Before You Read

Press the tips of two fingers to the inside of your wrist, at a point just below your thumb. Can you feel the regular pulsing of your blood? Count the number of beats you feel in fifteen seconds. Record that number on the line below. Multiply the number by four. Then read the section to learn what the number means and how your heart creates its regular rhythm.

Read to Learn

Functions of the Circulatory System

The circulatory system is the body’s transport system. It delivers oxygen and nutrients to the cells and removes waste products. The parts of the circulatory system are blood, the heart, blood vessels, and the lymphatic system. These parts work together to maintain homeostasis in the body. The heart pumps blood through tubes inside your body called blood vessels. In Chapter 37, you will learn about the lymphatic system, which also is part of the immune system.

In addition to oxygen and nutrients, the circulatory system transports disease-fighting materials produced by the immune system. The blood contains cell fragments and proteins for blood clotting. It also distributes heat throughout the body to help to control body temperature.

Blood Vessels

Blood vessels circulate blood throughout the body. They help to keep blood flowing to and from the heart. The three major types of blood vessels are arteries, capillaries, and veins.

1. Name the three major types of blood vessels.

Blood delivers substances, such as oxygen, to cells and removes wastes, such as carbon dioxide, from cells.

What You’ll Learn

- the main functions of the circulatory system
- how blood flows through the heart and body
- the major components of blood
Why do arteries have a thick inner layer?

Arteries (AR tuh reez) are large blood vessels that carry oxygen-rich, or oxygenated, blood away from the heart. Arteries are made of three layers: an outer layer of connective tissue, a middle layer of smooth muscle, and an inner layer of endothelial tissue. The endothelial layer of an artery is thicker than that of other blood vessels because blood is under higher pressure when it is pumped from the heart.

What is the function of capillaries?

Capillaries (KAP uh ler eez) are microscopic blood vessels where the exchange of important substances and wastes occurs. These vessels are so small that red blood cells move single-file through them. Capillary walls are only one cell thick. As a result, the blood and body cells can easily exchange materials through the capillary walls.

Where do veins carry blood?

After blood moves through the capillaries, it enters the veins—the largest blood vessels. Veins (VAYNZ) carry oxygen-poor, or deoxygenated, blood back to the heart. The endothelial walls of veins are thinner than those of arteries because by the time blood reaches the veins, the heart’s original pushing force has lessened. The contractions of skeletal muscles keep the blood moving. Larger veins have flaps of tissue called valves that prevent blood from flowing backward. Breathing movements squeeze against veins in the chest, forcing blood back to the heart.

The Heart

The heart is a hollow, muscular organ that pumps blood throughout the body. It is located in the center of the chest. The heart performs two pumping functions at the same time—it pumps oxygenated blood throughout the body, and it pumps deoxygenated blood to the lungs.

What are the parts of the heart?

The heart is made of cardiac muscle. This unique muscle can create and conduct electrical impulses for muscular contractions. The heart is divided into four chambers, as shown in the figure on the next page. The two chambers in the top half of the heart are the right atrium (plural, atria) and left atrium. The atria receive returning blood. The right and left ventricles, below the atria, pump blood away from the heart. Valves keep blood flowing in one direction.
How does the heart beat?

First, the atria fill with blood. Next, the atria contract, filling the ventricles with blood. Once the ventricles are full, they contract to pump the blood out of the heart and into the lungs and body.

The heart works in a regular rhythm. A group of cells in the right atrium, called the pacemaker or sinoatrial (SA) node, send out signals that tell the heart muscle to contract. The SA node receives signals about the body’s need for oxygen. It then responds by adjusting the heart rate. The signal from the SA node causes both atria to contract. This signal then travels to the atrioventricular (AV) node, causing both ventricles to contract. This two-step contraction is one complete heartbeat.

Think it Over

3. Apply Suppose you are running hard as you play soccer. How do you think the SA node will respond to this situation?

Picture This

4. Determine When blood is returning from the body to the heart, which chamber of the heart does the blood enter first?

What causes a pulse?

During the Before You Read activity, the beat you felt in your wrist was your pulse. As your left ventricle contracts, it pushes blood through your arteries, causing the arteries to expand. Between contractions, the arteries relax. The pulse is the alternating expansion and relaxation of the artery wall. The number of times your artery pulses is the number of times your heart beats. The heart beats approximately 70 times per minute.
What does a blood pressure reading mean?

Blood pressure is a measure of how much pressure the blood is applying against the vessel walls. Blood pressure readings provide information about the health of arteries. The contraction of the heart, or systole (SIS tuh lee), causes blood pressure to rise to its highest point. Relaxation of the heart, or diastole (di AS tuh lee), causes blood pressure to drop to its lowest point. A normal blood pressure reading for a healthy adult is about 120 (systolic pressure)/80 (diastolic pressure).

How does blood flow through the body?

In the figure below, notice that blood flows in a figure eight pattern. In the first loop, blood travels from the heart to the lungs and back to the heart. In the second loop, blood is pumped from the heart through the body and back to the heart. The right side of the heart pumps oxygen-poor, or deoxygenated, blood to the lungs. The left side of the heart pumps oxygen-rich, or oxygenated, blood through the body.

To the lungs and back  When blood from the body flows into the right atrium, it contains a little oxygen and a lot of carbon dioxide. From the right atrium, the oxygen-poor blood flows into the right ventricle and into the lungs. The air in the lungs has a lot of oxygen. Oxygen diffuses through the capillaries of the lungs into the blood. At the same time, carbon dioxide diffuses from the blood into the capillaries of the lungs and then into the air. Oxygen-rich blood then flows to the left atrium of the heart to be pumped through the body.
To the body and back  The second loop of the figure eight begins as the left atrium fills with oxygen-rich blood from the lungs. The blood moves from the left atrium to the left ventricle. The left ventricle pumps the blood into the largest artery in the body called the aorta. From there, the blood flows into the capillaries throughout the body. The capillaries are in close contact with body cells. Oxygen is released from the blood into the body cells. Carbon dioxide moves from the cells into the blood. The oxygen-poor blood then flows back to the right atrium through the veins.

Blood Components

Blood contains living cells. It is made up of plasma, red and white blood cells, and cell fragments called platelets.

What is the role of plasma?

Plasma is the clear, yellowish fluid part of blood. Plasma is mostly water. It carries the products of digested food, such as glucose and fats. It also transports vitamins, minerals, and chemical signals. Waste products are carried away by plasma.

What do red blood cells transport?

Red blood cells carry oxygen to all body cells. They develop in the bone marrow. Red blood cells do not have a nucleus, and are made mostly of a protein called hemoglobin. Hemoglobin binds with oxygen and carries it to the body’s cells. Some carbon dioxide is carried by the hemoglobin, but most carbon dioxide is carried by plasma.

How do white blood cells fight disease?

White blood cells are the body’s disease fighters. Some recognize disease-causing organisms and alert the body. Other white blood cells produce chemicals to fight the invaders. Still others surround and kill the invaders. There are many more red than white blood cells.

Why does the body need platelets?

Platelets (PLAYT luts) 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. Platelets release chemicals that produce a protein called fibrin, also known as a clotting factor. Fibrin weaves fibers across the cut that trap platelets and red blood cells. As more platelets and blood cells get trapped, a blood clot or scab forms, slowing and then stopping the flow of blood.

7. Draw Conclusions
Which best describes the role of carbon dioxide in the body? (Circle your answer.)

- a. nutrient
- b. waste product

8. Explain the importance of hemoglobin.

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Reading Check
Blood Types

There are four types of blood. They are A, B, AB, and O.

What determines blood type?

Marker molecules attached to red blood cells determine blood type. Type A blood has A markers. Type B blood has B markers. Type AB has both A and B markers. Type O has neither A nor B markers.

Why is blood type important?

If you need a blood transfusion, you can only receive certain blood types, as shown in the table below. This is because plasma contains antibodies that recognize “foreign” markers and cause those red blood cells to clump together. For example, if your blood is type B, the antibodies in your plasma will cause red blood cells with A markers to clump, blocking blood flow.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>Marker Molecules</th>
<th>Can Donate Blood To:</th>
<th>Can Receive Blood From:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>marker molecule: A antibody: anti-B</td>
<td>A or AB</td>
<td>A or O</td>
</tr>
<tr>
<td>B</td>
<td>marker molecule: B antibody: anti-A</td>
<td>B or AB</td>
<td>B or O</td>
</tr>
<tr>
<td>AB</td>
<td>marker molecules: AB antibody: none</td>
<td>AB</td>
<td>A, B, AB, or O</td>
</tr>
<tr>
<td>O</td>
<td>marker molecules: none antibodies: anti-A, anti-B</td>
<td>A, B, AB, or O</td>
<td>O</td>
</tr>
</tbody>
</table>

How does Rh factor affect blood transfusion?

The Rh factor is another marker on the surface of red blood cells. Clumping will result if someone without the Rh factor (Rh-negative) receives a transfusion of blood with the Rh factor (Rh-positive).

Circulatory System Disorders

Blood clots and fats can block blood flow through arteries. The condition of blocked arteries is called atherosclerosis (ar thir re oh skluh ROH sus). Signs include high blood pressure and high cholesterol levels. Atherosclerosis can lead to heart attack or stroke, two leading causes of death. Heart attacks occur when blood does not reach the heart muscle. Strokes occur when clots form in blood vessels supplying oxygen to the brain.
Before You Read

Breathing happens automatically. You do not think about every breath you take. Look at the clock and count how many breaths you take in a minute. Write that number on the lines below. Then write one sentence describing a time when you did think about your breathing. In this section you will learn what happens in your body as you breathe.

Read to Learn

The Importance of Respiration

Your body’s cells need oxygen. Recall that cells use oxygen and glucose to produce energy-rich ATP molecules needed for cellular metabolism. This process is called cellular respiration. Cellular respiration releases energy. It also releases carbon dioxide and water.

How is breathing different from respiration?

The respiratory system supports cellular respiration by supplying oxygen to body cells and removing carbon dioxide waste from cells. Two processes make up the respiratory system: breathing and respiration.

First, air enters the body. Breathing is the mechanical movement of air into and out of the lungs. Second, gases are exchanged. External respiration is the exchange of gases between the atmosphere and the blood. Internal respiration is the exchange of gases between the blood and the body’s cells.
The Path of Air

As you read about the path air travels through your body, follow along in the figure below. First, air enters your mouth or nose. Hairs in your nose filter out dust in the air. Hairlike cilia that line your nasal passages trap particles from the air and sweep them toward the throat. This keeps particles from entering the lungs. Mucous membranes beneath the cilia warm and moisten the air, while trapping foreign particles.

What structures does air pass through as it travels to the lungs?

Filtered air then passes through the upper throat, or pharynx (FER ingks). A flap called the epiglottis covers the opening to the larynx (LER ingks). The epiglottis allows air to pass while keeping food out of the respiratory tubes. Air moves through the larynx to a tube in the chest called the trachea (TRAY kee uh), or windpipe. The trachea branches into two large tubes, called bronchi (BRAHN ki). The bronchi lead to the lungs, where gas exchange takes place. Each bronchus branches into smaller bronchioles (BRAHN kee ohlz). Branching continues until each branch ends in an air sac called an alveolus (al VEE uh lus) (plural, alveoli). Alveoli have walls that are one cell thick and are surrounded by capillaries.

How does gas exchange occur?

Oxygen in the air diffuses across the thin walls of the alveoli into capillaries and then into red blood cells. The blood carries the oxygen to the cells. At the same time, carbon dioxide moves from the blood into the capillaries. It diffuses into the alveoli to be returned to the atmosphere.
Breathing

Your brain directs the rate of your breathing. If you have a lot of carbon dioxide in your blood, you need more oxygen, so you breathe faster.

As shown in the figure below, the rib and diaphragm muscles contract during inhalation. This increases the size of the chest cavity, allowing air to move into the lungs. During exhalation, the rib and diaphragm muscles relax. This reduces the size of the chest cavity, allowing air to flow out.

Picture This

4. Compare how the diaphragm moves during inhalation and exhalation.

Respiratory Disorders

The table below lists common disorders that affect the respiratory system. Smoking irritates respiratory tissues and inhibits cellular metabolism. Allergic reactions to particles in the air can also lead to respiratory problems.

<table>
<thead>
<tr>
<th>Lung Disorder</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>Respiratory pathways become irritated and bronchioles constrict.</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>Infected respiratory pathways result in coughing and production of mucus.</td>
</tr>
<tr>
<td>Emphysema</td>
<td>Alveoli break down, resulting in reduced surface area needed for gas exchange.</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Infection in the lungs causes alveoli to collect mucus.</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>A bacterium infects the lungs, harming the capillaries surrounding the alveoli and inhibiting gas exchange.</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>Uncontrolled cell growth in the lungs can lead to persistent cough, shortness of breath, bronchitis or pneumonia, and death.</td>
</tr>
</tbody>
</table>

Picture This

5. Identify the lung disorder that damages the alveoli.
Before You Read
You might be responsible for taking out your family’s trash. On the lines below, describe what might happen if no one removed the trash from your home for several months. Read the section to learn how the body gets rid of wastes.

Read to Learn
Parts of the Excretory System
The lungs, skin, and kidneys make up the excretory system. The lungs excrete carbon dioxide. The skin excretes water and salts in sweat. The main excretory organs are the kidneys.

What is the purpose of the excretory system?
The body produces wastes, such as toxins and carbon dioxide, during metabolism. The excretory system removes these wastes. The excretory system also controls the amount of fluids and salts in the body and maintains the pH of the blood. All of these activities help maintain homeostasis.

The Kidneys
The kidneys are two bean-shaped organs that filter out wastes, water, and salts from the blood. The kidneys are divided into two regions: the outer renal cortex and the inner renal medulla. The body’s filters are found in the renal pelvis in the center of the kidney.
How do the nephrons filter the blood?

Nephrons, shown above, are the kidney’s filters. Each kidney contains approximately one million nephrons. Blood enters each nephron through a long tube. A ball of capillaries called the glomerulus (gluh MER uh lus) (plural, glomeruli) surrounds the tube. The glomerulus lies within the Bowman’s capsule.

The renal artery transports nutrients and wastes to the kidney. This artery branches into smaller blood vessels, eventually reaching the capillaries in the glomerulus. The walls of the capillaries are very thin. The force of the blood pushes water and substances dissolved in water, such as the nitrogenous waste product urea (yoo REE uh), through the capillary walls into the Bowman’s capsule. Larger molecules, such as red blood cells and proteins, remain in the bloodstream.

How is urine formed?

Materials collected in the Bowman’s capsule flow through the renal tubule. Water and useful materials, such as glucose and minerals, return to the capillaries in a process called reabsorption. Urine, which is waste and unneeded fluids, leaves the kidney through ducts called ureters (YOO ruh turz). The urine is stored in the urinary bladder until it exits the body through the urethra (yoo REE thruh). The process of filtering wastes and reabsorbing useful materials requires large amounts of energy. The kidneys account for only 1 percent of a person’s body weight, but they use 20 to 25 percent of the body’s oxygen to generate the energy needed to function properly.
Kidney Disorders

Kidney infection is a common problem. Symptoms include fever, chills, and mid- to low-back pain. To avoid permanent damage to the kidneys, antibiotics are used to treat a bacterial infection. The table below lists other common excretory disorders.

Kidneys can also be damaged by other diseases in the body, such as diabetes and high blood pressure. In addition, kidneys can be damaged by prescription drugs and by illegal drug use.

<table>
<thead>
<tr>
<th>Excretory Disorder</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nephritis</td>
<td>painful swelling of the glomeruli; large particles in the blood become lodged in the glomeruli</td>
</tr>
<tr>
<td>Kidney stones</td>
<td>crystallized solids form in the kidneys; small stones pass out of the body in urine; larger stones can block urine flow</td>
</tr>
<tr>
<td>Urinary tract blockage</td>
<td>abnormal formation at birth can block urine flow</td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td>genetic disorder in which many fluid-filled cysts grow in the kidneys; can reduce kidney function or lead to kidney failure</td>
</tr>
<tr>
<td>Kidney cancer</td>
<td>uncontrolled cell growth that often begins in the lining of kidney tubules; can spread to other organs; can lead to death</td>
</tr>
</tbody>
</table>

Kidney Treatments

If kidney problems are not treated or kidney damage occurs, wastes accumulate in the body, leading to coma, seizure, and death. Modern medicine offers two possible treatments.

How is dialysis performed?

Dialysis is a procedure that filters out wastes from the patient’s blood. In one type of dialysis, the patient’s blood passes through a machine that filters the blood and returns it to the patient’s body. This procedure requires three sessions a week.

A second type of dialysis uses the membrane lining the abdomen as an artificial kidney. A special fluid is injected through a tube attached to the body. The patient’s waste fluid is drained. This procedure is performed daily.

What is a kidney transplant?

In a kidney transplant, a healthy kidney from a donor is placed in the patient’s body during surgery. Transplants are becoming more successful. However, the supply of donated kidneys is far below the number of kidneys needed.