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?

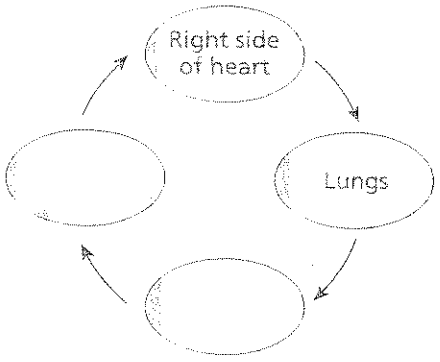
Key Terms

- 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



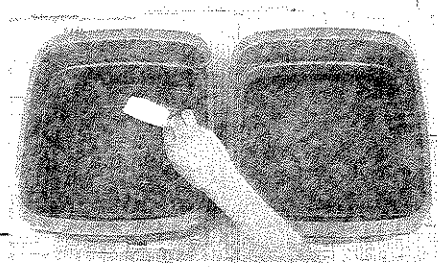
Lab zone Discover Activity

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 to prevent anyone from slipping.* Have a partner time you for 30 seconds. As you work, count how many transfers you make in 30 seconds.
4. Multiply your results by 2 to find the number of transfers for 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?



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

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 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.

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

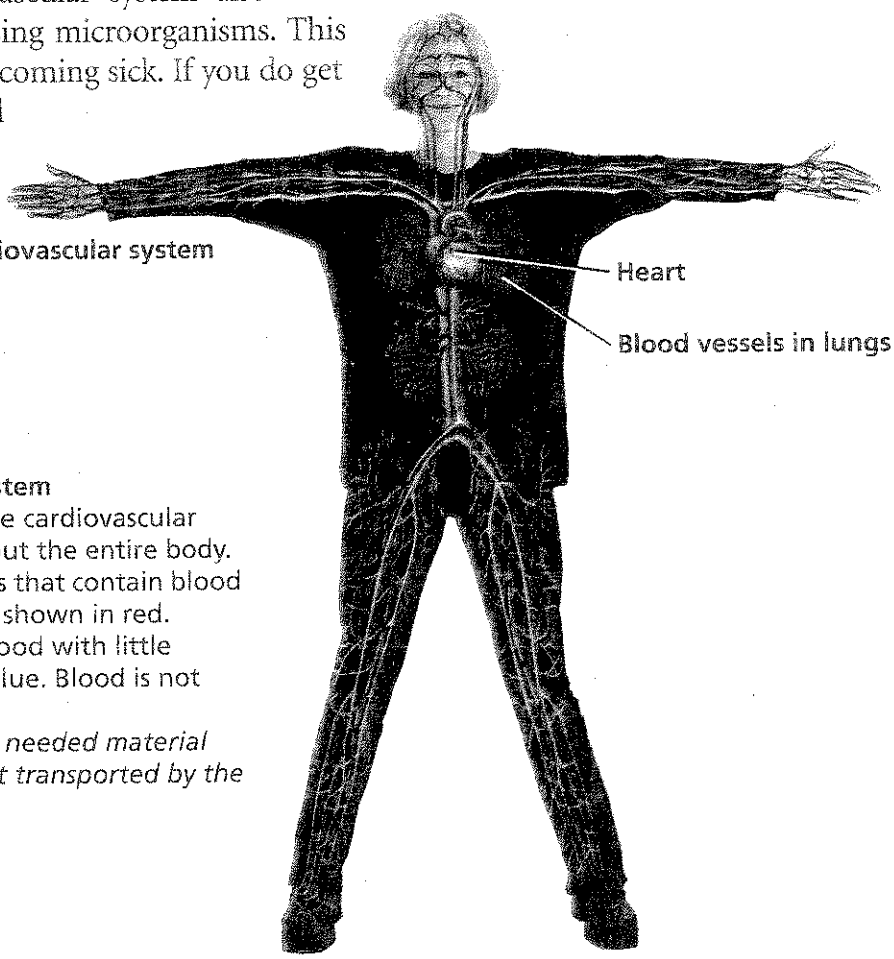


FIGURE 1
The Cardiovascular System
The blood vessels of the cardiovascular system reach throughout the entire body. In this textbook, vessels that contain blood with much oxygen are shown in red. Vessels that contain blood with little oxygen are shown in blue. Blood is not actually blue in color.
Classifying *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.

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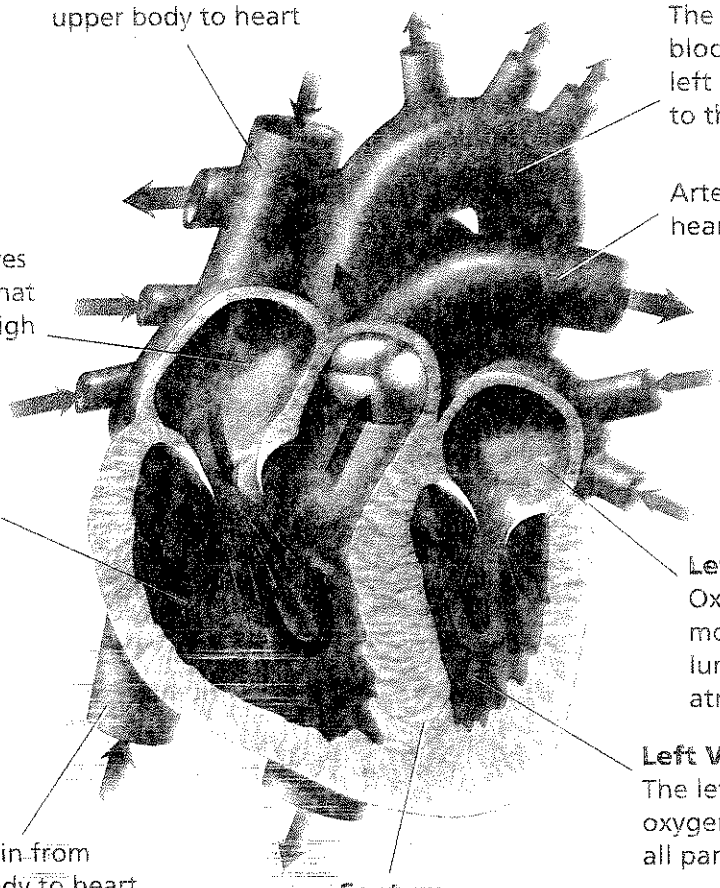
FIGURE 2
Structure of the Heart

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.



Major vein from upper body to heart

Aorta
The aorta carries blood from the left ventricle to the body.

Artery from heart to lungs

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

Right Ventricle
The right ventricle pumps oxygen-poor blood to the lungs.

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

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

Major vein from lower body to heart

Septum
The septum prevents oxygen-rich and oxygen-poor blood from mixing in the heart.

The Heart's Structure Look closely at Figure 2 as you read about the structure of the heart. **Notice that the heart has a right side and a left side. These two sides are completely separated from each other 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.

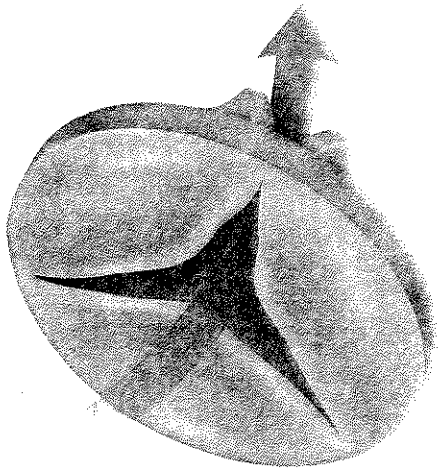
Each lower chamber, called a **ventricle,** pumps blood out of the heart. The atria are separated from the ventricles by valves. A **valve** is a flap of tissue that prevents blood from flowing backward. Valves are also located between the ventricles and the large blood vessels that carry blood away 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.

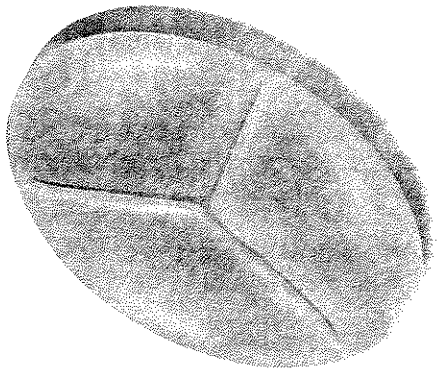
When the heart muscle relaxes, blood flows into the chambers. Then, the atria contract. This muscle contraction squeezes blood out of the atria, through the valves, and into the ventricles. Next, the ventricles contract. This contraction closes the valves between the atria and ventricles, making the *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 ventricle muscle cells contract, they exert a force on the blood. A force is a push or a pull. You see examples of forces all around you. When you lift a book off a table, for example, you exert a force on the book, making it move upward. The force exerted by the ventricles 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.



Open Valve



Closed Valve

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

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 do.

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. 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 electric impulses travel from the battery through the wires. These impulses make the heart contract at a constant rate.

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,** which are the vessels that carry blood back to the heart.

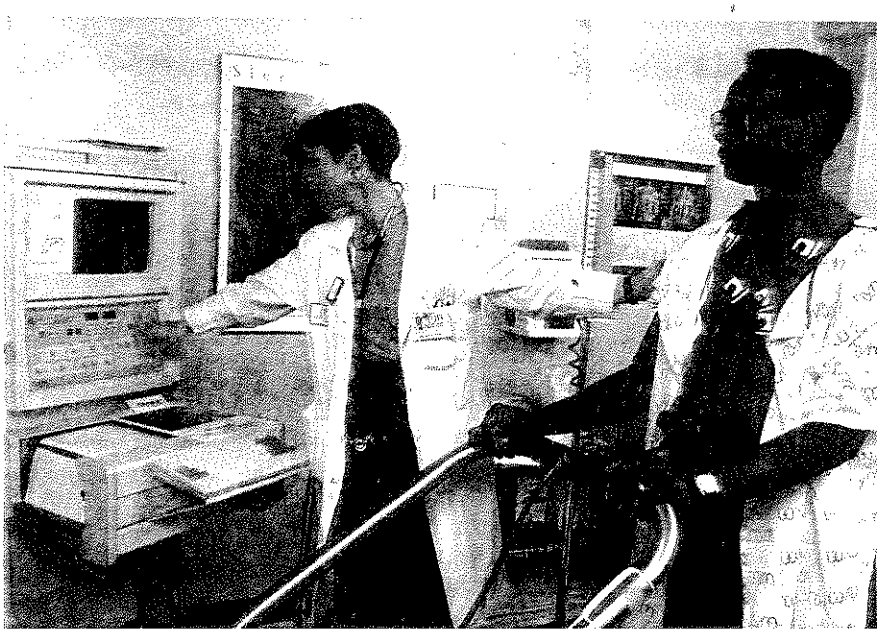


FIGURE 4
Monitoring Heart Rate
Sensors attached to the skin monitor the heart rate and detect any irregularities in heart rhythm.

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.

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 through 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.

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, 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 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.

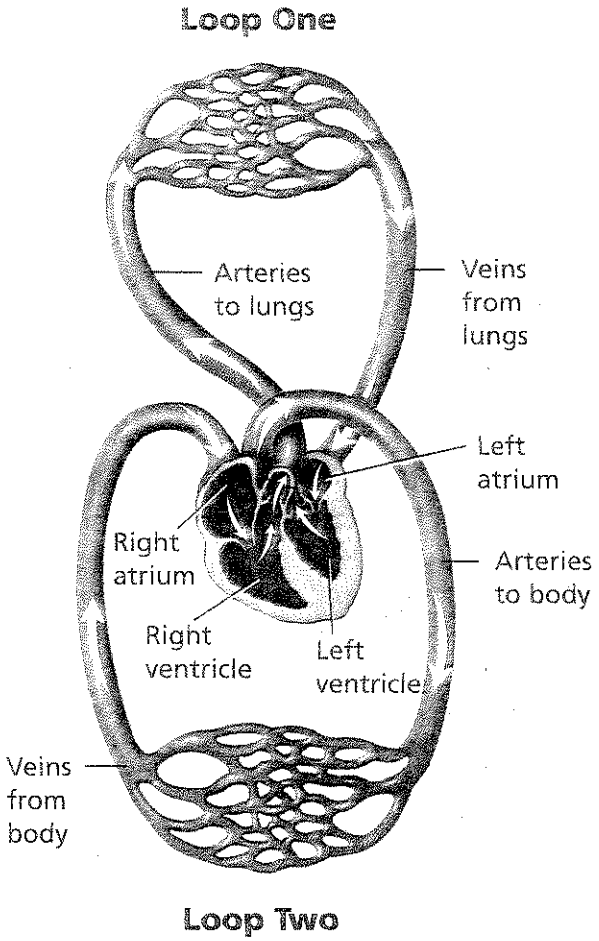


FIGURE 5
Direction of Blood Flow
Blood circulates through the body in two loops, with the heart at the center. Loop one goes from the heart to the lungs and back. Loop two circulates blood throughout the body.
Interpreting Diagrams *Where does the blood that enters the left atrium come from?*

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

Eventually, after passing through branching arteries, blood flows through tiny capillaries in different parts of your body, such as your brain, liver, and legs. These vessels are in close contact with body cells. Oxygen moves out of the blood and into the body cells. At the same time, carbon dioxide passes from the body cells 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. Listing Name three functions of the cardiovascular system.
   b. Describing What substances does the cardiovascular system transport among cells?
   c. Comparing and Contrasting Distinguish between substances the cardiovascular system transports to cells and substances transported away from cells.
2. a. Reviewing Identify the four chambers of the heart.
   b. Identifying What structures in the heart separate one chamber from another?
   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 Look at 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 carry blood from the right ventricle?

Writing in Science

Summarizing Imagine you are a blood cell. Describe your journey throughout the cardiovascular system in one or two paragraphs. Tell what happens when you arrive in the lungs. *Hint:* You can use words like *first*, *next*, and *last* to tell the order in which things happen to you.