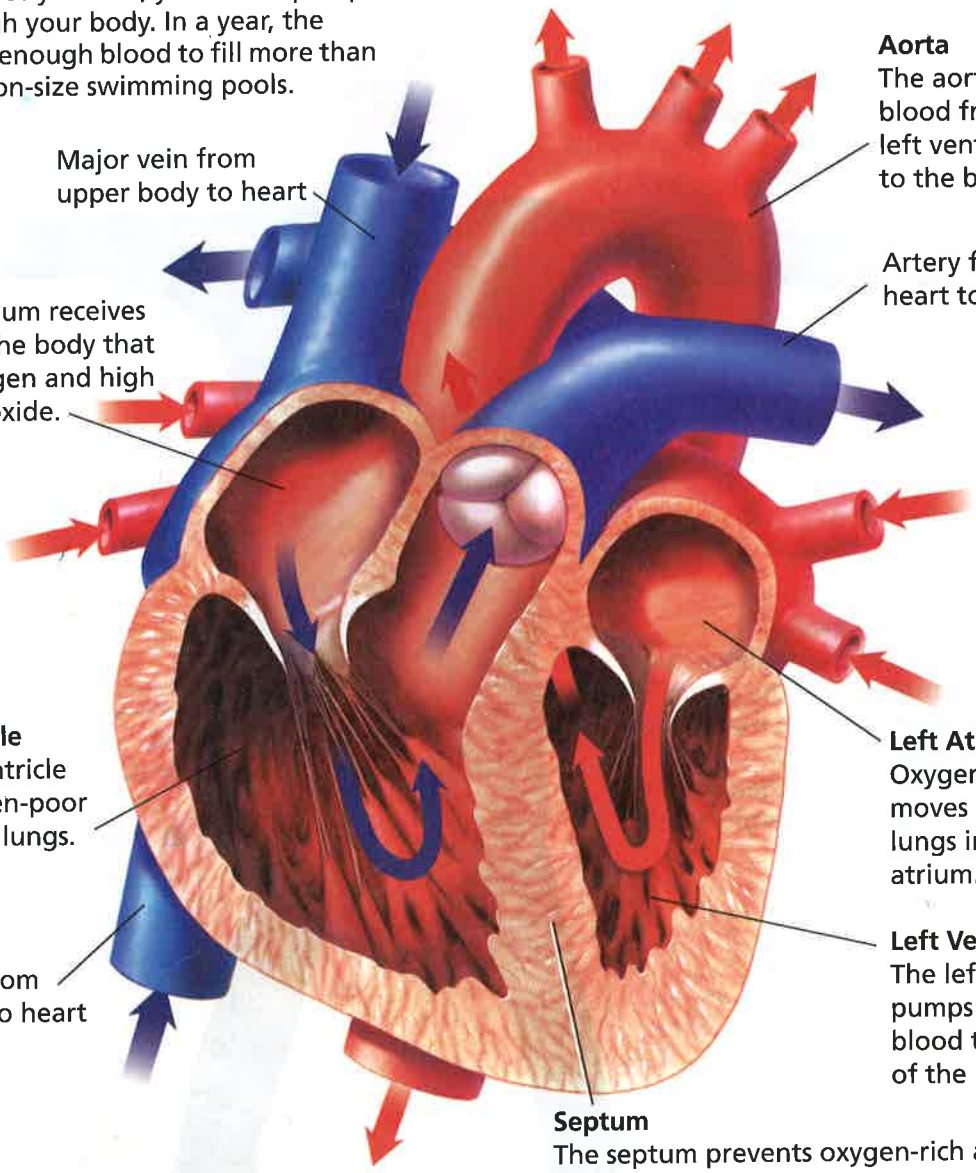
FIGURE 2
The Heart

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



The Heart's Structure Notice in Figure 2 that 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.

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. This muscle contraction squeezes 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. All of this happens in less than a second.

The Force of the Ventricles When muscle cells in the ventricles contract, they exert a force on the blood. A force is a push or a pull. The force exerted by the ventricles pushes blood out of your heart and into arteries.

The contraction of the left ventricle exerts much more force than the contraction of the right ventricle. The right ventricle pumps blood only to the lungs. In contrast, the left ventricle pumps blood throughout the body.

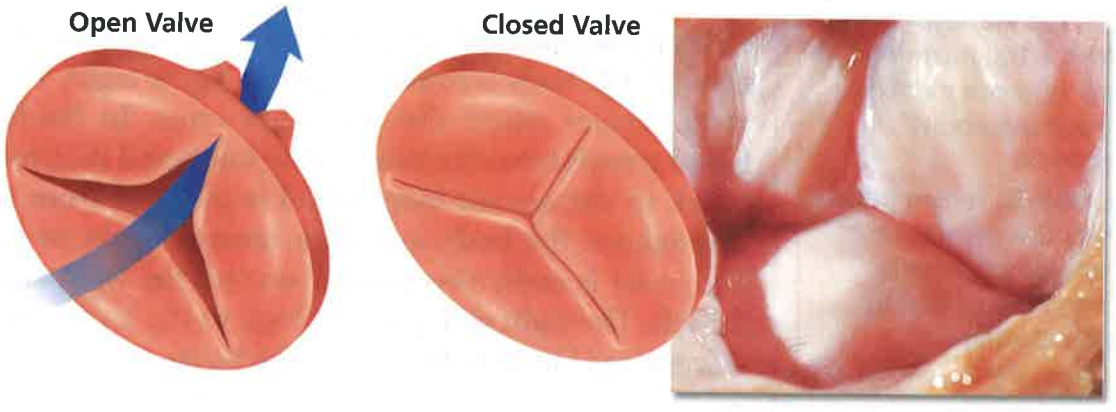


FIGURE 3
Open and Closed Heart Valves
As blood flows out of the heart and toward the lungs, it passes through a valve like the one in the photograph. **Applying Concepts** *What is the function of a closed heart valve?*

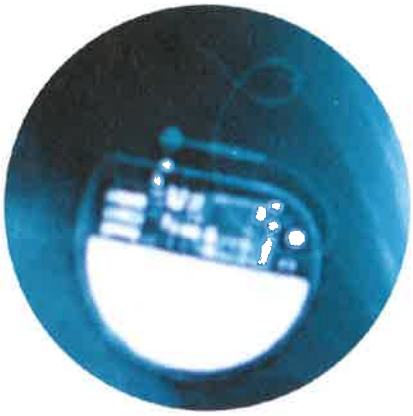


FIGURE 4
An Artificial Pacemaker
This pacemaker has been implanted beneath a patient's skin and connected with wires to the heart. The pacemaker will regulate the patient's heartbeat.

Lab zone Skills Activity

Creating Data Tables

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

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

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

Regulation of Heartbeat A group of heart cells called the **pacemaker** sends out signals that make the heart muscle contract. The pacemaker is located in the right atrium of the heart.

The pacemaker constantly receives messages about the body's oxygen needs. It then adjusts the heart rate to match. For example, your heart beats much faster when you are exercising than when you are sitting quietly. When you exercise, the entire process from the beginning of one heartbeat to the beginning of the next can take less than half a second. Your muscles need more oxygen during exercise. Your rapid heartbeat supplies blood that carries the oxygen throughout your body.

In some people, the pacemaker becomes damaged as a result of disease or an accident. Damage to the pacemaker often results in an irregular or slow heartbeat. In the 1950s, doctors and engineers developed an artificial, battery-operated pacemaker. Modern artificial pacemakers are implanted beneath the skin and are connected by wires to the heart. Tiny electrical impulses travel from the battery through the wires, and make the heart contract.

Reading Checkpoint **What is the function of the heart's pacemaker?**

Two Loops

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

Pattern of Blood Flow The overall pattern of blood flow through the body is something like a figure eight. The heart is at the center where the two loops cross. **In the first loop, blood travels from the heart to the lungs and then back to the heart. In the second loop, blood is pumped from the heart throughout the body and then returns again to the heart.** The heart is really two pumps, one on the right and one on the left. The right side pumps blood to the lungs, and the left side pumps blood to the rest of the body.

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

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

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. Therefore, 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 contains little carbon dioxide. This blood, which is bright red, flows to the left side of the heart and will be pumped through 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?*

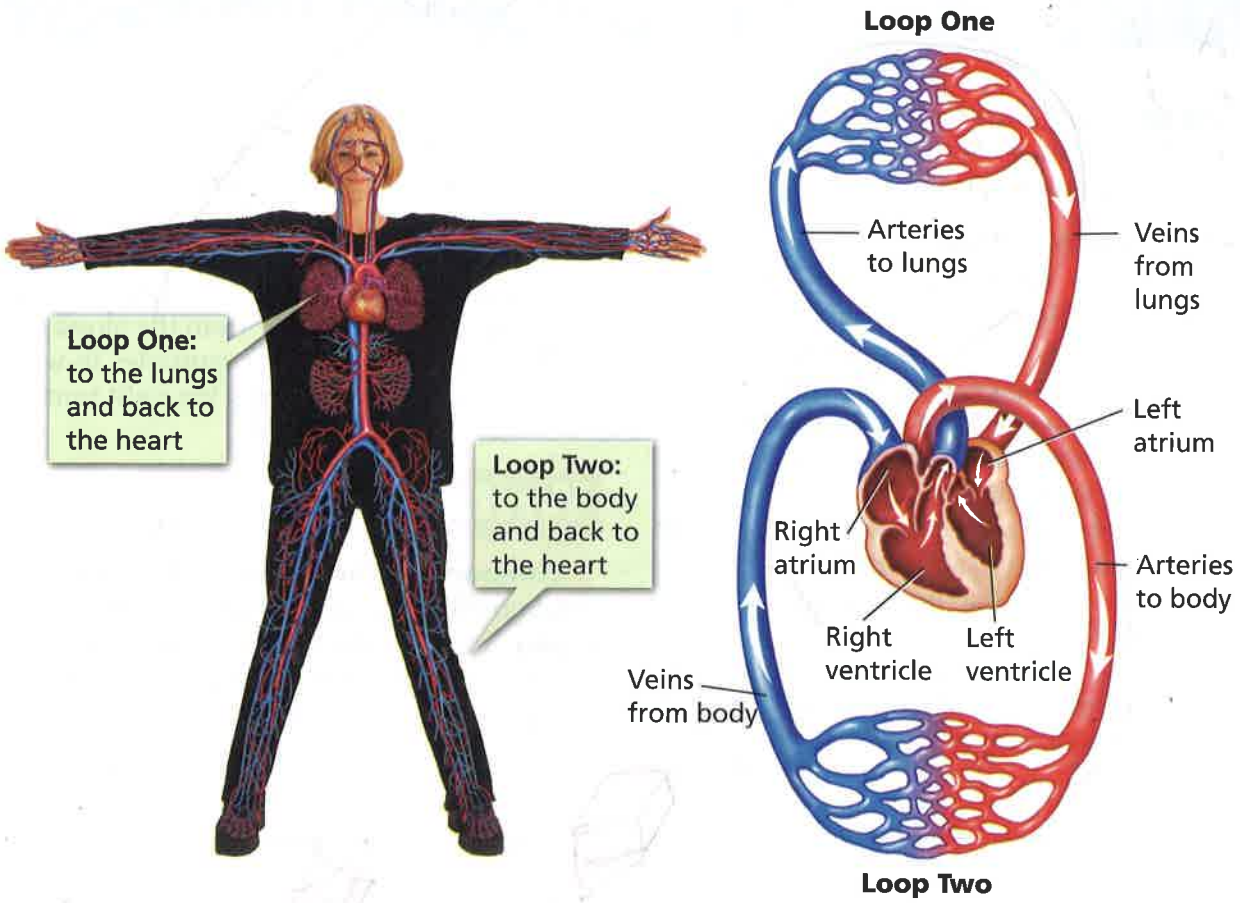


FIGURE 6
Getting Blood to Body Cells
In loop two, oxygen-rich blood is pumped throughout the body. The oxygen moves out of the blood and into the body cells in this swimmer's arms and legs.

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 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.

Reading Checkpoint **What is the largest artery in the body?**

Section 1 Assessment

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

Reviewing Key Concepts

1. a. Reviewing What three functions does the cardiovascular system perform?
   b. Comparing and Contrasting Distinguish between substances that the cardiovascular system transports to cells and substances that it transports away from cells.
2. a. Listing Name the four chambers of the heart. What structures in the heart separate one chamber from another?
   b. Summarizing What function does the heart perform?
   c. Predicting What would happen if the valve between the right atrium and 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?
   c. Interpreting Diagrams Review Figure 5. How does the blood in the artery leaving the right ventricle differ from the blood in the artery leaving the left ventricle? To where does the artery leaving the right ventricle carry blood?

Writing in Science

Comparison Paragraph Write a paragraph comparing the cardiovascular system in the body to a system of roads, telephone lines, or any other "network" you can think of. How are the two systems alike? How do they differ?