

A Closer Look at Blood Vessels

Reading Preview

Key Concepts

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

Key Terms

- coronary artery • pulse
- diffusion • blood pressure

Target Reading Skill

Comparing and Contrasting As you read, compare and contrast the three kinds of blood vessels by completing a table like the one below.

Comparing Blood Vessels

Blood Vessel	Function	Structure of Wall
Artery	Carries blood away from heart	
Capillary		
Vein		



Discover Activity

How Does Pressure Affect Blood Flow?

1. Spread newspapers over a table or desktop. Then, fill a plastic squeeze bottle with water.
2.  Hold the bottle over a dishpan. Squeeze the bottle with one hand. Observe how far the water travels. **CAUTION:** *Wipe up spills on the floor to prevent anyone from slipping.*
3. Now, grasp the bottle with both hands and squeeze again. Observe how far the water travels this time.



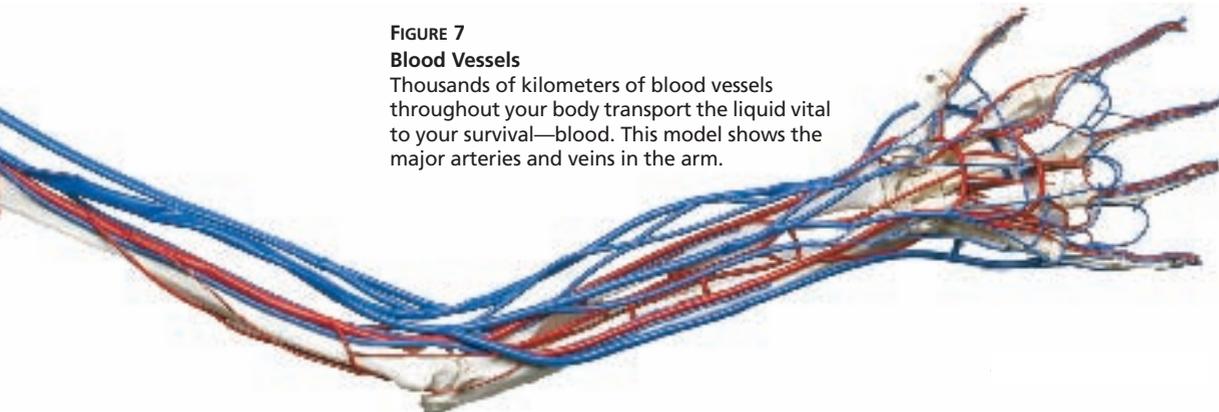
Think It Over

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

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

FIGURE 7
Blood Vessels

Thousands of kilometers of blood vessels throughout your body transport the liquid vital to your survival—blood. This model shows the major arteries and veins in the arm.



Discover Activity

Skills Focus Inferring

L1

Expected Outcome Water should travel farther when both hands are used.

Materials plastic squeeze bottle, dishpan, newspapers, paper towels

Time 10 minutes

Tips  Mop up spills immediately. Because of spillage, you may wish to do this activity outdoors.

Think It Over Squeezing with both hands models an artery, because more force is exerted. Squeezing with one hand models a vein. The heart provides the pushing force.

A Closer Look at Blood Vessels

Objectives

After this lesson, students will be able to

- D.3.2.1** Describe the structures and functions of arteries.
- D.3.2.2** Describe the structures and functions of capillaries and veins.
- D.3.2.3** Explain what causes blood pressure.

Target Reading Skill

Comparing and Contrasting Explain that comparing and contrasting information shows how ideas, facts, and events are similar and different. The results of the comparison can have importance.

Answers

Sample answers:

Artery: Carries blood away from the heart; Thick walls consisting of three cell layers with thick muscle in the middle layer

Capillary: Exchange of materials between the blood and body cells; Thin walls consisting of one cell layer

Vein: Carries blood back to the heart; Thick walls consisting of three cell layers with thin muscle in the middle layer

All in One Teaching Resources

- Transparency D25

Preteach

Build Background Knowledge

L1

Taking a Pulse

Review with students how to take their pulse, and have them do it. Ask: **What type of blood vessel are you feeling?** (*Artery*) **Can the pulse be felt in the arteries, veins, or both?** (*Arteries*) At this point do not correct any misconceptions. Tell students that they will learn more about the pulse in this section. After students have read the section, discuss pulse again to correct any misconceptions.

Instruct

Arteries

Teach Key Concepts

L2

Functions of Arteries

Focus Remind students that arteries carry blood away from the heart.

Teach Explain that the heart itself must receive oxygen-rich blood to function. Ask:

How does it get this blood? (*Coronary arteries supply blood to the heart.*) Sketch a cross-section of an artery. Ask: **How does the structure of an artery relate to its function?**

(*The smooth inner layer helps blood to flow freely. The muscular middle layer expands and relaxes in response to the heart pumping. The outer connective tissue makes the artery strong yet flexible.*) **What are you feeling when you take a pulse?** (*A spurt of blood pushing the artery walls and making them expand*)

Apply Refer students to Figure 8. Ask: **What is the main difference between the structure of arteries and veins, and why is this?** (*Arteries are thicker because the force of blood pumped through these vessels is stronger than the force flowing through the veins.*)

learning modality: visual

Independent Practice

L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: A Closer Look at Blood Vessels

Student Edition on Audio CD

Math Skills

Math Skill Calculating a rate

Focus Tell students that the units of pulse rate are heartbeats per minute.

Teach Explain that people often calculate heart rate by counting the pulse for 10, 15, or 30 seconds and then multiplying.

Answer

68 beats per minute

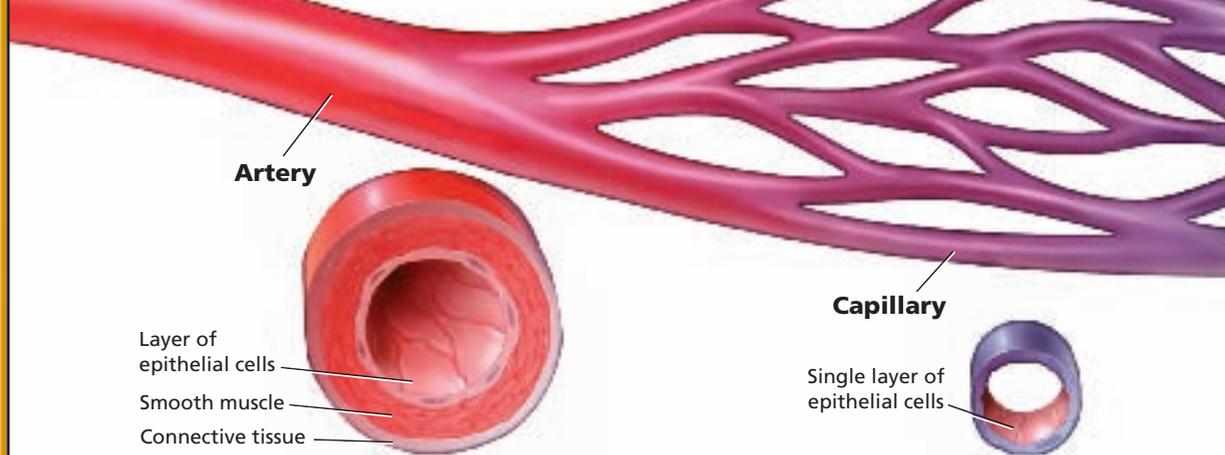


FIGURE 8

Artery, Capillary, and Vein

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



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

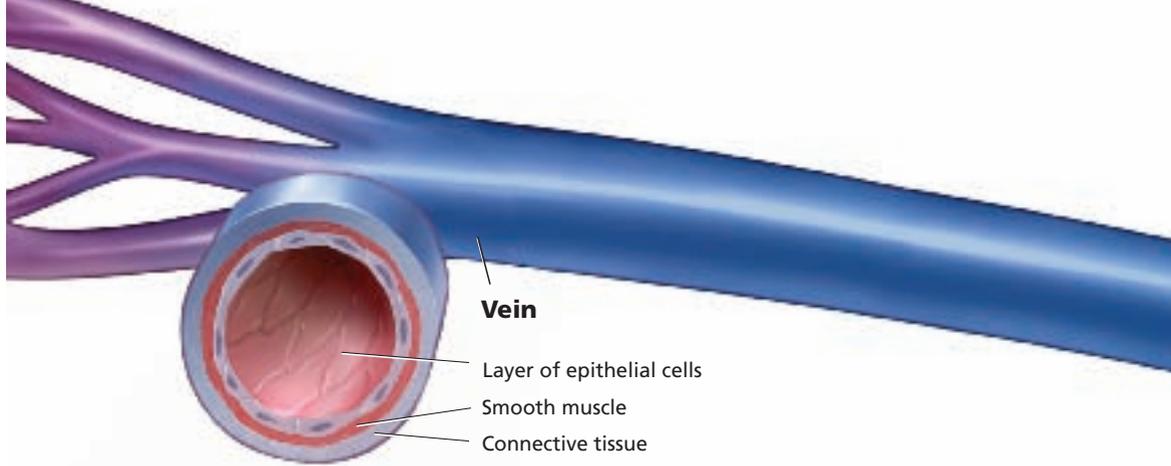
Arteries

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

Artery Structure The walls of arteries are generally very thick. In fact, artery walls consist of three cell layers. The innermost layer, which is made up of epithelial cells, is smooth. This smooth surface enables blood to flow freely. The middle layer consists mostly of muscle tissue. The outer wall is made up of flexible connective tissue. Because of this layered structure, arteries have both strength and flexibility. Arteries are able to withstand the enormous pressure of blood as it is pumped by the heart and to expand and relax between heart beats.

Pulse If you lightly touch the inside of your wrist, you can feel the artery in your wrist rise and fall repeatedly. This **pulse** is caused by the alternating expansion and relaxation of the artery wall. Every time the heart's ventricles contract, they send a spurt of blood out through all the arteries in your body. As this spurt travels through the arteries, it pushes the artery walls and makes them expand. After the spurt passes, the artery walls relax and become narrower again.

When you count the number of times an artery pulses beneath your fingers, you are counting heartbeats. By taking your pulse rate, you can determine how fast your heart is beating.



Regulating Blood Flow The layer of muscle in an artery acts as a control gate, adjusting the amount of blood sent to different organs. When the muscle contracts, the opening in the artery becomes smaller. When the muscle relaxes, the opening becomes larger. For example, after you eat, your stomach and intestines need a greater blood supply for digestion. The arteries leading to those organs open wider, and more blood flows through them. In contrast, when you are running, your stomach and intestines need less blood than the muscles in your legs. The arteries leading to the digestive organs become narrower, decreasing the blood flow to these organs.



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.

Capillaries

Teach Key Concepts

L1

Function of Capillaries

Focus Refer students to Figure 8.

Teach Ask: **Why are capillary walls so thin?** (*Materials must be able to pass easily between them and body cells.*)

Apply Tell students that blood cells must pass through capillaries in single file.

learning modality: visual

All in One Teaching Resources

- Transparency D26



Teacher Demo

L1

Observing Diffusion

Materials 2 beakers, food coloring, salt, teaspoon

Time 10 minutes over two days

Focus Review the process of diffusion.

Teach Pour water into a beaker until it is one-third full. Add one-half teaspoon of salt and a few drops of food coloring. Stir until you have a uniform solution. Pour water into a second beaker until it is one-half full. Next, carefully pour the contents of the first beaker into the second. The salt water will sink to the bottom. Let the beaker stand overnight. The liquid will be uniformly colored.

Apply Ask: **How is this process like diffusion in capillaries?** (*The concentration of salt in the salt water was higher than that in the fresh water; thus, the salt water diffused into the fresh. Glucose is higher in concentration in blood than in body cells, so it moves from the blood to body cells.*) **learning modality: visual**

Differentiated Instruction

Less Proficient Readers

Illustrating Blood Vessels Have students draw each type of blood vessel. The drawing should include tag lines labeling any parts discussed in the text and captions describing the functions of each type of vessel. Pair students with more proficient readers to read the

L1

corresponding text and to identify information to include in the drawings. Students can copy and expand upon the illustrations in the text or their own charts. Encourage students to use different-colored markers to distinguish structures. **learning modality: visual**

Monitor Progress

L2

Writing Ask students to explain the differences between arteries and capillaries.

Answers

Figure 8 By diffusion



Alternating expansion and relaxation of the artery wall

Veins

Teach Key Concepts

L2

Returning Blood to the Heart

Focus Review the function of veins.

Teach Ask: **How does the pushing force of the heart in veins compare to the pushing force in arteries?** (*The pushing force of the heart has less effect by the time blood reaches the veins.*) **What factors help move blood through veins?** (*Contraction of skeletal muscles, valves, and breathing movements*)

Apply Ask: **Would your blood move best through the veins while you were sitting for 45 minutes or while you were playing soccer for 45 minutes? Why?** (*Playing soccer; skeletal muscles help push blood along when they contract.*) **learning modality: logical/mathematical**

Blood Pressure

Teach Key Concepts

L2

What Causes Blood Pressure

Focus Ask: **What happens to the force of blood as moves away from the heart?** (*It decreases.*)

Teach Explain that blood pressure is caused when the heart contracts and produces a wave of fluid pressure through the arteries. Blood pressure decreases when the heart relaxes, but the system still remains under pressure. Ask: **How do these differences explain the different numbers in a blood pressure reading?** (*The first number measures the blood pressure when the heart contracts, so it is higher. The second number is lower because it shows the pressure when the heart relaxes.*)

Apply Ask: **Why is a cut in an artery generally a more serious injury than a cut in a vein of the same size?** (*Blood pressure is higher in arteries, so blood loss from a cut artery can occur more rapidly.*) **learning modality: verbal**



FIGURE 9

Artery and Vein

In this photo, you can compare the wall of an artery (top) with the wall of a vein (bottom).

Comparing and Contrasting

Where is the pushing force of the heart greater—in arteries or in veins?

Veins

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

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



How do skeletal muscles help move blood in veins?

Blood Pressure

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

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

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

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

FIGURE 10
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 2 Assessment

Target Reading Skill Comparing and Contrasting Use the information in your table about blood vessels to help you answer the questions below.

Reviewing Key Concepts

- a. Identifying** In which direction do arteries carry blood?

b. Explaining How does the structure of arteries enable them to withstand high pressure?

c. Applying Concepts Arteries adjust the amount of blood flowing to different parts of the body, depending on where blood is needed. Use this fact to explain why you should not exercise vigorously shortly after you eat.
- a. Reviewing** What is the function of capillaries in the body?

b. Summarizing Summarize the factors that enable blood in your leg veins to return to the heart in spite of the downward pull of gravity.

- a. Defining** What is blood pressure?

b. Relating Cause and Effect Why is blood pressure lower in leg veins than in the aorta?

c. Predicting How might having low blood pressure affect your body?

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. After resting for 15 minutes, you count 31 beats in 30 seconds.

- Calculating a Rate** What was your pulse rate per minute before the run?
- Calculating a Rate** What was your pulse rate immediately after the run? After resting for 15 minutes?

Lab zone Chapter Project

Keep Students on Track Advise students to begin constructing their displays if they haven't begun. Help students determine the best way to organize the information for their own understanding. Suggest that students begin to prepare a rough draft of their written descriptions. Suggest students make flowcharts to help them prepare rough drafts.

Math Practice

Math Skills Calculating a rate

Answers

- 58 ($29 \times 2 = 58$)
- 126 ($63 \times 2 = 126$); 62 ($31 \times 2 = 62$)

Monitor Progress L2

Answers

Figure 9 In arteries



The contraction of the muscles helps push the blood along.

Assess

Reviewing Key Concepts

- a.** Away from the heart. **b.** The walls of arteries are thick and flexible. **c.** After eating, more blood is routed to the digestive system. If someone exercises right after eating, the body might not be able to supply enough blood to both the digestive system and the skeletal muscles.
- a.** To exchange materials between the blood and the body's cells. **b.** The contraction of skeletal muscles helps move blood through veins. Larger veins have valves in them that prevent blood from flowing backward. Breathing movements force blood toward the heart.
- a.** The force blood exerts on the walls of blood vessels **b.** The farther away from the ventricle the blood moves, the lower the force pushing it. **c.** With low blood pressure, cells might not receive enough blood, and therefore, not enough oxygen and glucose. A person might feel tired and lack energy.

Reteach L1

Have students summarize the structures and functions of arteries, veins, and capillaries.

Performance Assessment L2

Drawing Have students diagram the movement of blood through arteries, capillaries, veins, and the heart.

All in One Teaching Resources

- Section Summary: *A Closer Look at Blood Vessels*
- Review and Reinforce: *A Closer Look at Blood Vessels*
- Enrich: *A Closer Look at Blood Vessels*

Heart Beat, Health Beat

Prepare for Inquiry

Skills Objectives

After this lab, students will be able to

- graph their pulse rate under different conditions
- interpret data on pulse rate
- draw conclusions about the relationship between physical activity and pulse rate



Prep Time none

Class Time 40 minutes

Advance Planning

Students with relevant health problems can keep time and record data.

Safety



Students with medical reasons to avoid exercise should do only steps 1–3.

Review the safety guidelines in Appendix A.

All in One Teaching Resources

- Lab Worksheet: *Heart Beat, Health Beat*

Guide Inquiry

Introduce the Procedure

Have students practice taking their pulse.

Troubleshooting the Experiment

Ask the class to be quiet during the lab.

Expected Outcome

Pulse will increase more when running than walking, then return to a resting rate (70–80 beats per minute).

Extend Inquiry

Design an Experiment Students' plans will include measuring the resting pulse rate of people of different ages.



Heart Beat, Health Beat

Problem

How does physical activity affect your pulse rate?

Skills Focus

graphing, interpreting data, drawing conclusions

Materials



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

Procedure



1. Predict how your pulse rate will change as you go from resting to being active, then back to resting again. Then, copy the data table into your notebook.
2. Locate your pulse by placing the index and middle finger of one hand on your other wrist at the base of your thumb. Move the two fingers slightly until you feel your pulse. If you are using a heart rate monitor, see your teacher for instructions.
3. Work with a partner for the rest of this lab. Begin by determining your resting pulse rate. Count the number of beats in your pulse for exactly 1 minute while your partner times you. Record your resting pulse rate in your data table. **CAUTION:** Do not complete the rest of this lab if there is any medical reason why you should avoid physical activities.

Data Table	
Activity	Pulse Rate
Resting	
Walking	
Running	
Resting after exercise (1 min)	
Resting after exercise (3+ min)	

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.

Analyze and Conclude

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

Design an Experiment

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

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Students can share data online.

Analyze and Conclude

1. Graphs will reflect data similar to those in the table. Graphs should be clearly labeled.
2. The pulse returns to the resting rate.
3. The heart is beating faster.
4. Pulse rate increases during exercise.
5. Answers should include the idea that taking many measurements and finding an average improves accuracy.