33.1 The Circulatory System

Lesson Objectives

- Identify the functions of the human circulatory system.
- Describe the structure of the heart and explain how it pumps blood through the body.
- Name three types of blood vessels in the circulatory system.

Lesson Summary

Functions of the Circulatory System  The circulatory system transports oxygen, nutrients, and other substances throughout the body, and removes wastes from tissues.

The Heart  The muscle layer of the heart is the myocardium. Its powerful contractions pump blood through the circulatory system. The human heart has four chambers. A wall called the septum separates the right side of the heart from the left side. On each side of the septum are an upper and lower chamber.

- Each upper chamber, or atrium (plural: atria), receives blood from the body; each lower chamber, or ventricle, pumps blood out of the heart.

- Flaps of connective tissue called valves are located between the atria and the ventricles and between the ventricles and blood vessels leaving the heart. The valves open and close to keep blood moving in one direction.

The heart pumps blood through two pathways:

- **Pulmonary circulation** pumps blood from the heart to the lungs and back to the heart again. Blood picks up oxygen and releases carbon dioxide in the lungs.

- **Systemic circulation** pumps blood from the heart to the rest of the body. Cells absorb much of the oxygen and load the blood with carbon dioxide.

The heart muscle beats in an orderly and coordinated way. A small group of cardiac muscle fibers, the sinoatrial node (SA node), is also called the pacemaker. When the pacemaker fires, an electrical impulse causes the atria to contract. Another group of muscle fibers, the atrioventricular node (AV node), causes the ventricles to contract. The nervous system influences the SA node, increasing or decreasing heart rate to meet the body's needs.

Blood Vessels  Blood flows through the circulatory system in blood vessels:

- **Arteries** are large vessels that carry blood away from the heart to the tissues of the body. Except for the pulmonary arteries, all arteries carry oxygen-rich blood.

- **Capillaries** are the smallest vessels. Their thin walls allow oxygen and nutrients to pass from blood into tissues and wastes to move from tissues into blood.

- **Veins** return blood to the heart. Many have valves that prevent backflow.

The contractions of the heart produce a wave of fluid pressure in the arteries, known as blood pressure. Without that pressure, blood would stop flowing through the body. The body regulates blood pressure through actions of the brain and the kidneys.
Functions of the Circulatory System

1. Why do animals with millions of cells “need” a circulatory system while animals with few cells can do without one?

*If all cells are in direct contact with the environment, diffusion and active transport can provide nutrients and oxygen and remove wastes. Large, multicellular organisms have cells that are not in direct contact with the environment. A circulatory system is required to serve those functions.*

Marie lives in a large city. She is disabled and cannot leave her home. Everything she needs must be delivered to her, and all her garbage must be hauled away. Compare how the streets and highways of the city supply Marie’s needs with how the circulatory system supplies the needs of individual cells of the human body.

*Marie’s food, medicines, and other supplies are brought to her door by delivery people who travel along streets and highways. Garbage collectors use those same streets and highways to collect and haul away her trash. The same thing happens in the body. Delivery people (blood cells) travel along streets and highways (arteries and veins). They deliver supplies like oxygen and nutrients. They also collect waste products like carbon dioxide and haul them away.*

The Heart

2. **Visual Analogy** Marie lives in a large city. She is disabled and cannot leave her home. Everything she needs must be delivered to her, and all her garbage must be hauled away. Compare how the streets and highways of the city supply Marie’s needs with how the circulatory system supplies the needs of individual cells of the human body.

3. Complete the table.

<table>
<thead>
<tr>
<th>Circulation Pathway</th>
<th>Side of Heart Pumping</th>
<th>Destination After Leaving Heart</th>
<th>Blood Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary</td>
<td><strong>Right</strong></td>
<td><strong>Lungs</strong></td>
<td><strong>Oxygen poor to oxygen rich</strong></td>
</tr>
<tr>
<td>Systemic</td>
<td><strong>Left</strong></td>
<td><strong>Body</strong></td>
<td><strong>Oxygen rich to oxygen poor</strong></td>
</tr>
</tbody>
</table>
4. Label the diagram at the points indicated to show the structures of the human circulatory system. Add arrows to show the direction of blood flow.

![Diagram of the human circulatory system]

- Capillaries of head and arms
- Superior vena cava
- Aorta
- Pulmonary artery
- Pulmonary capillaries
- Lung
- Vein
- Inferior vena cava
- Capillaries of abdominal organs and legs

5. Complete the flowchart to show the actions that keep the heart beating in an orderly way.

- The SA node fires
- Electrical impulse spreads through the atria and the atria contract
- Impulse is delayed while the atria contract and pump blood to the ventricles
- AV node produces impulses that spread through the ventricles
- Ventricles contract and pump blood out of the heart
- Impulse from the SA node is picked up by the AV node
- Impulse from the SA node is picked up by the AV node
Blood Vessels

6. As blood flows through the body, it passes through three types of blood vessels. Complete the table by naming each type and describing its structure and function.

<table>
<thead>
<tr>
<th>Blood vessels</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteries</td>
<td>Thick, elastic walls containing connective tissue, smooth muscle, and endothelium</td>
<td>Carry blood from the heart to the tissues of the body</td>
</tr>
<tr>
<td>Capillaries</td>
<td>Smallest blood vessels; extremely thin walls</td>
<td>Allow oxygen and nutrients to diffuse from blood into tissues, and wastes to move from tissues into blood</td>
</tr>
<tr>
<td>Veins</td>
<td>Large vessels; many contain valves to ensure that blood flows in one direction</td>
<td>Carry blood toward the heart</td>
</tr>
</tbody>
</table>

7. Complete the feedback diagram to show how the nervous system regulates blood pressure.

8. The left side of the heart is larger and more muscular than the right side. Also, artery walls are thicker than those of veins. Explain how those differences in structure are important to function.

**SAMPLE ANSWER:** The left side of the heart must pump blood through the entire body. It has to be stronger than the right side, which only pumps blood to the lungs. Arteries carry blood away from the heart. They must be stronger and more flexible than veins to withstand the pressure of the pumping heart.
Lesson 33.2  Blood and the Lymphatic System

Explain the functions of blood plasma, red blood cells, white blood cells, and platelets.
Describe the role of the lymphatic system.
List three common circulatory diseases.
Describe the connection between cholesterol and circulatory disease.

Lesson Summary

Blood  Blood has four main components:
- **Plasma** is a straw-colored fluid. It is about 90 percent water and 10 percent dissolved gases, salts, nutrients, enzymes, hormones, waste products, plasma proteins, cholesterol, and other important compounds. Parts of plasma help control body temperature, transport substances, and fight infection. Plasma proteins are involved in blood clotting.
- **Red blood cells** transport oxygen. Blood gets its red color from the iron in **hemoglobin**, a protein that binds oxygen in the lungs and releases it in the capillaries.
- **White blood cells** guard against infection, fight parasites, and attack bacteria.
- **Platelets** are cell fragments involved in blood clotting.

The Lymphatic System  The lymphatic system is a network of vessels, nodes, and organs that collects the fluid that leaves the capillaries, “screens” it for microorganisms, and returns it to the circulatory system.
- **Lymph** is fluid that consists of blood components that have moved through the walls of capillaries.
- Lymph vessels transport materials and lymph nodes act as filters, trapping microorganisms, stray cancer cells, and debris.

Circulatory System Diseases  Three common and serious diseases of the circulatory system are:
- **Heart disease**: A leading cause of heart disease is **atherosclerosis**, a condition in which fatty deposits called plaque build up in artery walls and eventually cause the arteries to stiffen. A heart attack occurs as heart muscle cells become damaged.
- **Stroke**: A clot that blocks a blood vessel in the brain may cause a stroke, which is the sudden death of brain cells when their blood supply is interrupted. A stroke can also occur if a weak vessel breaks and causes bleeding in the brain.
- **High blood pressure**, or hypertension, is usually defined as blood pressure higher than 140/90. Uncontrolled high blood pressure can damage the heart and blood vessels. It can also lead to heart attack, stroke, and kidney damage.

Understanding Circulatory Disease  Cholesterol is a lipid that is part of animal cell membranes. It is transported in the blood primarily by two types of lipoproteins: low-density lipoprotein (LDL) and high-density lipoprotein (HDL). The liver manufactures cholesterol, but it also comes from animal product foods. High cholesterol levels, along with other risk factors, lead to atherosclerosis and higher risk of heart attack.
Blood

For Questions 1–5, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

True 1. Blood helps regulate body temperature and fight infections.
4–6 2. The human body contains 8–10 liters of blood.
90 proteins 3. Plasma is about 50 percent water.
True 4. Albumin, globulins, and fibrinogen are nucleic acids in blood.
True 5. Fibrinogen is necessary for blood clotting.

6. Complete the table to describe the characteristics and functions of blood.

<table>
<thead>
<tr>
<th>Component</th>
<th>Characteristics</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>It is 90 percent water and 10 percent dissolved gases, salts, nutrients, enzymes, hormones, waste proteins, and other compounds.</td>
<td>Helps control body temperature, transports fatty acids, hormones and vitamins, and helps with osmotic pressure and clotting.</td>
</tr>
<tr>
<td>Red blood cells</td>
<td>They are disks that are thinner in their center than along the edges. They get their red color from the iron in hemoglobin.</td>
<td>Hemoglobin binds to oxygen. Red blood cells transport oxygen to cells and some carbon dioxide to the lungs.</td>
</tr>
<tr>
<td>White blood cells</td>
<td>There are different types, such as macrophages, B lymphocytes, and T lymphocytes.</td>
<td>Macrophages engulf pathogens. B lymphocytes produce antibodies. T lymphocytes help fight tumors and viruses.</td>
</tr>
<tr>
<td>Platelets</td>
<td>They are fragments of the cytoplasm of certain bone marrow cells. They are enclosed in a membrane.</td>
<td>They cluster around a wound and release proteins called clotting factors that start blood clotting.</td>
</tr>
</tbody>
</table>
The Lymphatic System

For Questions 7–14, write the letter of the correct answer on the line at the left.

7. Fluid and small particles that leave the blood are collectively called
   A. plasma.  C. platelets.
   B. lymphocytes.  D. lymph.

8. Some of the lymph is collected in a network of vessels, nodes, and organs called the
   A. circulatory system.  C. respiratory system.
   B. lymphatic system.  D. excretory system.

9. How does lymph help protect against infection?
   A. It screens for microorganisms.
   B. It causes fevers when viruses are present.
   C. It removes defective DNA from cells.
   D. It removes toxins from the liver.

10. What moves lymph into ducts?
    A. valves in the veins
    B. the pumping action of the heart
    C. pressure from skeletal muscles
    D. the thin walls of capillaries

11. Where does lymph return to the bloodstream?
    A. through veins just below the shoulders
    B. through veins in the legs
    C. through arteries in the abdomen
    D. through capillaries in the liver

12. What nutrients does the lymphatic system pick up in the digestive tract and transport to the bloodstream?
    A. fats and fat-soluble vitamins
    B. water and water-soluble vitamins
    C. water and proteins
    D. fatty acids and cholesterol

13. Which of the following is NOT a function of lymph nodes?
    A. pumping blood to the lungs
    B. trapping microorganisms
    C. collecting cancer cells
    D. gathering debris from the body

14. Which organ of the lymphatic system stores platelets?
    A. heart  C. thymus
    B. lymph node  D. spleen
Circulatory System Diseases

15. Why is the first sign of a circulatory problem an event that affects the heart or brain?

_The tissues of these vital organs begin to die within moments if their oxygen supply is interrupted._

16. What is atherosclerosis?

_It is a condition in which fatty deposits called plaques build up in artery walls and cause arteries to stiffen._

17. What is angina, and what causes it?

_It is chest pain caused by restricted blood flow to the heart._

18. What is one cause of heart failure?

_The heart is weakened or damaged by oxygen deprivation._

19. What is a heart attack, and what causes most heart attacks?

_A heart attack occurs when blood flow to heart muscle tissue is blocked and the tissue is damaged. A heart attack may occur if the cap of a plaque ruptures, and a blood clot forms that completely blocks an artery._

20. How is a stroke like a heart attack?

_A stroke and heart attack may have the same cause: a clot blocks the blood supply to tissue (brain for a stroke, heart for a heart attack)._  

21. How does high blood pressure damage the heart?

_The heart struggles to push blood through the vessels. Also, hypertension causes small tears in blood vessels; the plaques of atherosclerosis can form in the tears._

Understanding Circulatory Diseases

For Questions 22–25, complete each statement by writing the correct word or words.

22. Cholesterol is transported through the body by **low density** lipoprotein and **high density** lipoprotein.

23. A cholesterol level in the range of 100–200 mg/dL is considered normal.

24. Cholesterol is made in the **liver**, but can also be found in foods high in **fat**.

25. High cholesterol is one of the risk factors for **atherosclerosis** and heart attack.
26. Fill in the concept map to compare the path of cholesterol in normal liver cells and defective liver cells.

**Normal**
- LDL binds to receptors on liver cell membrane and is taken into the cell
- LDL is stored or used for making more cholesterol or bile
- Cholesterol levels are low
- Liver produces more cholesterol

**Defective**
- LDL cannot bind to LDL receptors
- Cholesterol remains in the blood
- Liver continues producing more cholesterol
- Cholesterol levels are high
- Liver stops producing cholesterol

27. What did Brown and Goldstein discover about people who eat high-fat diets?

They store extra cholesterol in their liver cells. Those cells then stop making LDL receptors and removing cholesterol from blood. The excess blood cholesterol is then deposited in the arteries.

28. Heart disease, stroke, and high blood pressure are major killers in the United States, yet much can be done to prevent them. How can a healthy diet and exercise keep the circulatory system functioning properly to prevent these diseases?

A healthy diet low in fat prevents LDL levels from rising and leading to atherosclerosis. Exercise keeps the heart muscles strong and pumping blood efficiently.
33.3 The Respiratory System

Identify the structures of the respiratory system and describe their functions.
Describe gas exchange.
Describe how breathing is controlled.
Describe the effects of smoking on the respiratory system.

Lesson Summary

Structures of the Respiratory System  For organisms, respiration means the process of gas exchange between a body and the environment. The human respiratory system picks up oxygen from the air we inhale and releases carbon dioxide into the air we exhale. The structures of the respiratory system include the nose, where air is filtered, moistened, and warmed.
▶ pharynx, or throat, which serves as a passageway for both air and food.
▶ trachea, or windpipe, and the larynx, or vocal cords.
▶ bronchi, two large tubes that lead to the lungs. Each bronchus branches into smaller passageways called bronchioles that end in tiny air sacs called alveoli within the lungs.

Gas Exchange and Transport  Oxygen and carbon dioxide are exchanged across the walls of alveoli and capillaries. Chemical properties of blood and red blood cells allow for efficient transport of gases throughout the body.
▶ Carbon dioxide and oxygen are exchanged across capillary and alveolus walls.
▶ Hemoglobin binds with and transports oxygen that diffuses from alveoli to capillaries. It also increases the efficiency of gas exchange.
▶ Carbon dioxide is transported in the blood in three ways. Most combines with water and forms carbonic acid. Some dissolves in plasma. Some binds to hemoglobin and proteins in plasma.

Breathing  Movements of the diaphragm and rib cage change air pressure in the chest cavity during inhalation and exhalation.
▶ The dome-shaped muscle at the bottom of the chest cavity is the diaphragm. During inhalation, contraction of the diaphragm and rib muscles increases chest volume and air rushes in. In exhalation, these muscles relax and air rushes out.
▶ The nervous system has final control of the breathing muscles. Breathing does not require conscious control.

Smoking and the Respiratory System  Chemicals in tobacco smoke damage structures throughout the respiratory system and have other negative health effects. Smoking causes a number of diseases, including chronic bronchitis, emphysema, and lung cancer.
Structures of the Respiratory System

1. Label each of the structures indicated in this drawing of the human respiratory system.

   - nose
   - pharynx
   - larynx
   - trachea
   - bronchus
   - lung

Gas Exchange and Transport

For Questions 2–7, complete each statement by writing the correct word or words.

2. The surface area for gas exchange in the lungs is provided by the ________ alveoli ________.

3. The gases exchanged in the lungs are carbon dioxide and ________ oxygen ________.

4. The process that exchanges gases across the walls of capillaries is ________ diffusion ________.

5. Oxygen diffuses from an area of ________ greater ________ concentration to an area of lesser concentration.

6. ________ Hemoglobin ________ binds with oxygen and increases the blood’s oxygen-carrying capacity.

7. Most carbon dioxide combines with ________ water ________ in the blood, forming carbonic acid.
Breathing

8. Complete the flowchart to show how breathing works.

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Diaphragm contracts → Rib cage rises → Air inhaled

Diaphragm relaxes → Rib cage lowers → Air exhaled
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Smoking and the Respiratory System

9. Complete the table to describe the health effects of three substances in tobacco smoke.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotine</td>
<td><em>Nicotine is addictive. It increases heart rate and blood pressure.</em></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>*Carbon monoxide is a poisonous gas that blocks hemoglobin from bind-</td>
</tr>
<tr>
<td></td>
<td>ing with oxygen, thus interfering with oxygen transport in the blood.*</td>
</tr>
<tr>
<td>Tar</td>
<td><em>Tar contains at least 60 compounds known to cause cancer.</em></td>
</tr>
</tbody>
</table>

10. What causes smoker’s cough?

*Tobacco smoke paralyzes cilia in the trachea. Inhaled particles stick to the walls of the respiratory tract or enter the lungs. Smoke-laden mucus is trapped along the airways. Irritation from all this triggers a cough as the smoker tries to clear the airways.*

11. Smoking even a few cigarettes on a regular basis can lead to chronic bronchitis. What happens to people with this disease?

*They often find simple activities, like climbing stairs, difficult.*

Apply the Big Idea

12. Smoking and secondhand smoke damage both the respiratory system and the circulatory system. Explain how the close structural relationship of these two systems accounts for the effect of smoke on both systems.

*Gases are exchanged across the thin membranes of alveoli and the thin walls of the capillaries. Compounds in smoke affect both structures, reducing airflow in the alveoli and interfering with the oxygen-binding capacity of hemoglobin.*