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UAE Edition
Grade 11-12 General
Student Edition
Volume 1



McGraw-Hill Education

Biology

United Arab Emirates Edition

Grade 11-12 General

Volume 1





Biology
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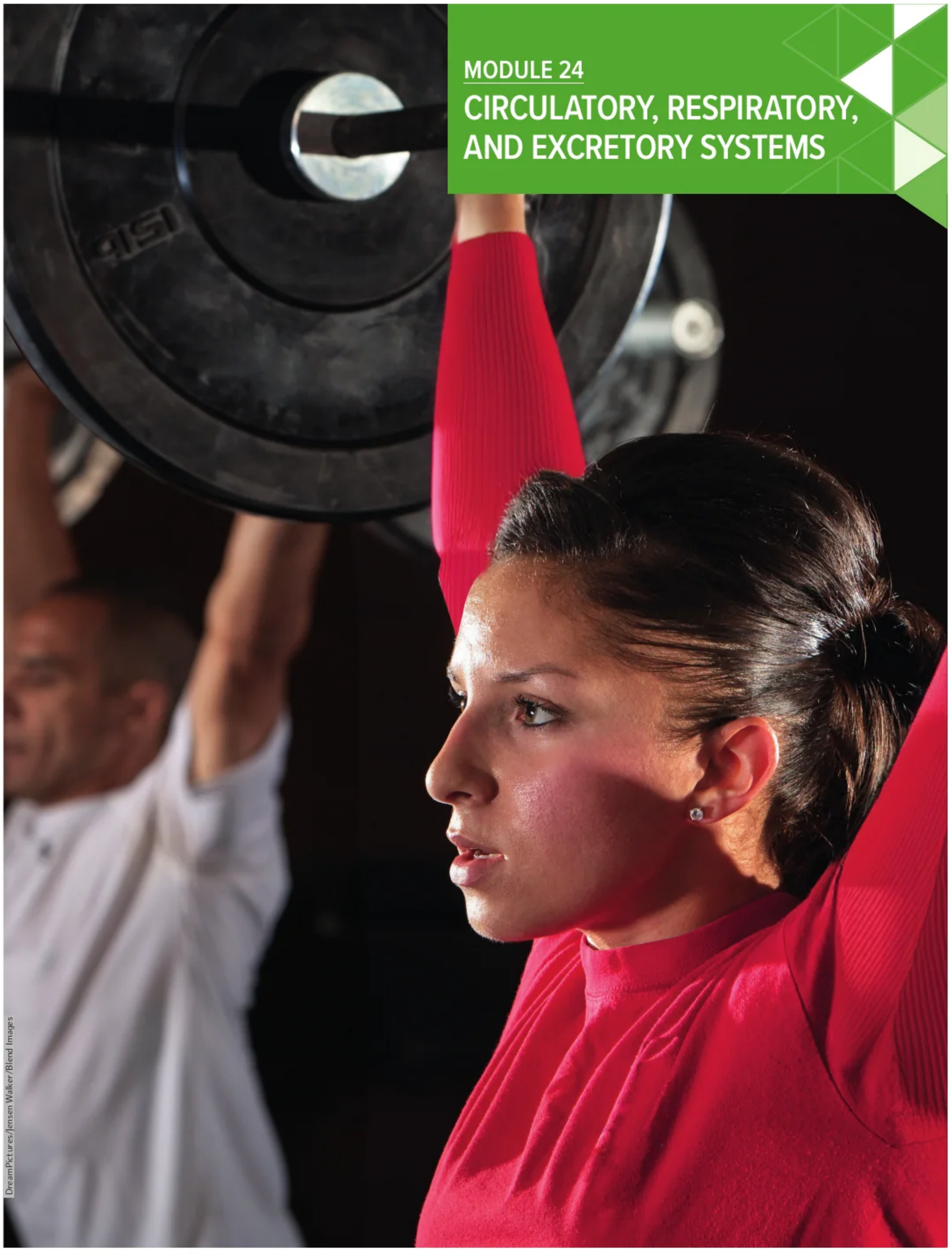
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Credits. 49



DreamPictures/Jensen Walker/Blend Images

MODULE 24

CIRCULATORY, RESPIRATORY, AND EXCRETORY SYSTEMS

MODULE 24

CIRCULATORY, RESPIRATORY, AND EXCRETORY SYSTEMS

ENCOUNTER THE PHENOMENON

What is the woman's body doing in response to lifting? Why?



GO ONLINE to play a video about the flow of oxygen during exercise.

SEP Ask Questions

Do you have other questions about the phenomenon? If so, add them to the driving question board.

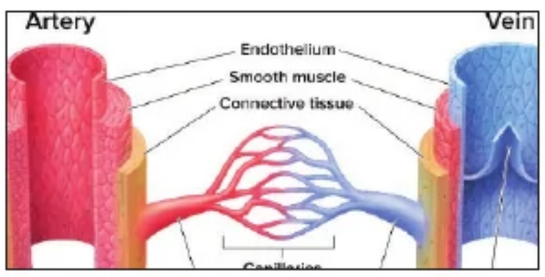
CER Claim, Evidence, Reasoning

Make Your Claim Use your CER chart to make a claim about what the woman's body is doing in response to lifting and why. Explain your reasoning.

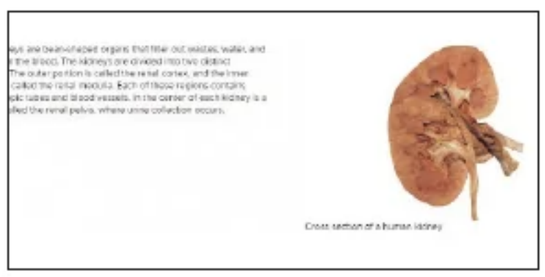
Collect Evidence Use the lessons in this module to collect evidence to support your claim. Record your evidence as you move through the module.

Explain Your Reasoning You will revisit your claim and explain your reasoning at the end of the module.

GO ONLINE to access your CER chart and explore resources that can help you collect evidence.



LESSON 1: Explore & Explain: The Circulatory System: Blood Vessels and Blood Components



LESSON 3: Explore & Explain: The Excretory System: How Kidneys Work

Additional Resources

(t)Video Supplied by BBC Worldwide Learning; (b)Rebecca Gray/McGraw-Hill Education

LESSON 1

CIRCULATORY SYSTEM

FOCUS QUESTION

How does exercise, such as lifting weights, positively affect the circulatory system?

Blood Vessels

Highways have lanes that separate traffic. They also have access ramps that take vehicles to and from roads. Similarly, the body has a network of channels—the blood vessels. Blood vessels circulate blood throughout the body and help keep the blood flowing to and from the heart.

As illustrated in **Figure 1**, the three major blood vessels are arteries, capillaries, and veins. **Figure 2,** on the next page, shows that Greek physician Praxagoras first observed the three types of blood vessels. Other discoveries and medical advances are shown in **Figure 2**, including the establishment of the first blood banks for blood transfusions and the successful implantation of the first artificial heart.

Arteries

Oxygen-rich blood, or oxygenated blood, is carried away from the heart in large blood vessels called **arteries.** These strong, thick-walled vessels are elastic and durable. They are capable of withstanding high pressures exerted by blood as it is pumped by the heart. As shown in **Figure 1**, arteries are composed 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 the artery is thicker than that of the other blood vessels. The endothelial layer of arteries needs to be thicker because blood is under higher pressure when it is pumped from the heart into the arteries.

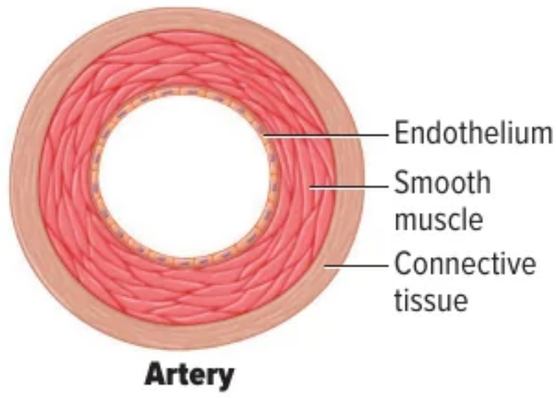


Figure 1 The three major blood vessels in the body are arteries, veins, and capillaries.

Predict *By what process do you think materials cross the walls of capillaries?*

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Quick Investigation: Investigate Blood Pressure

Carry out an investigation to determine the effects of exercise on blood pressure.

Virtual Investigation: Blood Pressure

Use a model to determine the cause of hypertension.

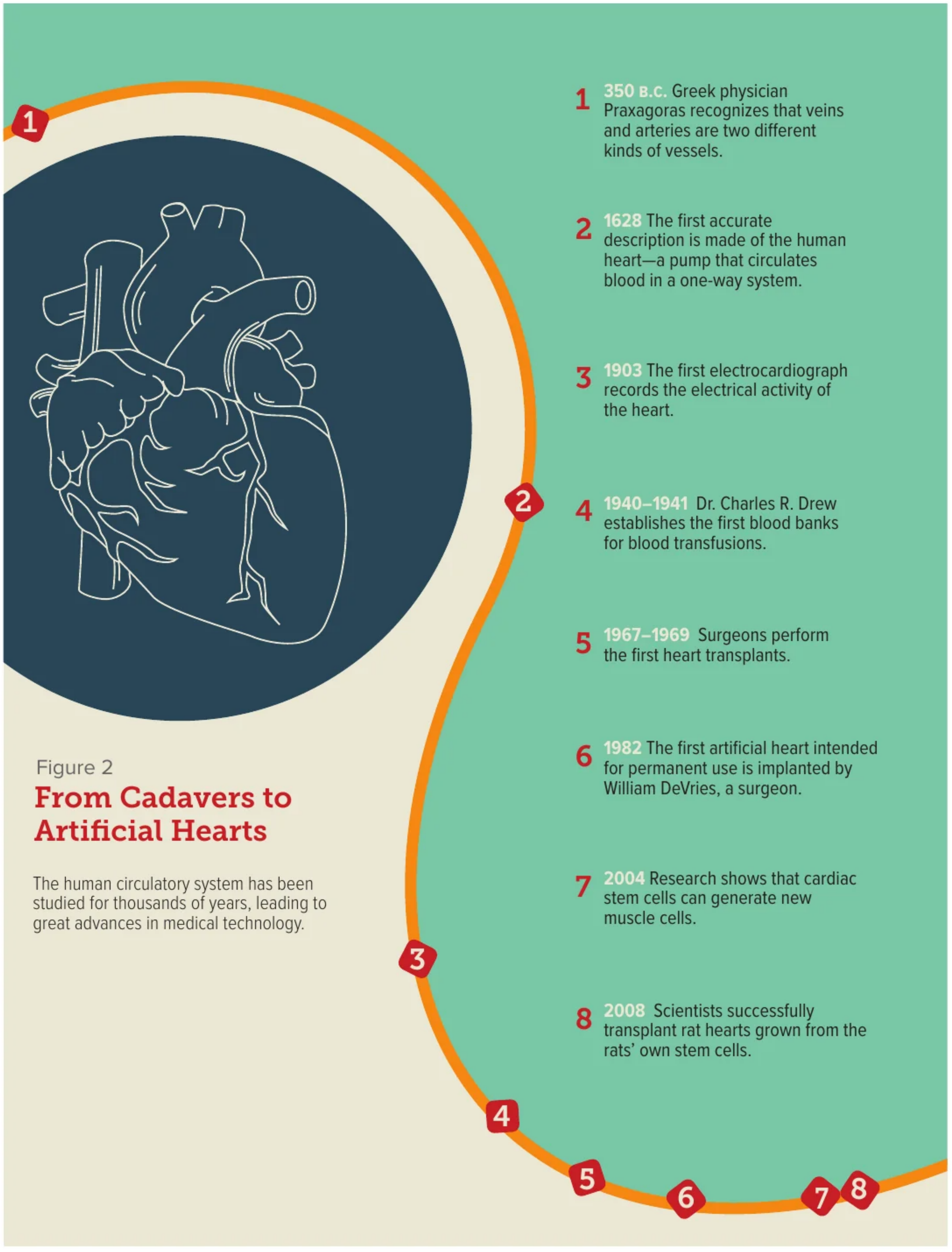


Figure 2

From Cadavers to Artificial Hearts

The human circulatory system has been studied for thousands of years, leading to great advances in medical technology.

Capillaries

Arteries branch into smaller vessels called arterioles, which become smaller in diameter as they grow farther away from the main vessel. The smallest branches are capillaries. **Capillaries** are microscopic blood vessels where the exchange of important substances and wastes occurs. Capillary walls are only one cell thick, as illustrated in **Figure 1**. This permits the easy exchange of materials between the blood and body cells through the process of diffusion. Capillaries are so small that red blood cells move single-file through these vessels.

The diameter of blood vessels changes in response to the needs of the body. For example, when you are exercising, muscle capillaries expand, or dilate. This increases blood flow to working muscles, which brings more oxygen to cells and removes extra wastes from cells.

Veins

After blood moves through the tiny capillaries, it enters the larger vessels called venules, and then enters the largest blood vessels, called veins. **Veins** carry oxygen-poor blood, or deoxygenated blood, back to the heart. The endothelial walls of veins are much thinner than the walls of arteries. The pressure of the blood decreases when the blood flows through capillaries before it enters the veins. By the time blood flows into the veins, the heart's original pushing force has less effect on making the blood move. So how does the blood keep moving? Many veins are located near skeletal muscles, and the contraction of these muscles helps keep the blood moving. Larger veins in the body also have flaps of tissue called **valves,** such as the one in **Figure 3**, which prevent blood from flowing backward. Lastly, breathing movements exert a squeezing pressure against veins in the chest, forcing blood back to the heart.

Get It?

Describe the differences in structure among arteries, capillaries, and veins.

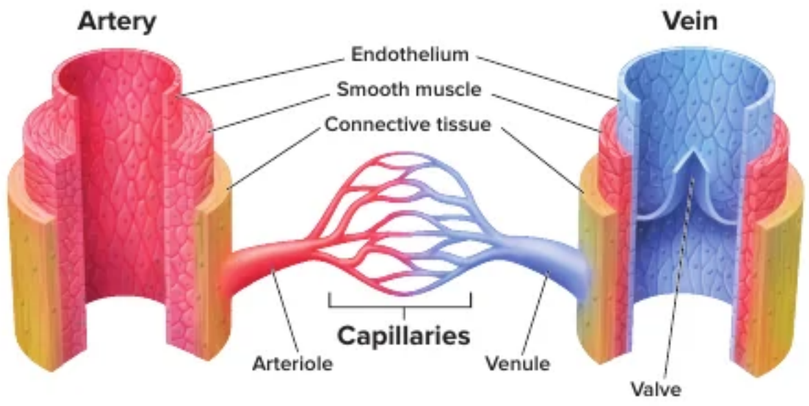


Figure 3 Blood circulates throughout the body inside blood vessels.

Hypothesize *how body temperature can be regulated by the diameter of blood vessels.*

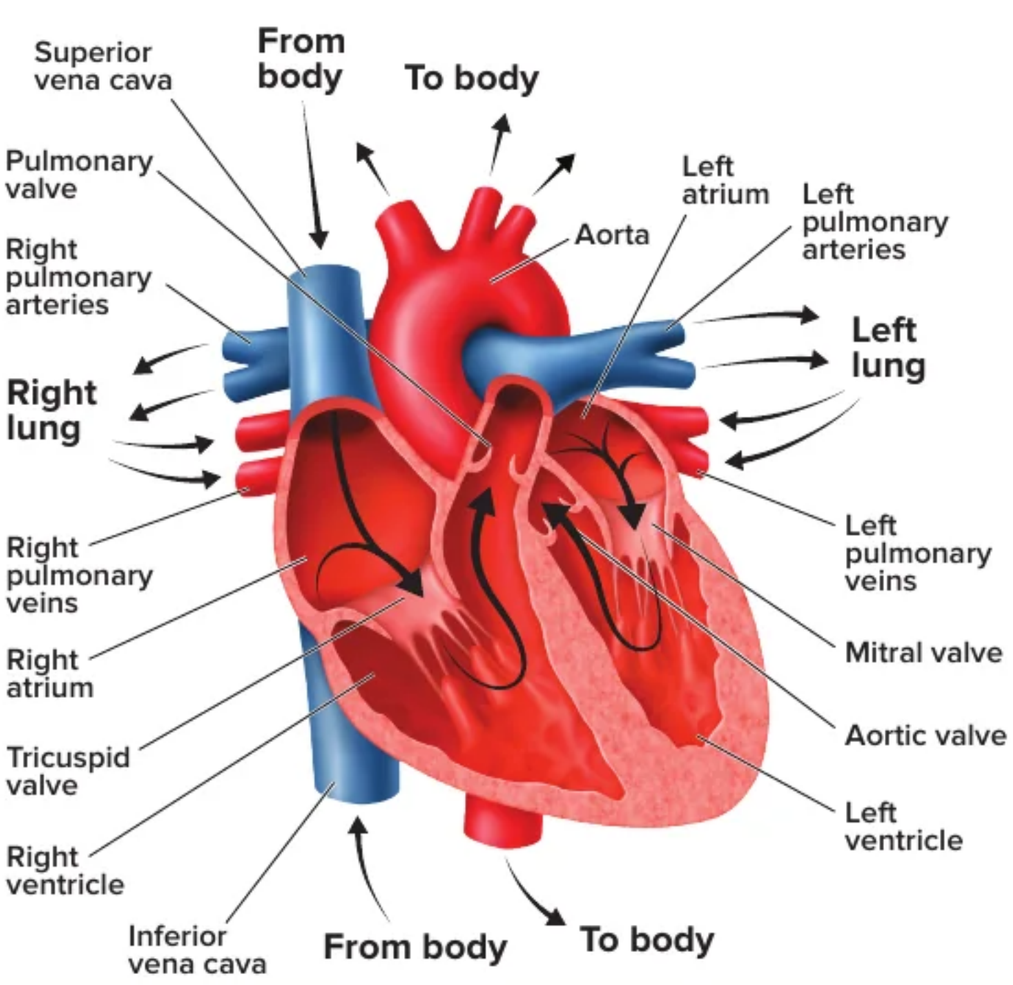
The Heart

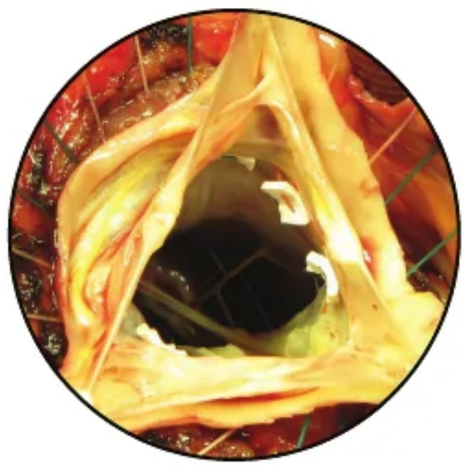
The **heart** is a muscular organ that is about as large as your fist and is located at the center of your chest. This hollow organ pumps blood throughout the body. The heart performs two pumping functions at the same time. The heart pumps oxygenated blood to the body, and it pumps deoxygenated blood to the lungs.

Structure of the heart

Recall that the heart is made of cardiac muscle. It is capable of conducting electrical impulses for muscular contractions. The heart is divided into four compartments called chambers, as illustrated in **Figure 4**. The two chambers in the top half of the heart, the right atrium and the left atrium (plural, atria), receive blood that is returning to the heart. Below the atria are the right and left ventricles, which pump blood away from the heart.

A strong muscular wall separates the left side of the heart from the right side of the heart. The right and left atria have thinner muscular walls and do less work than the ventricles. Notice the valves in **Figure 4** that separate the atria from the ventricles and keep blood flowing in one direction. Valves, such as the aortic valve shown in a opened position in **Figure 4**, are also located between each ventricle and the large blood vessels that carry blood away from the heart.





Aortic valve in an opened position

Figure 4 The arrows map the path of blood as it circulates through the heart.

Diagram *the path of blood through the heart.*

STEM CAREER Connection

Cardiovascular Invasive Specialists

These technologists help physicians determine whether patients have structural or electrical heart problems or blocked vessels. They assist with cardiac catheterization, a procedure that involves guiding a tube through a patient's blood vessels into their heart. They also help prepare patients for other cardiovascular interventions.

CCC CROSSCUTTING CONCEPTS

Systems and System Models Review the information about the functions of the different blood vessels. Work with a partner to develop a model, such as a flow chart, to explain the role played by each type of vessel.

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How the heart beats

The heart acts in two main phases. In the first phase, the atria fill with blood. The atria contract, filling the ventricles with blood. In the second phase, the ventricles contract to pump blood out of the heart, into the lungs, and forward into the body.

The heart works in a regular rhythm. A group of cells located 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 internal stimuli about the body's oxygen needs, and then it responds by adjusting the heart rate. The signal initiated by the SA node causes both atria to contract. Then the signal travels to another area in the heart called the atrioventricular (AV) node, as illustrated in **Figure 5**. The signal moves through fibers, causing both ventricles to contract. This two-step contraction makes up one complete heartbeat.

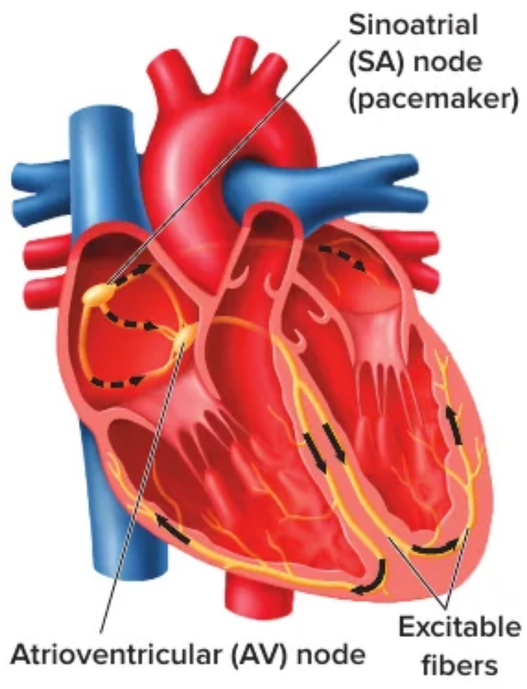


Figure 5 The SA node initiates the contraction of the heart, which spreads through both atria to the AV node. The AV node transmits the signal through excitable fibers that stimulate both ventricles.

Get It?

Compare and contrast the SA node and the AV node.

Pulse The heart pulses about 70 times each minute. If you touch the inside of your wrist just below your thumb, you can feel the artery in your wrist rise and fall. This pulse is the alternating expansion and relaxation of the artery wall caused by the contraction of the left ventricle. The number of times the artery in your wrist pulses is the number of times your heart beats.



Figure 6 A sphygmomanometer measures the blood pressure in an artery.

Determine *What is this person's blood pressure? Is it normal? Explain.*

Blood pressure Blood pressure is a measure of how much pressure is exerted against the vessel walls by the blood. Blood-pressure readings can provide information about the condition of arteries. The contraction of the heart, or systole (SIS tuh lee), causes blood pressure to rise to its highest point, and the relaxation of the heart, or diastole (di AS tuh lee), brings blood pressure down to its lowest point. The ideal normal blood-pressure reading for a healthy adult is 120 (systolic pressure)/80 (diastolic pressure). Blood pressure is measured using an instrument called a sphygmomanometer (sfig moh muh NOM i ter), like the one shown in **Figure 6**. When reading the results, the top number is the systolic pressure and the number underneath that is the diastolic pressure.

High blood pressure can develop over a period of many years, and many people do not experience symptoms. However, damage to blood vessels and the heart still occur. High blood pressure that remains untreated can lead to an increased risk of heart attack and stroke. Treatment for high blood pressure includes lifestyle changes such as exercising, eating a healthy diet, and maintaining a healthy weight. If needed, medication is prescribed to help lower blood pressure.

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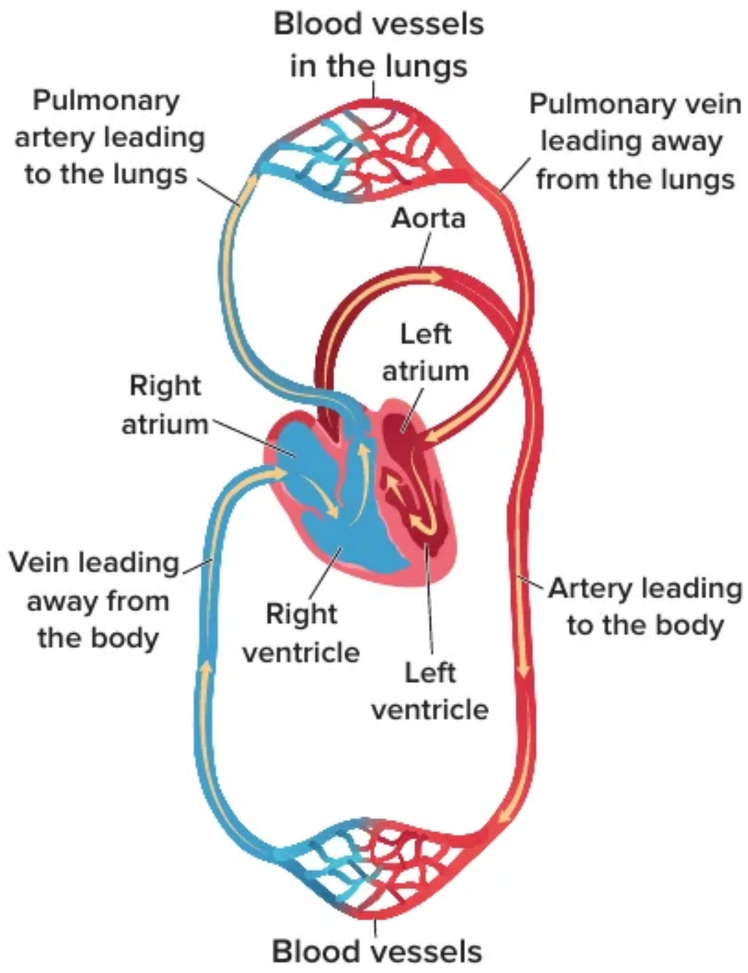


Figure 7 Blood flow through the body consists of two different circulatory loops.

Blood flow in the body

If you follow the flow of blood shown in **Figure 7**, you will notice that it flows in two loops. First, the blood travels from the heart to the lungs and back to the heart. Then, the blood is pumped in another loop from the heart through the body and back. The right side of the heart pumps deoxygenated blood to the lungs, and the left side of the heart pumps oxygenated blood to the rest of the body.

To the lungs and back When blood from the body flows into the right atrium, it has a low concentration of oxygen but a high concentration of carbon dioxide. The blood flows from the right atrium into the right ventricle and is pumped into the pulmonary arteries that lead to the lungs, as shown in **Figure 7**.

Eventually, blood flows into capillaries in the lungs that are in close contact with the air that enters the lungs. The air in the lungs has a greater concentration of oxygen than the blood in the capillaries does, so oxygen diffuses from the lungs into the blood. At the same time, carbon dioxide diffuses in the opposite direction—from the blood into the airspace in the lungs. Oxygenated blood flows to the left atrium of the heart to be pumped out to the body.

To the body and back The second loop begins as the blood moves from the left atrium into the left ventricle. As shown in **Figure 7**, the left ventricle then pumps the blood into the largest artery in the body called the aorta. Eventually, blood flows into the capillaries that branch throughout the body. The capillaries are in close contact with body cells. Oxygen is released from the blood into the body cells by diffusion, and carbon dioxide moves from the cells to the blood by diffusion. The deoxygenated blood then flows back to the right atrium through veins.

Functions of the Circulatory System

The circulatory system is the body's transport system. Blood carries important substances, such as oxygen and nutrients, to all parts of the body. It carries waste products, such as carbon dioxide, away from body cells. The blood also carries disease-fighting materials produced by the immune system. The blood contains cell fragments and proteins for blood clotting. The heart pumps blood through blood vessels. The lymphatic system is considered part of the circulatory and immune systems. All of these components work together to maintain homeostasis in the body. Finally, the circulatory system distributes heat throughout the body to help regulate body temperature.

Blood Components

Blood is the fluid of life because it transports important substances throughout the body. Blood is made up of a liquid medium called plasma, red blood cells, platelets, and white blood cells.

Plasma

The clear, yellowish fluid portion of blood is the **plasma,** shown in **Figure 8**. More than 50 percent of blood is plasma. Ninety percent of plasma is water, and nearly 10 percent is dissolved materials. Plasma carries the broken-down products of digested food, such as glucose and fats. Plasma also transports vitamins, minerals, and chemical messengers including hormones that signal body activities, such as the uptake of glucose by the cells. In addition, waste products from the cells are carried away by plasma.

There are three groups of plasma proteins that give plasma its yellow color. One group helps to regulate the amount of water in blood. The second group, produced by white blood cells, helps fight disease. The third group helps to form blood clots.



Figure 8 Plasma is the clear, yellowish portion of the blood, made up mostly water.

Get It?

Explain the functions of plasma.

Red blood cells

The **red blood cells** carry oxygen to all of the body's cells. Red blood cells resemble discs with pinched-in centers, as shown in **Figure 9**. Recall that red blood cells develop in the marrow—the center portion of large bones. Red blood cells have no nuclei and live for only about 120 days.

Red blood cells mostly consist of an iron-containing protein called hemoglobin. Hemoglobin chemically binds with oxygen molecules and carries oxygen to the body's cells. Red blood cells also carry carbon dioxide away from cells to the lungs, where it is exhaled.

Because hemoglobin is an iron-containing protein, eating foods that are high in iron is an important part of keeping red blood cells healthy. Foods that contain iron include dark green leafy vegetables, such as spinach and kale, beans, red meat, and iron-enriched cereals.

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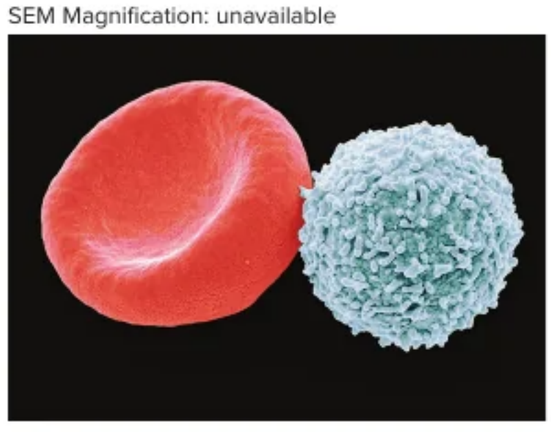


Figure 9 Blood is composed of liquid plasma, red blood cells (dimpled disc on the left), white blood cells (irregularly shaped cell on the right), and platelets (flat fragments, not shown).

Infer *What might be occurring if there are too many white blood cells?*

Platelets

Have you ever cut your finger? If so, you probably noticed that in a short while, the blood flowing from the cut slowed down and then stopped as a blood clot formed a scab. **Platelets** are cell fragments that are important in forming blood clots.

(t) TippaPatt/Shutterstock.com; (b) Science Photo Library/Alamy

When a blood vessel is cut, platelets collect and stick to the vessel at the site of the wound. The platelets then release chemicals that produce a protein called fibrin. Fibrin weaves a network of fibers across the cut that traps blood platelets and red blood cells, as shown in **Figure 10**. As more and more platelets and blood cells are trapped, a blood clot forms.



Figure 10 A scab forms as fibrin threads trap blood cells and platelets.

White blood cells

The body's disease fighters are the **white blood cells.** Like red blood cells, white blood cells are produced in bone marrow. Some white blood cells recognize disease-causing organisms, such as bacteria, and alert the body that it has been invaded. Other white blood cells produce chemicals to fight the invaders. Still, other white blood cells surround and kill the invaders.

White blood cells are different from red blood cells in important ways. Many white blood cells move from the marrow to other sites in the body to mature. Unlike red blood cells, there are fewer white blood cells—only about one white blood cell for every 500 to 1000 red blood cells. Also, white blood cells have nuclei. Finally, most white blood cells live for months or years.

Blood Groups

How do you know what type of blood you have? There are marker molecules attached to red blood cells. These markers are called blood groups, which determine blood type.

STUDY TIP

Graphic Organizer Make a word map with the word blood in a large circle in the middle. Place the words components, blood groups, circulation, and heart in smaller circles around the large circle. Find information you learned in the module and add it to the appropriate smaller circles.

(l) ThamKC/Shutterstock.com; (r) ©Steve Gschmeissner/Science Photo Library/Alamy

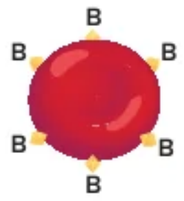
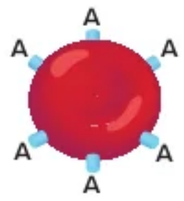
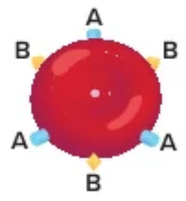
ABO blood group

There are four types of blood: A, B, AB, and O. If your blood type is A, you have A markers on your blood cells. If your blood type is B, you have B markers on your blood cells. If your blood type is AB, you have both A and B markers. If your blood type is O, you do not have A or B markers.

Importance of blood type

If you ever need a blood transfusion, you will be able to receive only certain blood types, as shown in **Table 1**. This is because plasma contains proteins called antibodies that recognize red blood cells with foreign markers and cause those cells to clump together. For example, if you have blood type B, your blood contains antibodies that cause cells with A markers to clump. If you received a transfusion of type-A blood, your clumping proteins would make the type-A cells clump together. Clumping of blood cells can be dangerous because it can block blood flow.

Table 1 Blood Types

Blood Type	A	B	AB	O
Marker molecule and antibody	Marker molecule: A Antibody: anti-B	Marker molecules: B Antibody: anti-A	Marker molecules: AB Antibody: none	Marker molecules: none Antibodies: anti-A, anti-B
Example				
Can donate blood to:	A or AB	B or AB	AB	A, B, AB, or O
Can receive blood from:	A or O	B or O	A, B, AB, or O	O

Rh blood group

The Rh factor, another marker on red blood cells, can cause complications during some pregnancies. If a fetus's Rh-positive blood mixes with the mother's Rh-negative blood, the mother will make anti-Rh antibodies. During another pregnancy, these antibodies can cross the placenta and destroy red blood cells if the fetus has Rh-positive blood.

STEM CAREER Connection

Blood Bank Technician

Blood bank technicians play a key role in collecting, analyzing, and properly storing blood used for transfusions. A career as a blood bank technician requires a desire to work with blood donors and an understanding of human blood types. Most blood bank technicians have an associates degree.

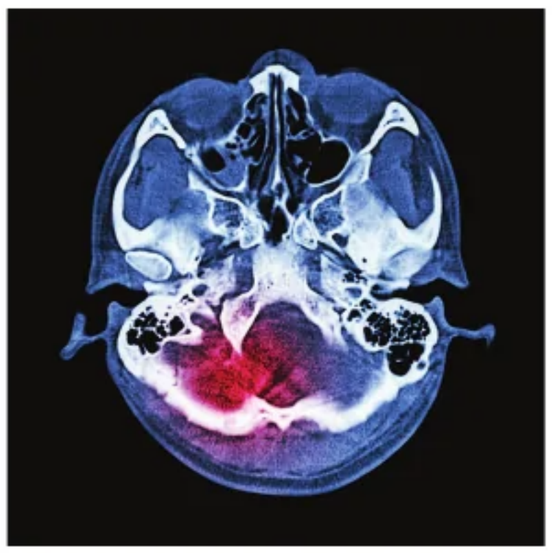


Figure 11 A stroke is associated with ruptured blood vessels in the brain, as shown in red.

Circulatory System Disorders

Several disorders of the blood vessels, heart, and brain are associated with the circulatory system. Blood clots and other matter, such as fat deposits, can reduce the flow of oxygen-rich and nutrient-rich blood traveling through arteries. Physicians refer to the condition of blocked arteries as **atherosclerosis** (a thuh roh skluh ROH sus). When blood flow is reduced or blocked, the heart must work even harder to pump blood, and vessels can burst.

Atherosclerosis can lead to a heart attack or stroke. A heart attack occurs when blood does not reach the heart muscle. This can result in damage to the heart, and can even result in death if not treated. A stroke occurs when clots form in the blood vessels that supply oxygen to the brain. This can lead to ruptured blood vessels and internal bleeding, as shown in **Figure 11**. Parts of the brain die because brain cells are deprived of oxygen.

Check Your Progress

Summary

- Blood vessels transport important substances throughout the body.
- The top half of the heart is made up of two atria, and the bottom half is made up of two ventricles.
- The heart pumps deoxygenated blood to the lungs, and it pumps oxygenated blood to the body.
- Blood is made up of plasma, red blood cells, white blood cells, and platelets.
- Blood is classified by the following four blood types: A, B, AB, and O.

Demonstrate Understanding

1. **Diagram** the path of blood through the heart and body.
2. **Compare and contrast** the structure of arteries and the structure of veins.
3. **Calculate** the average number of red blood cells for every 100 white blood cells in the human body.
4. **Summarize** the main functions of the circulatory system.
5. **Explain** the essential functions of life performed by the specialized cells that make up blood.

Explain Your Thinking

6. **Cause and Effect** If a pacemaker received faulty signals from the brain, what would happen?
7. **Hypothesize** why exercise helps to maintain a healthy heart.
8. **MATH Connection** Count the number of times your heart beats during 15 seconds. What is your heart rate per minute?

LEARNSMART Go online to follow your personalized learning path to review, practice, and reinforce your understanding.

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LESSON 2

RESPIRATORY SYSTEM

FOCUS QUESTION

Why is exercise good for the respiratory system?

The Importance of Respiration

Your body's cells require oxygen. Recall that oxygen and glucose are used by cells to produce energy-rich ATP molecules needed to maintain cellular metabolism. This process is called cellular respiration. In addition to releasing energy, cellular respiration releases carbon dioxide and water.

Breathing and respiration

The respiratory system sustains cellular respiration by supplying oxygen to body cells and by removing carbon dioxide waste from cells.

The functions of the respiratory system can be divided into two processes: breathing and respiration. First, air must enter the body through breathing. **Breathing** is the mechanical movement of air into and out of your lungs. **Figure 12** illustrates air being released from the lungs into the air. Second, gases are exchanged in the body. **External respiration** is the exchange of gases between the atmosphere and the blood, which occurs in the lungs. **Internal respiration** is the exchange of gases between the blood and the body's cells.



Stanislaw Pytel/DigitalVision/Getty Images

Figure 12 Exhaled air from a person's lungs can be seen on a chilly day.

Infer *how the air that you inhale is different from the air that you exhale.*

Get It?

Compare and contrast external respiration and internal respiration.

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Quick Investigation: Investigate Blood Pressure

Carry out an investigation to determine the cause and effect exercise has on the circulatory and respiratory systems.

CCC **Identify Crosscutting Concepts**

Create a table of the crosscutting concepts and fill in examples you find as you read.

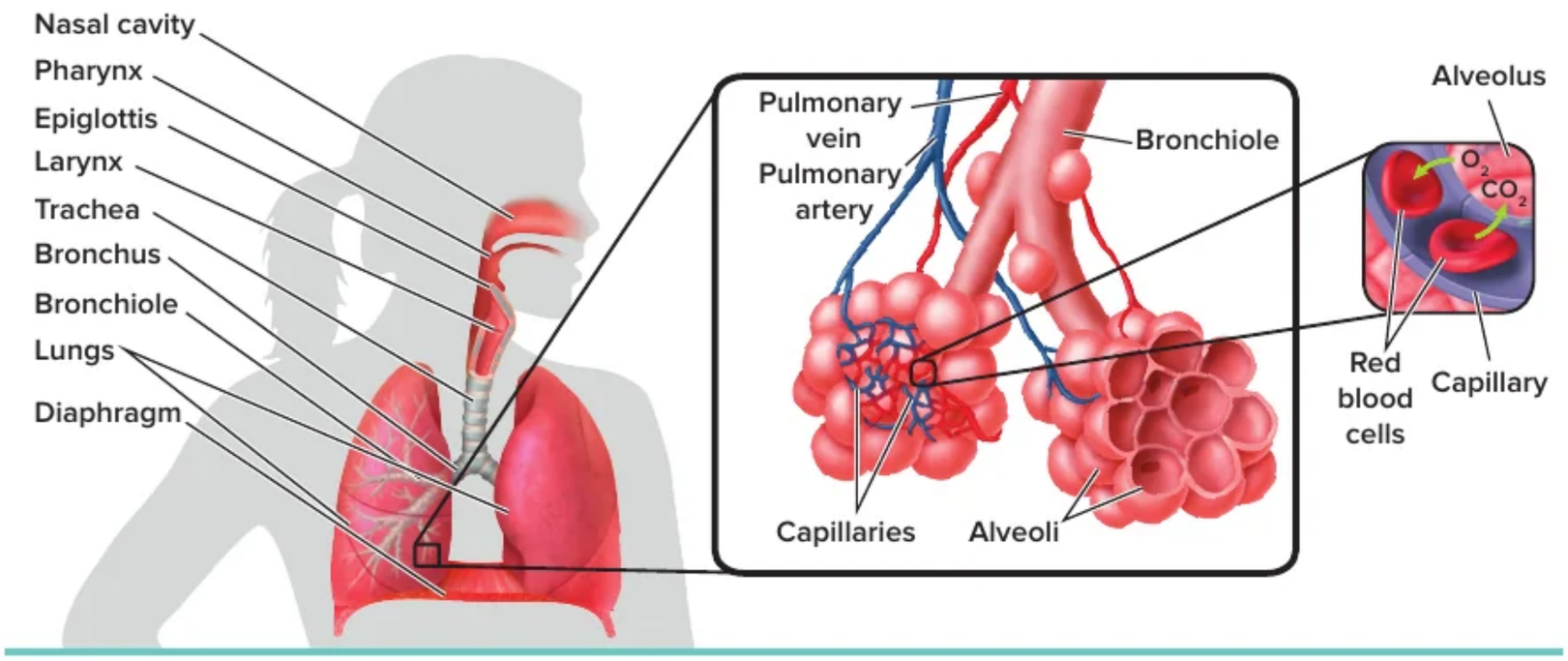


Figure 13 Air travels into the alveoli of the lungs, where gases are exchanged across thin capillary walls.

Diagram *Trace the path of oxygen from the atmosphere to the alveoli in the lungs.*

The Path of Air

The respiratory system is made up of the nasal passages, pharynx (FER ingks), larynx (LER ingks) or voice box, epiglottis, trachea, lungs, bronchi, bronchioles, alveoli (al VEE uh li), and diaphragm. Air travels from the outside environment to the lungs, where it passes through the alveoli, as shown in **Figure 13**.

First, air enters the mouth or nose. Hairs in the nose filter out dust and other large particles in the air. Hairlike structures called cilia, shown in **Figure 14**, also line the nasal passages, as well as other respiratory tubes. Cilia trap foreign particles from the air and sweep them toward the throat so that they do not enter the lungs. Mucous membranes beneath the cilia in the nasal passages, also shown in **Figure 14**, warm and moisten the air while trapping foreign materials.

Get It?

Identify the role of cilia in the respiratory system.

Filtered air then passes through the upper throat, called the pharynx. A flap of tissue called the epiglottis, which covers the opening to the larynx, prevents food particles from entering the respiratory tubes. The epiglottis allows air to pass from the larynx to a long tube in the chest cavity called the **trachea,** or windpipe. The trachea branches into two large tubes, called **bronchi** (BRAHN ki) (singular, bronchus), which lead to the lungs. The **lungs** are the largest organs in the respiratory system, and gas exchange takes place in the lungs. Each bronchus branches into smaller tubes called bronchioles (BRAHN kee ohlz), which continue to branch into even smaller passageways. Each of these ends in an individual air sac called an **alveolus** (plural, alveoli). Each alveolus has a thin wall—only one cell thick—and is surrounded by very thin capillaries.

Color-Enhanced SEM Magnification: 2000×



Figure 14 Hairlike cilia line the mucous membranes of the nasal cavity.

Eye of Science/Science Source

Gas exchange in the lungs

Air travels to individual alveoli, where oxygen diffuses across the moist, thin walls into capillaries and then into red blood cells. The oxygen is then transported to be released to tissue cells in the body during internal respiration. Meanwhile, carbon dioxide in the blood crosses capillary walls and diffuses into the alveoli to be returned to the atmosphere during external respiration. Carbon dioxide in the blood is found as carbonic acid in the red blood cells, dissolved in plasma, and bound to hemoglobin in red blood cells.

Breathing

The brain directs the rate of breathing by responding to internal stimuli that indicate how much oxygen the body needs. When the concentration of carbon dioxide in the blood is high, the breathing rate increases because cells need more oxygen.

Inhalation is the act of taking air into the lungs. During inhalation, as shown in **Figure 15**, the diaphragm contracts. This causes the chest cavity to expand as the diaphragm moves down, allowing air to move into the lungs. During exhalation, the diaphragm relaxes and returns to its normal resting position. This reduces the size of the chest cavity as the diaphragm moves up. Air naturally flows out from the greater pressure of the lungs. Follow **Figure 16** on the next page to learn how circulation and respiration work together to supply the needed oxygen and to get rid of carbon dioxide.

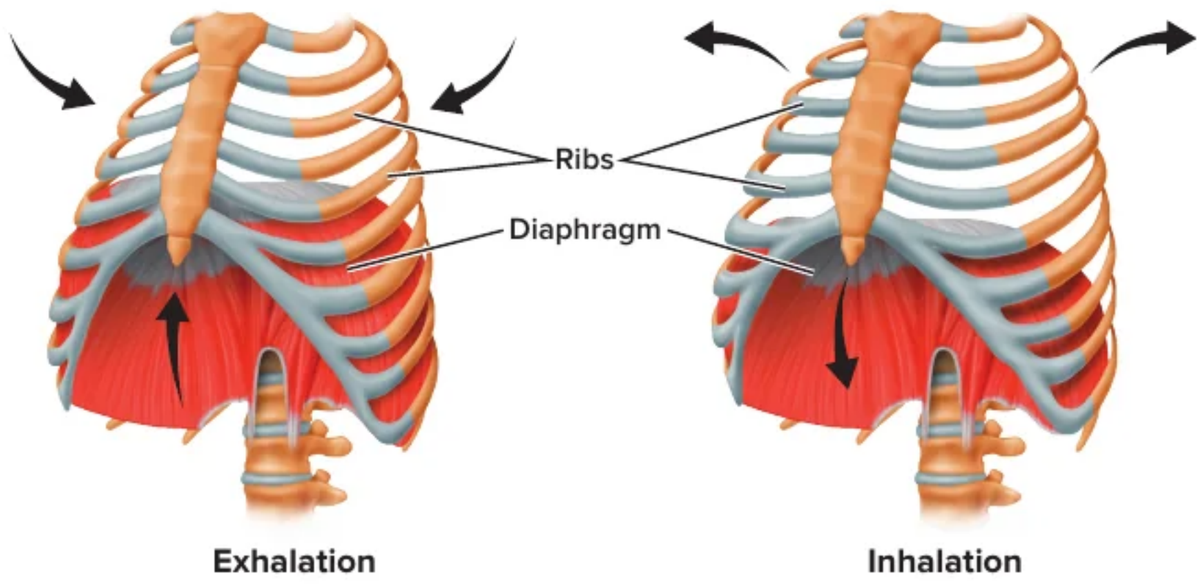


Figure 15 Rib and diaphragm muscles contract and relax during breathing.
Analyze *how air pressure is involved in breathing.*

WORD ORIGINS

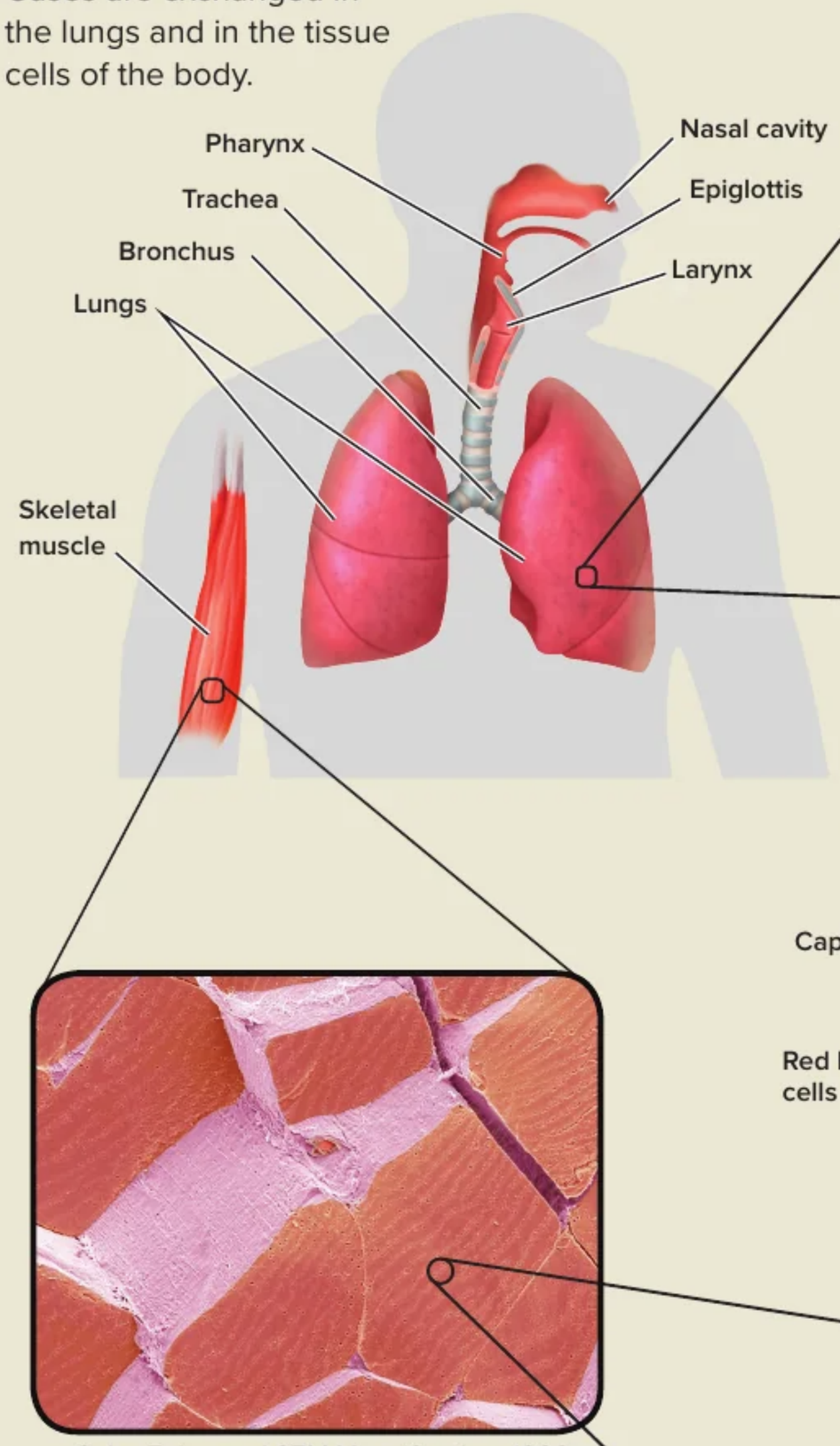
alveolus
comes from the Latin word *alveus*, meaning *belly* or *hollow space*

CCC CROSSCUTTING CONCEPTS

Systems and System Models Design a model of the respiratory system. Define the system and discuss how the model provides a tool for understanding the system. What are the limitations of your model? How could you improve your model?

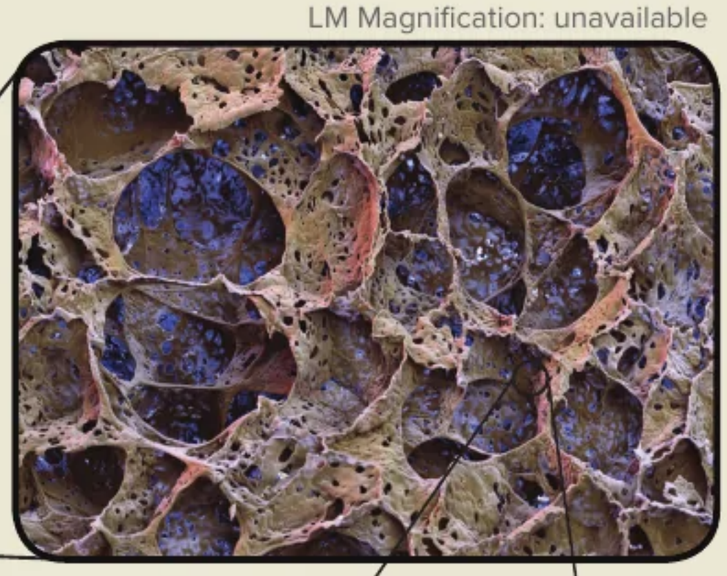
Figure 16 Visualizing Gas Exchange

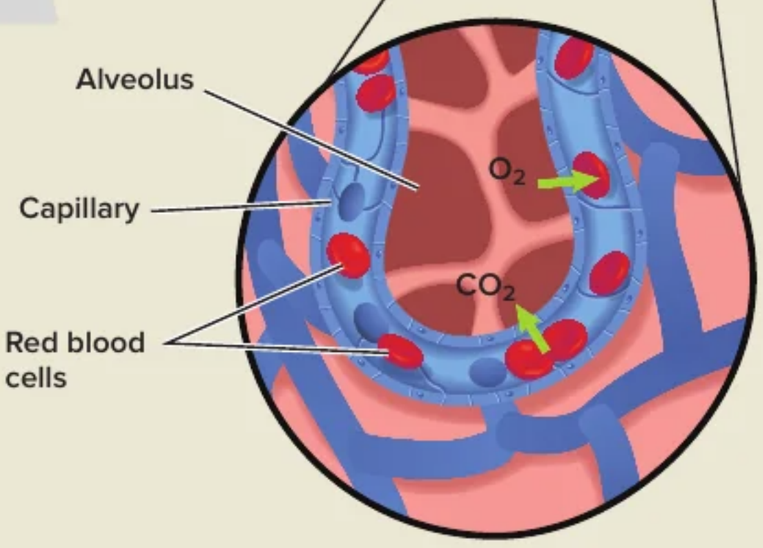
Gases are exchanged in the lungs and in the tissue cells of the body.



In the lungs, oxygen (O_2) that is inhaled moves into capillaries and is transported to body cells. Carbon dioxide (CO_2) leaves the capillaries and is exhaled from the lungs.

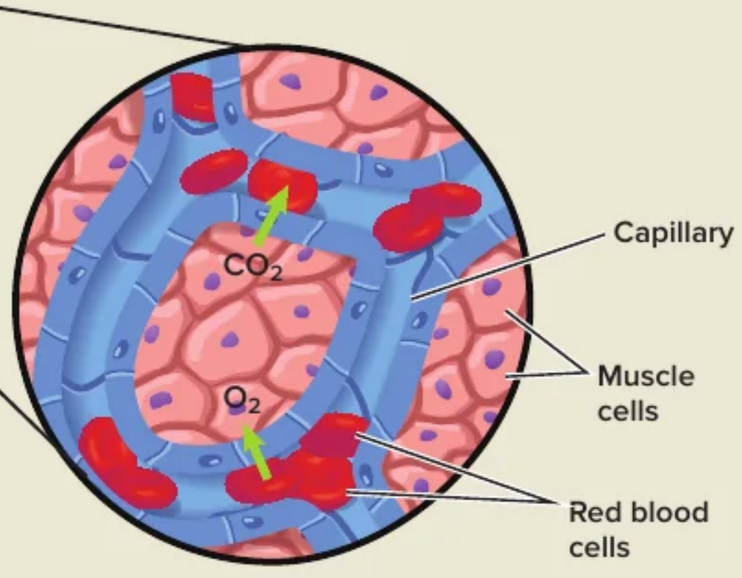
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In body tissues, such as muscle tissues, oxygen (O_2) moves from capillaries into tissue cells. Carbon dioxide (CO_2) produced by cellular respiration leaves tissue cells and moves into capillaries, and then it is transported to the lungs.



(t) Eye of Science/Science Source; (b) Steve Gschmeissner/Science Photo Library/Alamy

Table 2 Common Respiratory Disorders

Disorder	Brief Description
Asthma	Respiratory pathways become irritated, and bronchioles constrict.
Bronchitis	Respiratory pathways become infected, resulting in coughing and production of mucus.
Emphysema	Alveoli break down, resulting in reduced surface area needed for gas exchange with the alveoli's blood capillaries.
Pneumonia	Infection of the lungs causes the alveoli to collect mucous material.
Lung cancer	Uncontrolled cell growth in lung tissue can lead to a persistent cough, shortness of breath, bronchitis, or pneumonia, and can lead to death.

Respiratory Disorders

Some diseases and disorders irritate, inflame, or infect the respiratory system, as described in **Table 2**. These disorders can produce tissue damage that reduces the effectiveness of the bronchi and alveoli. When these tissues become damaged, respiration becomes difficult. Smoking also causes chronic irritation to respiratory tissues and inhibits cellular metabolism. Finally, exposure to airborne materials, such as pollen, can produce respiratory problems in some people who have allergic reactions.

Check Your Progress

Summary

- Alveoli in the lungs are the sites of gas exchange between the respiratory and circulatory systems.
- The pathway of air starts with the mouth or nose and ends at the alveoli located in the lungs.
- Inhalation and exhalation are the processes of taking in and expelling air.
- Respiratory disorders can inhibit respiration.

Demonstrate Understanding

1. **Identify** the main function of the respiratory system.
2. **Distinguish** between internal and external respiration.
3. **Sequence** the path of air from the nasal passages to the bloodstream.
4. **Describe** the mechanics of inhalation and exhalation.
5. **Infer** how the respiratory system would compensate for a circulatory disorder.
6. **Describe** three disorders of the respiratory system.

Explain Your Thinking

7. **Hypothesize** an advantage of heating and moisturizing air before it reaches the alveoli.
8. **MATH Connection** The total surface area of the alveoli tissue in your lungs is approximately 70 m^2. This is more than 40 times the surface area of the skin. What is the surface area of your skin?

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LESSON 3

THE EXCRETORY SYSTEM

FOCUS QUESTION

Can exercise affect the excretory system?

Parts of the Excretory System

As you breathe, eat, walk, study, and sleep, your body collects wastes. These wastes include toxins, waste products, and carbon dioxide, that result from metabolic functions that occur in your body constantly and without you thinking about it.

What happens to all of these wastes? The excretory system removes them from the body. In addition, the excretory system regulates the amount of fluid and salts in the body, and it maintains the pH of the blood. All of these functions help to maintain homeostasis.

The components that make up the excretory system include the lungs, skin, and kidneys, as illustrated in **Figure 17**. The lungs primarily excrete carbon dioxide. The skin primarily excretes water and salts contained in sweat. The kidneys, however, are the major excretory organs in the body. The kidneys filter wastes and other substances from the blood. The ureters carry urine produced in the kidneys to the bladder. Urine exits the body through the urethra.

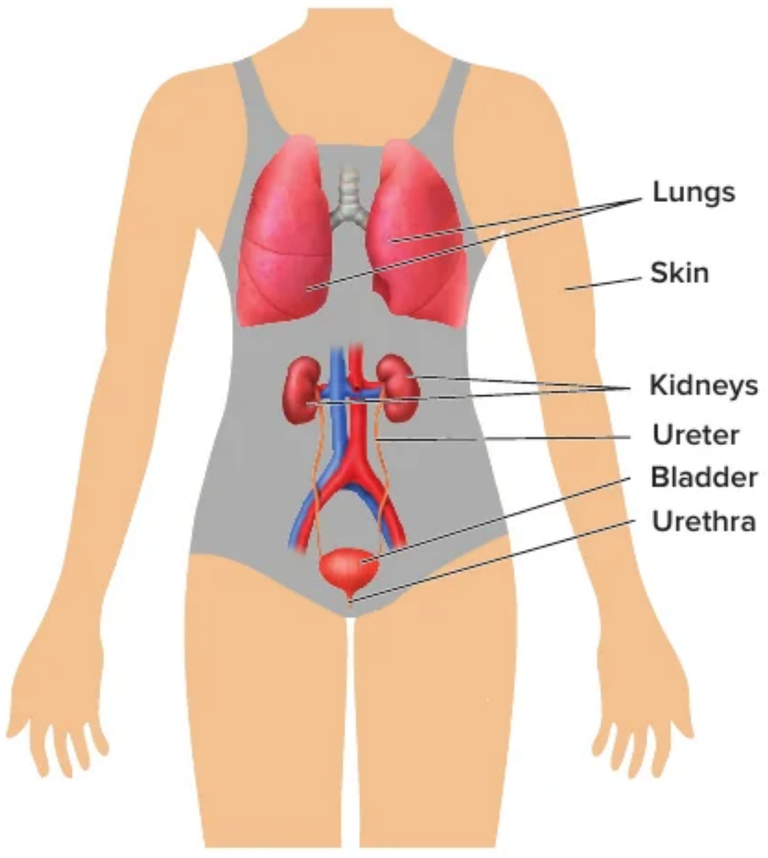


Figure 17 The organs of excretion work together to eliminate wastes from the body. These organs include the lungs, skin, and kidneys.

Get It?

Identify the components of the excretory system.

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

BioLab: Internet: Make Positive Health Choices

Plan and carry out an investigation to determine how lifestyle choices affect the function of the circulatory, respiratory, and excretory systems.

Revisit the Encounter the Phenomenon Question

What information from this lesson can help you answer the Unit and Module questions?

The Kidneys

As shown in **Figure 18**, the **kidneys** are bean-shaped organs that filter out wastes, water, and salts from the blood. The kidneys are divided into two distinct regions, also illustrated in **Figure 18**. The outer portion is called the renal cortex and the inner region is called the renal medulla. Each of these regions contains microscopic tubes and blood vessels. In the center of each kidney is a region called the renal pelvis, where urine collection occurs. Follow **Figure 18** as you read about how the kidneys function.

Nephron filtration

Each kidney contains approximately one million filtering units called nephrons. Blood enters each nephron through a long tube that is surrounded by a ball of capillaries called the glomerulus (gluh MER uh lus) (plural, glomeruli). The glomerulus is surrounded by a structure called the Bowman's capsule.

The renal artery transports nutrients and wastes to the kidney and branches into smaller and smaller blood vessels, eventually reaching the tiny capillaries in the glomerulus. The walls of the capillaries are very thin, and the blood is under great pressure. As a result, water and substances dissolved in the water, such as the nitrogenous waste product called **urea,** are pushed through the capillary walls into the Bowman's capsule. Larger molecules, such as red blood cells and proteins, remain in the bloodstream.

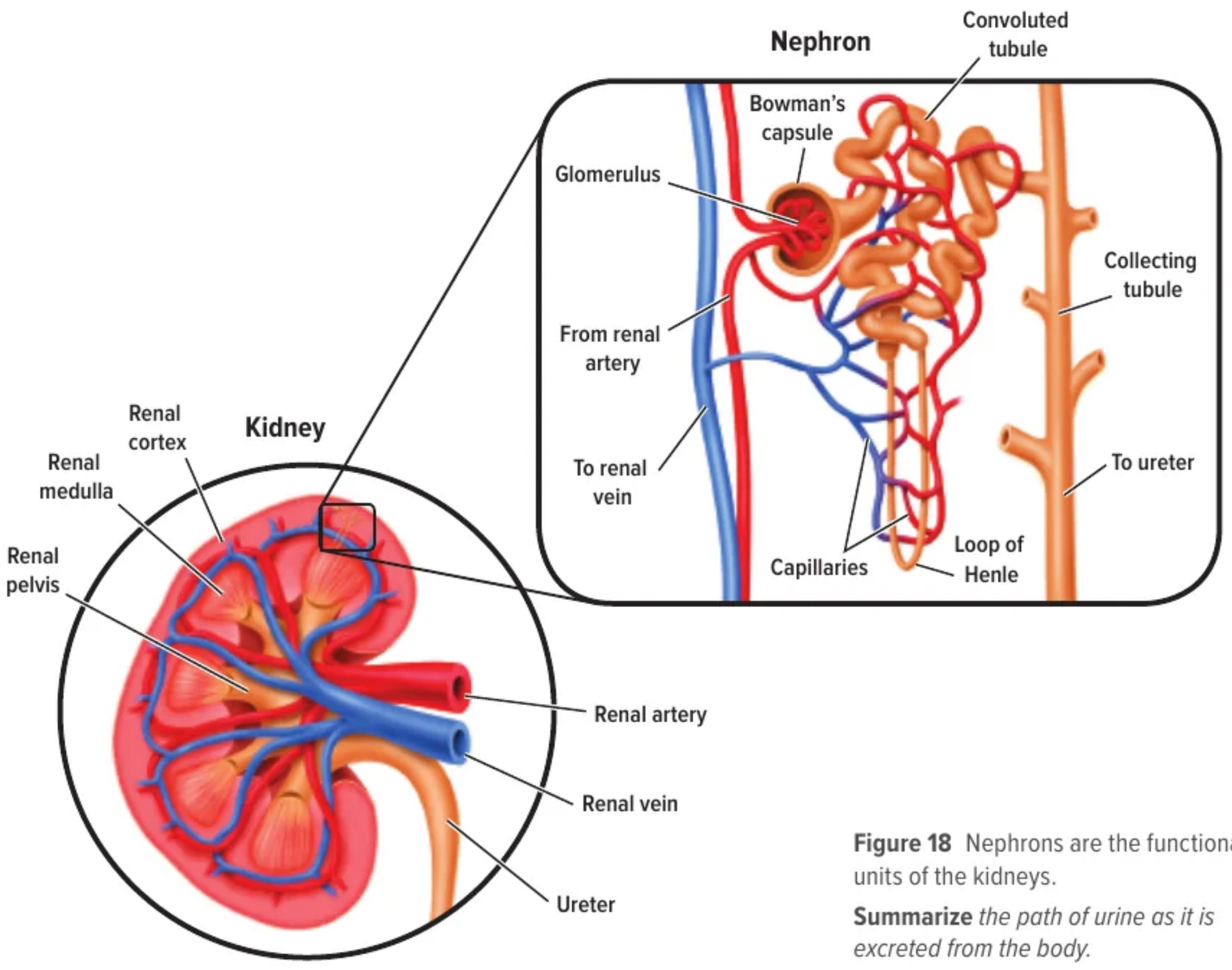


Figure 18 Nephrons are the functional units of the kidneys.

Summarize *the path of urine as it is excreted from the body.*

Reabsorption and the formation of urine

The filtrate collected in the Bowman's capsule flows through the renal tubule, which consists of the convoluted tubule, the loop of Henle, and the collecting tubule, as illustrated in **Figure 18**.

Much of the lost water and useful substances, such as glucose and minerals, are reabsorbed into the capillaries surrounding the renal tubule. This process is called reabsorption. At the same time, excess fluids and toxic substances in the capillaries are passed to the collecting tubules. This waste product is called urine. Urine leaves the kidney through ducts called the ureters (YOO ruh turz), as shown in **Figure 18**. Urine is then stored in the urinary bladder and exits the body through the urethra.

The kidneys filter about 180 L of blood each day in adults but produce only about 1.5 L of urine. The processes of filtration and reabsorption from the blood require large amounts of energy. Although kidneys account for only one percent of body weight, they use 20 to 25 percent of the body's oxygen intake for their internal energy requirements.

CHEMISTRY Connection The kidneys can help maintain a normal pH in the blood by adjusting the acid-base balance. Recall that low pH results when there is an abundance of H^+. When the blood pH is too low, the kidneys can increase pH levels in the body by excreting hydrogen (H^+) ions and ammonia into the renal tubules. The kidneys can decrease pH levels by reabsorbing buffers such as bicarbonate (HCO_3^-) and sodium (Na^+) ions. Because biological processes normally require pH between 6.5 and 7.5, the kidneys help to maintain homeostasis by keeping pH levels within the normal range.

Get It?

Describe the process of reabsorption.

Kidney Disorders

Sometimes kidney function can be inhibited or impaired by infections or disorders. When kidney function is impaired, the body cannot rid itself of wastes and homeostasis might be disrupted.

Infections

Symptoms of a kidney infection include fever, chills, and mid- to low-back pain. Kidney infections often start as urinary bladder infections that spread to the kidneys. Obstructions in the kidneys also can cause an infection. If the infection is not treated, the kidneys can become scarred and their function might be permanently impaired. Antibiotics usually are effective in treating bacterial infections.

STEM CAREER Connection

Nephrology Nurse

Do you want a career that gives you the opportunity to help people who are seriously ill? Nephrology nurses are registered nurses who care for patients of all ages who have kidney-related health conditions, such as high blood pressure, diabetes, infections, birth defects, and substance abuse. These highly skilled nurses require advanced education and training.

CCC CROSSCUTTING CONCEPTS

Stability and Change Make a graphic organizer that summarizes how the kidneys help maintain homeostasis and a normal pH in the blood. Use specific information from the text.

Nephritis

Another common kidney problem is nephritis (nih FRIH tus), which often is caused by inflammation or painful swelling of some of the glomeruli, as listed in **Table 3**. This occurs for many reasons, such as when large particles in the bloodstream become lodged in some of the glomeruli. Symptoms of this condition include blood in the urine, swelling of body tissues, and protein in the urine. If this condition does not improve on its own, the patient may need a special diet or prescription drugs to treat the infection.

Kidney stones

Kidney stones are another type of kidney disorder, as listed in **Table 3** and shown in **Figure 19**. A kidney stone is a crystallized solid, such as calcium compounds, that forms in the kidney. Small stones can pass out of the body in urine; this can be quite painful. Larger stones often are broken into small pieces by ultrasonic sound waves. The smaller stones then can pass out of the body. In some cases, surgery might be required to remove large stones.



Figure 19 Kidney stones form as minerals, such as calcium, and become solid masses.

Kidneys also can be damaged by other diseases present in the body. Diabetes and high blood pressure are the two most common reasons for reduced kidney function and kidney failure. In addition, kidneys can be damaged by prescription and illegal drug use.

Table 3 Common Excretory Disorders

Excretory Disorder	Brief Description
Nephritis	Inflammation of the glomeruli can lead to inflammation of the entire kidneys. This disorder can lead to kidney failure if it is left untreated.
Kidney stones	Hard deposits form in the kidneys that might pass out of the body in urine. Larger kidney stones can block urine flow or irritate the lining of the urinary tract, leading to possible infection.
Urinary tract blockage	Malformations present at birth can lead to blockage of the normal flow of urine. If it is untreated, this blockage can lead to permanent damage of the kidneys.
Polycystic kidney disease	This is a genetic disorder distinguished by the growth of many fluid-filled cysts in the kidneys. This disorder can reduce kidney function and lead to kidney failure.
Kidney cancer	Uncontrolled cell growth often begins in the cells that line the tubules within the kidneys. This can lead to blood in the urine or a mass in the kidneys, or it can affect other organs as the cancer spreads, which can lead to death.

remik44992/Shutterstock.com

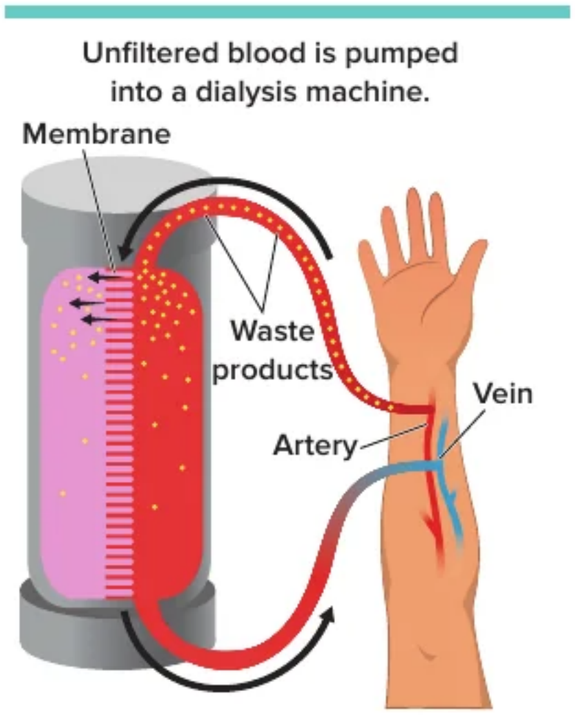


Figure 20 Dialysis is used to filter wastes and toxins from a patient's blood.

Kidney Treatments

Modern medicine offers two possible treatments for reduced kidney function or complete kidney failure.

Dialysis

Dialysis (di AH luh sus) is a procedure in which an artificial kidney machine filters out wastes and toxins from a patient's blood. One type of dialysis is illustrated in **Figure 20**. Blood is passed through a machine that temporarily filters and cleanses the blood. The filtered blood is then returned to the patient's body. The procedure lasts about three to four hours and requires three sessions per week.

Kidney transplant

A kidney transplant is the surgical placement of a healthy kidney from another person, called a donor, into the patient's body. Kidney transplants have shown increasing success in recent years. The major complication of a transplant is rejection of the donated organ. Rejection is prevented with medications such as steroids. Many transplant patients also need blood-pressure medication and other drugs to prevent infection.

Check Your Progress

Summary

- The kidneys are the main excretory organs in the body.
- Nephrons are independent filtration units in the kidneys.
- Water and important substances are reabsorbed into the blood after filtration.
- The kidneys produce a waste product called urine.

Demonstrate Understanding

1. **Explain** how the kidneys help maintain homeostasis.
2. **Diagram** the excretion of waste from the Bowman's capsule to the urethra.
3. **Compare and contrast** filtration and reabsorption in a nephron.
4. **Explain** how kidney disorders may result from genetic or environmental factors and how the disorder can affect an individual.

Explain Your Thinking

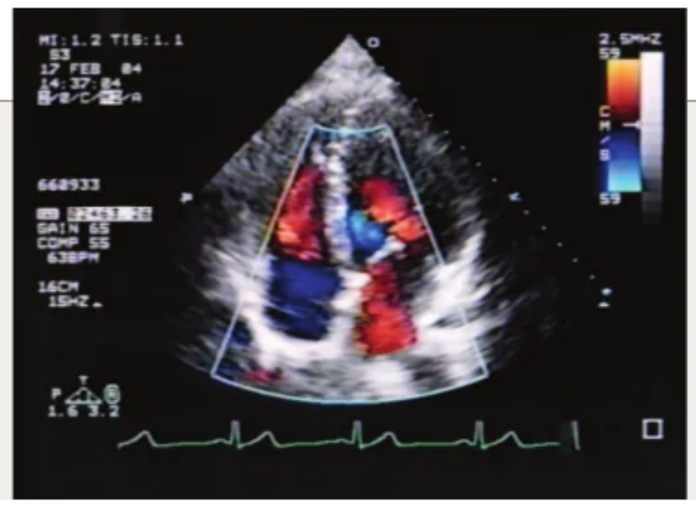
5. **Hypothesize** why kidney failure without dialysis can result in death.
6. **MATH Connection** Calculate the average amount of urine that the body produces in a week.

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SCIENCE & TECHNOLOGY

Matters of the Heart

Blood pressure and flow are two components of hemodynamics—the forces acting within the circulatory system as the heart pumps blood. By building models, physicians and scientists are understanding the relationship between hemodynamics and the physiology of the circulatory system.



Physicians use doppler echocardiograms like this one to observe blood flow through the heart of a patient.

Researchers are investigating the influence of hemodynamics on fetal development, cardiovascular disease progression, and cardiovascular device function—such as stents and replacement heart valves. A variety of models, from incubator-sized physical models of circulatory systems to elegant computational models, are used to understand how hemodynamics impact specific components of the system.

Hemodynamics is particularly important for understanding heart valve disease and for developing replacement valves. The heart's four valves operate based on hemodynamics. The changing pressures that occur with each heartbeat cause the valves to open and close, keeping oxygenated blood separate from deoxygenated blood. The doppler echocardiogram in the photo shows the pattern of blood flow through the heart.

When a heart valve needs to be replaced, surgeons typically use either mechanical valves or biologic valves. Mechanical valves do not contain any tissue and require the recipient to take medicine to prevent blood clots.

Biologic valves are constructed from animal tissue, typically from a sheep or a cow. Biologic valves often wear out and need to be replaced more than once. In children who need replacement heart valves, a biologic valve might only last a matter of months.

To design better replacement valves for all patients, researchers are looking to modeling to understand the forces acting on the valves. By using an incubator-sized model, researchers can test a newly designed replacement valve without putting it in a patient. They can adjust the fluid properties and pressures based on different parameters, and they can use the resulting data to refine the design of the replacement valve.

Other researchers use data from physical models and from patients to build computational models that help scientists understand the disease process in a specific patient.



COMMUNICATE SCIENTIFIC INFORMATION

Research heart valve replacement surgery. Write a paper summarizing the different treatment options.

Chris Gallagher/Science Source

MODULE 24
STUDY GUIDE

GO ONLINE to study with your Science Notebook.

Lesson 1 CIRCULATORY SYSTEM

- Blood vessels transport important substances throughout the body.
- The top half of the heart is made up of two atria, and the bottom half is made up of two ventricles.
- The heart pumps deoxygenated blood to the lungs, and it pumps oxygenated blood to the body.
- Blood is made up of plasma, red blood cells, white blood cells, and platelets.
- Blood is classified by the following four blood types: A, B, AB, and O.

- artery
- capillary
- vein
- valve
- heart
- pacemaker
- plasma
- red blood cell
- platelet
- white blood cell
- atherosclerosis

Lesson 2 RESPIRATORY SYSTEM

- Alveoli in the lungs are the sites of gas exchange between the respiratory and circulatory systems.
- The pathway of air starts with the mouth or nose and ends at the alveoli located in the lungs.
- Inhalation and exhalation are the processes of taking in and expelling air.
- Respiratory disorders can inhibit respiration.

- breathing
- external respiration
- internal respiration
- trachea
- bronchus
- lung
- alveolus

Lesson 3 EXCRETORY SYSTEM

- The kidneys are the main excretory organs in the body.
- Nephrons are independent filtration units in the kidneys.
- Water and important substances are reabsorbed into the blood after filtration.
- The kidneys produce a waste product called urine.

- kidney
- urea

THREE-DIMENSIONAL THINKING

Module Wrap-Up



REVISIT THE PHENOMENON

What is the woman's body doing in response to lifting? Why?

CER Claim, Evidence, Reasoning

Explain Your Reasoning Revisit the claim you made when you encountered the phenomenon. Summarize the evidence you gathered from your investigations and research and finalize your Summary Table. Does your evidence support your claim? If not, revise your claim. Explain why your evidence supports your claim.

STEM UNIT PROJECT

Now that you've completed the module, revisit your STEM unit project. You will summarize your evidence and apply it to the project.

GO FURTHER

SEP Data Analysis Lab

How do extreme conditions affect the average daily loss of water in the human body?

The body obtains water by absorbing it through the digestive tract. The body loses water primarily by excreting it in urine from the kidneys, through sweat, and through the lungs.

Data and Observations The table shows data collected for normal temperatures, for high temperatures, and during rigorous exercise.

CER Analyze and Interpret Data

1. **Claim, Evidence** Identify what the major source of water loss is during normal temperatures.
2. **Reasoning** Hypothesize why more water is lost in sweat during rigorous exercise than in urine.
3. **Calculate** the percent of water loss for each of the three conditions.

Average Daily Water Loss in Humans (in mL)

Source	Normal Temperatures	High Temperatures	Rigorous Exercise
Kidneys	1500	1400	750
Skin	450	1800	5000
Lungs	450	350	650

*Data obtained from: Beers, M. 2003. *The Merck Manual of Medical Information, Second Edition* West Point, PA.: Merck & Co. Inc.

DreamPictures/Jensen Walker/Blend Images



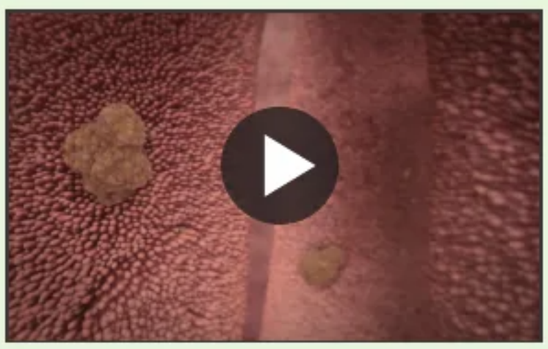
Makoto Watanabe/MIXA Co. Ltd./Alamy

MODULE 25

DIGESTIVE AND ENDOCRINE SYSTEMS

ENCOUNTER THE PHENOMENON

Why do we need a variety of foods in our diet?



GO ONLINE to play a video about the path that food and beverages travel within your body.

SEP Ask Questions

Do you have other questions about the phenomenon? If so, add them to the driving question board.

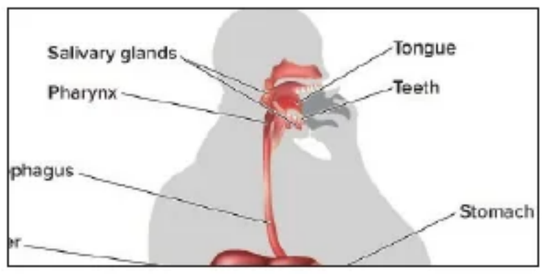
CER Claim, Evidence, Reasoning

Make Your Claim Use your CER chart to make a claim about why we need a variety of foods in our diet. Explain your reasoning.

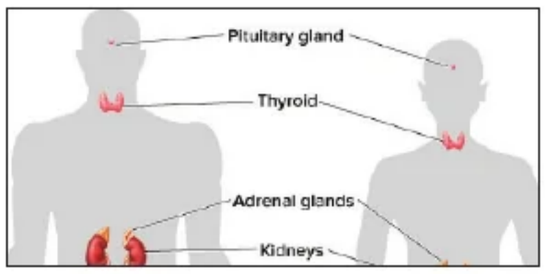
Collect Evidence Use the lessons in this module to collect evidence to support your claim. Record your evidence as you move through the module.

Explain Your Reasoning You will revisit your claim and explain your reasoning at the end of the module.

GO ONLINE to access your CER chart and explore resources that can help you collect evidence.



LESSON 1: Explore & Explain: The Digestive System



LESSON 3: Explore & Explain: The Endocrine System

Smithsonian

Additional Resources

Video Supplied by BBC Worldwide Learning

LESSON 1

THE DIGESTIVE SYSTEM

FOCUS QUESTION

What are the structures and functions of the digestive system?

Functions of the Digestive System

There are three main functions of the digestive system. The digestive system ingests food, breaks it down so nutrients can be absorbed, and eliminates what cannot be digested. Refer to **Figure 1** below and **Figure 2** on the next page as you learn about the structure and function of the digestive system.

Digestion

Mechanical digestion involves chewing food to break it down into smaller pieces. It also includes the action of smooth muscles in the stomach and small intestine that churn the food. **Chemical digestion** involves the breakdown of large molecules in food into smaller substances by enzymes, proteins that speed up chemical reactions. The smaller substances are absorbed into the body's cells. When you chew food, **amylase,** an enzyme in saliva, begins the process of chemical digestion by breaking down starches into sugars.

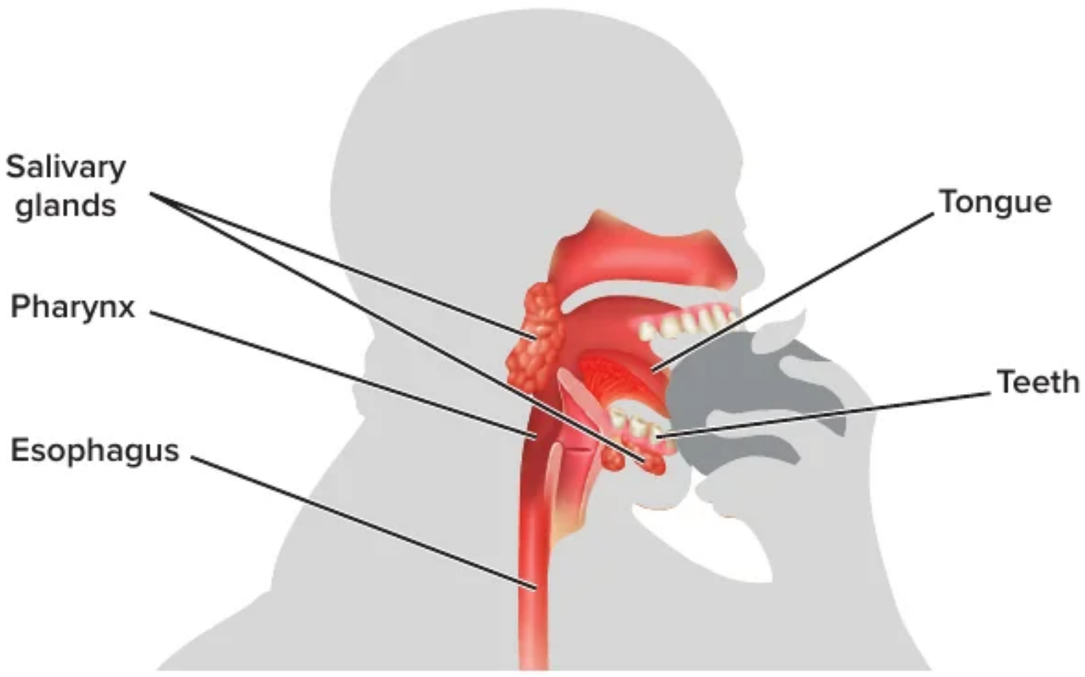


Figure 1 Mechanical digestion starts in the mouth. Secretions from the salivary glands keep food moist and begin the process of chemical digestion. Food moves through the pharynx into the esophagus.

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

BioLab: How does the rate of starch digestion compare among crackers?
Plan and carry out an investigation to determine the amount of time needed for starch to digest.

Virtual Investigation: The Digestive and Endocrine Systems
Use a model to determine the effect a healthy diet has on the digestive and endocrine systems.

Esophagus

When the tongue pushes chewed food to the back of the mouth, the swallowing reflex is stimulated. The food is forced by the action of the tongue into the upper portion of the esophagus. The **esophagus** (ih SAH fuh gus) is a muscular tube that connects the pharynx, or throat, to the stomach, as illustrated in **Figure 2**. The wall of the esophagus is lined with smooth muscles that contract rhythmically to move the food through the digestive system in a process called **peristalsis** (per uh STAHL sus). Peristalsis continues throughout the digestive tract. Even if a person were upside down, food would still move toward the stomach.

When a person swallows, the small plate of cartilage called the epiglottis covers the trachea. If this opening is not closed, food can enter the trachea and cause a person to choke. The body responds to this by initiating the coughing reflex in an attempt to expel the food to keep the food from entering the lungs.

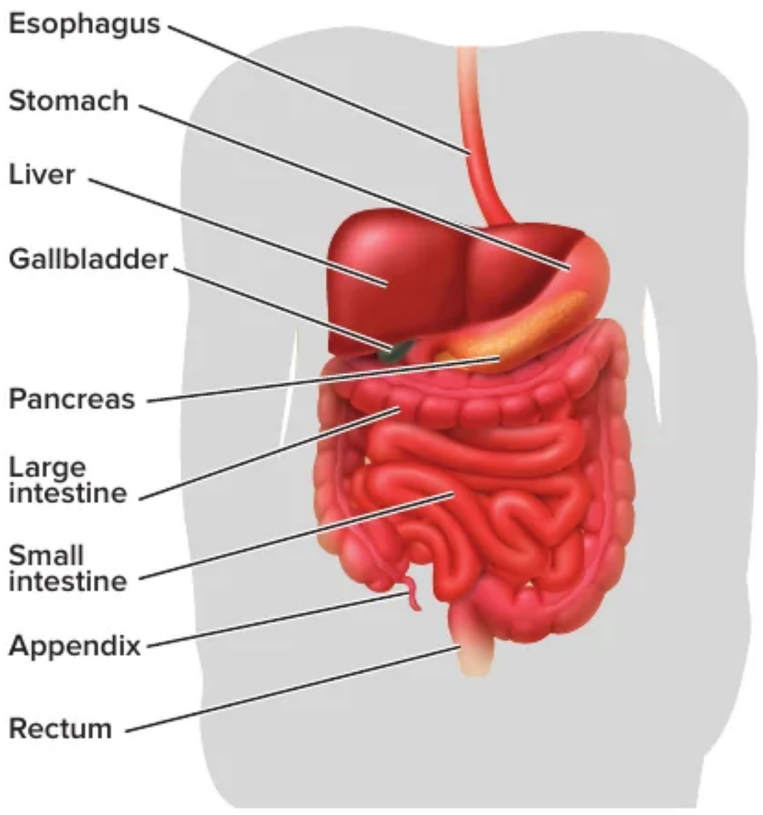


Figure 2 The human digestive system is made up of numerous parts, including the esophagus, which extends from the pharynx to the stomach and is approximately 25 cm long.

Get It?
Explain the importance of peristalsis to digestion.

Stomach

When food leaves the esophagus, it passes through a circular muscle called a sphincter, and into the stomach. The sphincter between the esophagus and stomach is the cardiac sphincter. The walls of the stomach are composed of three overlapping layers of smooth muscle that are involved with mechanical digestion. As the muscles contract, they further break down the food and mix it with the secretions of glands that line the inner wall of the stomach.

CHEMISTRY Connection Recall that pH is a measure of a solution's acidity. The environment inside the stomach is very acidic. Stomach glands, called gastric glands, secrete an acidic solution, which lowers the pH in the stomach to about 2. This is about the same level of acidity as lemon juice. If the sphincter in the upper portion of the stomach allows any leakage, some of this acid might move back into the esophagus, causing what is commonly known as heartburn.

The acidic environment in the stomach is favorable to the action of **pepsin,** an enzyme involved in the process of the chemical digestion of proteins. Cells in the lining of the stomach secrete mucus to help prevent damage from pepsin and the acidic environment. Although most absorption occurs in the small intestine, some substances, such as alcohol and aspirin, are absorbed by cells that line the stomach. While empty, the capacity of the stomach is about 50 mL. When full, it can expand to 2–4 L.

Get It?
Explain how both mechanical and chemical digestion occur in the stomach.

The muscular walls of the stomach contract and push food farther along the digestive tract. As the result of chemical and mechanical digestion in the stomach, the consistency of the food resembles tomato soup as it passes through the pyloric sphincter at the lower end of the stomach into the small intestine.

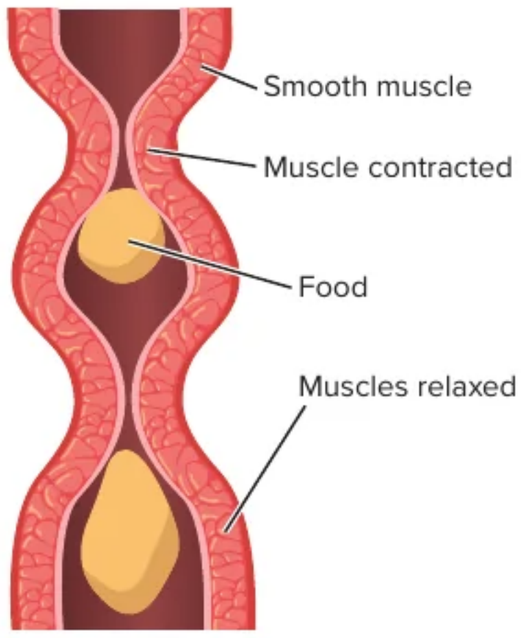


Figure 3 The smooth muscles in the walls of the digestive tract contract in the process of peristalsis.

Get It?
Compare digestion in the mouth with digestion in the stomach.

Small intestine

The **small intestine** is approximately 7 m in length and is the longest part of the digestive tract. It is called small because its diameter is 2.5 cm compared to the 6.5 cm diameter of the large intestine. The smooth muscles in the wall of the small intestine continue the process of mechanical digestion and push the food farther through the digestive tract by peristalsis, as shown in **Figure 3.**

The completion of chemical digestion in the small intestine depends on three accessory organs—the pancreas, liver, and gallbladder, as illustrated in **Figure 4**. The pancreas serves two main functions. One is to produce enzymes that digest carbohydrates, proteins, and fats. The other is to produce hormones, which will be discussed later in this module. The pancreas secretes an alkaline fluid to raise the pH in the small intestine to slightly above 7, which creates a favorable environment for the action of intestinal enzymes.

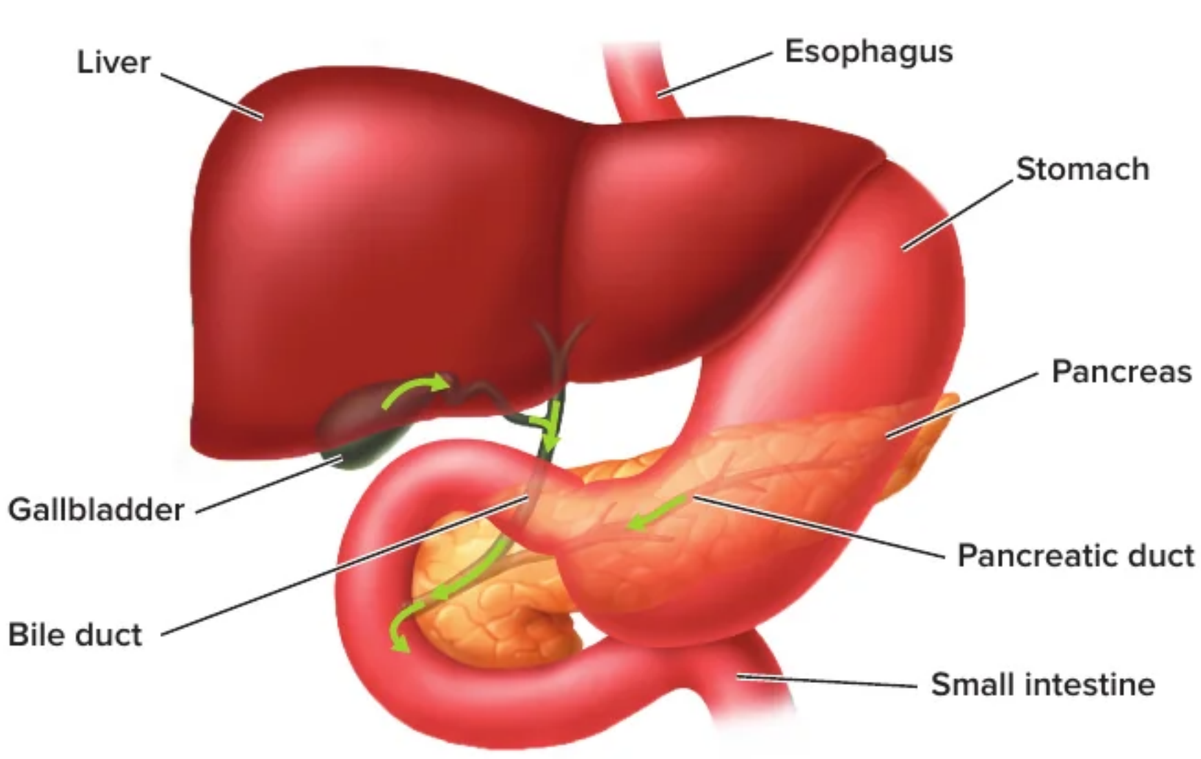


Figure 4 Chemical digestion in the small intestine depends on the activities of the liver, pancreas, and gallbladder.
Discuss *the importance of each of these organs in the process of chemical digestion.*

The **liver** is the largest internal organ of the body and produces bile, which helps to break down fats. About 1 L of bile is produced every day, and excess bile is stored in the gallbladder to be released into the small intestine when needed. **Figure 5** shows gallstones, which are cholesterol crystals that can form in the gallbladder.



Figure 5 Gallstones can obstruct the flow of bile from the gallbladder. Gallstones can be removed through surgery.

Chemical digestion is completed and most of the nutrients from food are absorbed from the small intestine into the bloodstream through fingerlike structures called **villi** (VIH li) (singular, villus). Villi, shown in **Figure 6**, increase surface area, giving the small intestine approximately the same surface area as a tennis court.

Refer again to **Figure 1** and **Figure 2** to follow the movement of digested food through the digestive system. Once digestion is complete, the remaining food, now in a semiliquid form called chyme (KIME), moves into the large intestine. Chyme is made up of materials that cannot be digested or absorbed by villi in the small intestine.

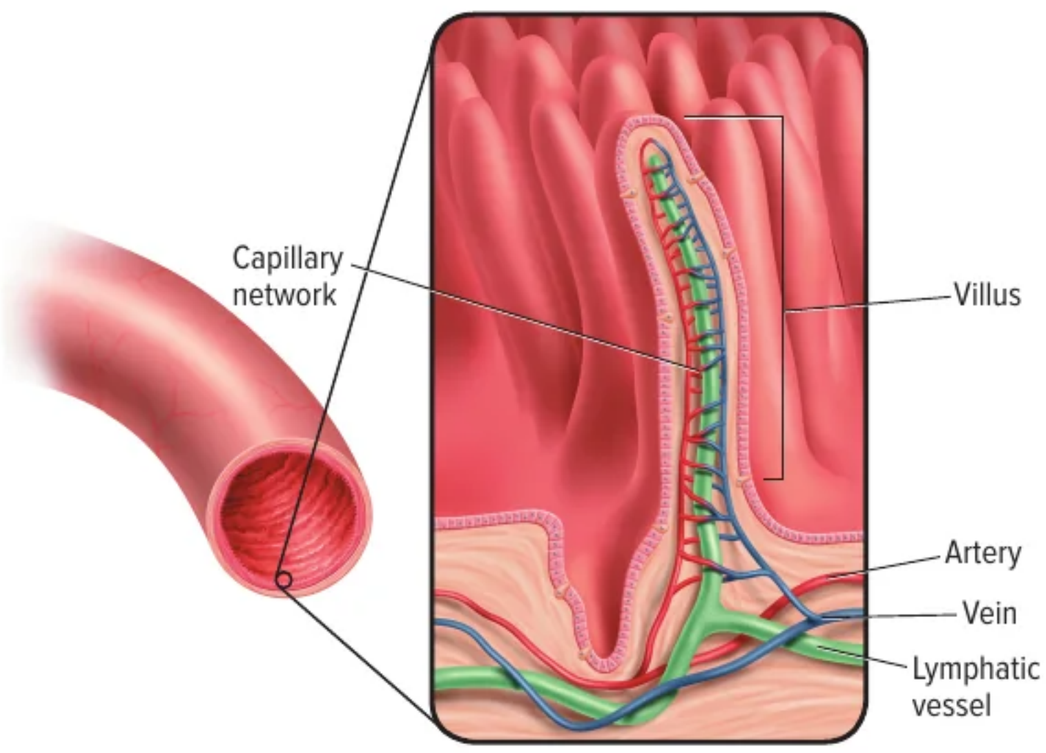


Figure 6 A villus is a fingerlike extension of the lining of the small intestine. Nutrients diffuse into capillaries in the villi and reach body cells by means of circulating blood.

Roblan/Shutterstock.com

STUDY TIP

Sequence and Order Using your notes, work with a partner to review the functions of the organs in the digestive system. Ask questions of one another for deeper learning.

CCC CROSSCUTTING CONCEPTS

Systems and Systems Models With a partner, review the information about the structures of the digestive system. Then, work with your partner to develop a model, such as a flow chart, to describe how matter flows within the digestive system.

Table 1 Time for Digestion

Digestive Structure	Primary Function	Time Food is in Structure
Mouth	Mechanical and chemical digestion	5–30 s
Esophagus	Transport (swallowing)	10 s
Stomach	Mechanical and chemical digestion	2–24 h
Small Intestine	Mechanical and chemical digestion	3–4 h
Large Intestine	Water absorption	18 h–2 days

Large intestine

The **large intestine** is the end portion of the digestive tract. It is about 1.5 m long and includes the colon, the rectum, and a small saclike appendage called the appendix. The appendix has no known function. Some kinds of beneficial bacteria are normal in the colon. These bacteria produce vitamin K and some B vitamins.

A primary function of the colon is to absorb water from the chyme. The indigestible material then becomes more solid and is called feces. Peristalsis continues to move feces toward the rectum, causing the walls of the rectum to stretch. This initiates a reflex that causes the final sphincter muscle to relax, and the feces are eliminated from the body through the anus. Refer to **Table 1** to review the primary function of each structure of the digestive system and how long food usually remains in each structure as it is being digested.

Check Your Progress

Summary

- The digestive system has three main functions.
- Digestion can be categorized as mechanical or chemical.
- Most nutrients are absorbed in the small intestine.
- Accessory organs provide enzymes and bile to aid digestion.
- Water is absorbed from chyme in the colon.

Demonstrate Understanding

1. **Describe** the process that breaks down food so that nutrients can be absorbed by the body.
2. **Analyze** the difference between mechanical digestion and chemical digestion. Explain why chemical digestion is necessary for the body.
3. **Summarize** the main functions of the digestive system.
4. **Analyze** what the consequence might be if the lining of the small intestine were completely smooth instead of having villi.

Explain Your Thinking

5. **Explain** why the pH in the digestive system changes. Design an experiment to gather data about the effect of pH on the digestion of different types of food.
6. **MATH Connection** A can of carbonated beverage typically holds about 354 mL of fluid. Compare this amount with the volume of an empty stomach. Give a ratio.

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LESSON 2

NUTRITION

FOCUS QUESTION

How can you maintain a healthy and balanced diet?

Calories

Nutrition is the process by which a person takes in and uses food. Foods supply the building blocks and energy to maintain body mass. The daily input of energy from food should equal the amount of energy a person uses daily. A **Calorie** (with an uppercase C) is the unit used to measure the energy content of foods. A Calorie is equal to 1 kilocalorie, or 1000 calories (with a lowercase c). A calorie is the amount of heat needed to raise the temperature of 1 mL of water by 1°C.

The energy content of a food can be measured by burning the food and converting the stored energy to heat. Not all foods have the same energy content. The same mass of different foods does not always equal the same number of Calories. For example, one gram of carbohydrate or protein contains four Calories. One gram of fat contains nine Calories. To lose weight, more Calories must be used than consumed. The opposite is true to gain weight. **Table 2** compares average Calorie usage with different activities. The exact number of calories burned will vary depending on weight and gender.

Table 2 Activities and Average Calories Usage

Activity	Calories Used Per Hour	Activity	Calories Used Per Hour
Baseball	282	Hiking and backpacking	564
Basketball	564	Hockey (field and ice)	546
Bicycling	240–410	Jogging	740–920
Football	540	Soccer	540

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Open Inquiry: The Human Body

Plan and carry out an investigation to determine the effect sugar has on mood.

CCC **Identify Crosscutting Concepts**

Create a table of the crosscutting concepts and fill in examples you find as you read.

Carbohydrates

Cereal, pasta, potatoes, strawberries, and rice all contain a high proportion of carbohydrates. Recall that sugars, such as glucose, fructose, and sucrose, are simple carbohydrates that are found in fruits, soda pop, and candy. Complex carbohydrates are macromolecules such as starches, which are long chains of sugars. Foods such as those in **Figure 7** have a high starch content, as do some vegetables.



Figure 7 Your body needs carbohydrate-rich foods like these every day.

Complex carbohydrates are broken down into simple sugars in the digestive tract. Simple sugars are absorbed through villi in the small intestine into the bloodstream and circulated throughout the body to provide energy for cells. Excess glucose is stored in the liver in the form of glycogen. Cellulose, sometimes called dietary fiber, is another complex carbohydrate found in plant foods. Although humans cannot digest fiber, it is important because fiber helps keep food moving through the digestive tract and helps with the elimination of wastes. Bran, whole-grain breads, and beans are good sources of fiber.

Get It?

Identify examples of carbohydrates shown in the photo at the beginning of the module.

Fats

In proper amounts, fats are an essential part of a healthful diet. Fats are the most concentrated energy source available to the body, and they are building blocks for the body. Fats also protect some internal organs and help maintain homeostasis by providing energy and by storing and transporting certain vitamins. However, not all fats are beneficial to the body.

HEALTH Connection Recall that fats, some of which are shown in **Figure 8**, are classified according to their chemical structure as saturated or unsaturated. Meats, cheeses, and other dairy products are sources of saturated fats. A diet high in saturated fats might result in high blood levels of cholesterol, which can lead to heart problems. Plants are the main source of unsaturated fats, which are not associated with the development of heart disease.



Figure 8 The oils here are sources of unsaturated fat. The butter is a source of saturated fat.

A general rule is that saturated fats are solid at room temperature and unsaturated fats are liquid at room temperature. The olive oil in **Figure 8** contains less saturated fat than the butter, which is why the olive oil is liquid at room temperature. Recall that, as matter moves through the body, chemical elements are recombined to form different products. Fats are digested in the small intestine and are broken down into fatty acids and glycerol. Fatty acids can be absorbed through the villi and circulated in the blood throughout the body.

(t) Elena Schweitzer/iStock/Getty Images; (b) Torbjörn Lagerwall/Alamy

Proteins

You have learned that proteins are basic structural components of all cells. Enzymes, hormones, neurotransmitters, and membrane receptors are just a few important proteins in the body.

During digestion, proteins are broken down into amino acids. The amino acids are absorbed into the bloodstream and carried to various body cells. These body cells recombine and reassemble the amino acids into proteins needed for body structures and functions.



Figure 9 Beans and rice can be combined to provide all the essential amino acids.

The human body can produce 12 of the 20 amino acids needed for cellular function. Essential amino acids are the eight amino acids that the body cannot produce, and must be included in a person's diet. Animal products, such as eggs and fish, are sources of all eight essential amino acids. Vegetables, fruits, and grains contain amino acids, but very few single plant food sources contain all eight essential amino acids. Certain combinations of plant foods, such as the beans and rice shown in **Figure 9**, provide all of the essential amino acids.

MyPlate

In 2011, the United States Department of Agriculture published a new nutrition guide, MyPlate, shown in **Figure 10**. MyPlate emphasizes the ratios of food groups rather than exact serving sizes. It recommends that a person eat about 30 percent grains, 30 percent vegetables, 20 percent fruits, 20 percent protein, with a small side of dairy such as a yogurt cup or glass of skim milk.

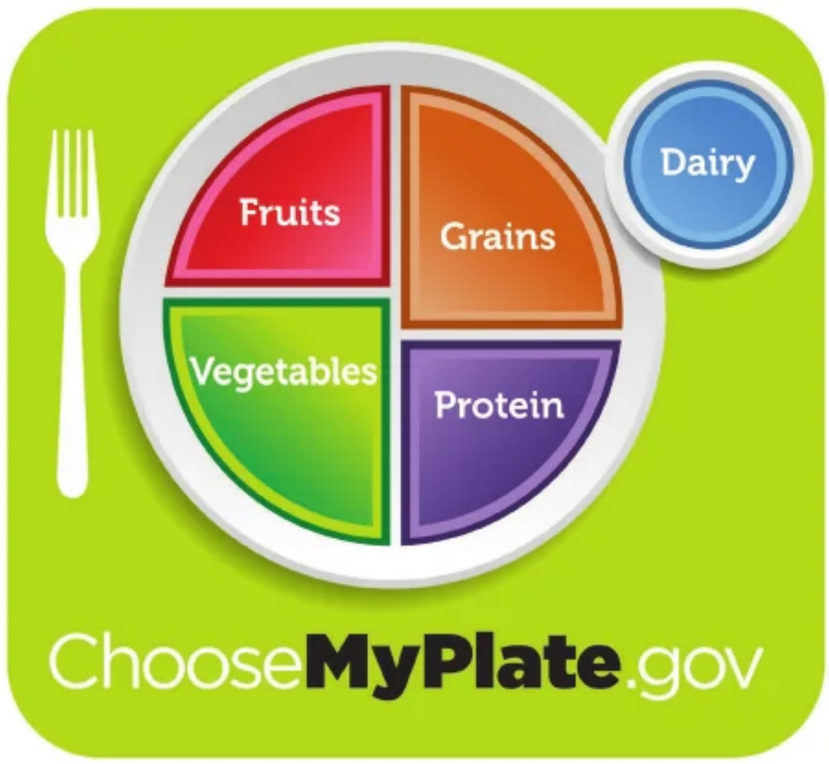


Figure 10 MyPlate can help you choose the foods and their amounts that are right for you.

(t) Amble Design/Shutterstock.com; (b) US Department of Agriculture

Vitamins and Minerals

In addition to carbohydrates, fats, and proteins, your body needs vitamins and minerals to function properly. **Vitamins** are organic compounds that are needed in small amounts for metabolic activities. Many vitamins help enzymes function properly. Some vitamins are produced within the body. Vitamin D is made by cells in your skin. Some B vitamins and vitamin K are produced by bacteria living in the large intestine. However, sufficient quantities of most vitamins cannot be made by the body, but a well-balanced diet can provide the vitamins that are needed. Some vitamins that are fat-soluble can be stored in small quantities in the liver and fatty tissues of the body. Other vitamins are water-soluble and cannot be stored in the body. Foods providing an adequate level of these vitamins should be included in a person's diet on a regular basis.

Minerals are inorganic compounds used by the body as building materials, and they are involved with metabolic functions. For example, the mineral iron is needed to make hemoglobin. Recall that oxygen binds to hemoglobin in red blood cells and is delivered to body cells as blood circulates in the body. Calcium, another mineral, is an important component of bones.

Get It?

Compare and contrast vitamins and minerals.

Vitamins and minerals are essential parts of a healthy diet. **Table 3** on the next page lists some important vitamins and minerals, their benefits, and some food sources that can provide these necessary nutrients. Over-the-counter vitamins and minerals, like those shown in **Figure 11**, are also available. Taking more than the recommended daily allowance, however, can be dangerous and should not be done without consulting a doctor.

Sometimes people suffer from a vitamin or mineral deficiency, meaning they do not get enough of the vitamin or mineral to maintain homeostasis. For example, children who do not get enough vitamin D can suffer from rickets, a disorder in which the bones are soft and do not develop properly. People who do not get enough iodine may develop problems with their thyroid.



Figure 11 Vitamins and minerals can be taken as supplements to vitamins and minerals obtained in food.

Montri Nipitvittaya/Shutterstock.com

STEM CAREER Connection

Chef

Do you enjoy preparing healthful and delicious foods? Do you understand the science of cooking? You might want to think about becoming a chef. A chef might plan menus, oversee other workers, or prepare foods. Many chefs work in restaurants, but some work in hospitals, nursing homes, or other facilities where food is served.

CCC CROSSCUTTING CONCEPTS

Energy and Matter With a small group, discuss evidence of how the energy and matter in food is used by the body. Write a bulleted list that summarizes the main points of your group's discussion.

Table 3 Major Roles of Some Vitamin and Minerals

Vitamin	Major Role in the Body	Possible Sources	Mineral	Major Role in the Body
A	• Vision • Health of skin and bones		Ca	• Strengthening of teeth and bone • Nerve conduction • Contraction of muscle
D	• Health of bones and teeth		P	• Strengthening of teeth and bones
E	• Strengthening of red blood cell membrane		Mg	• Synthesis of proteins
Riboflavin (B_2)	• Metabolism		Fe	• Synthesis of hemoglobin
Folic Acid	• Formation of red blood cells • Formation of DNA and RNA		Cu	• Synthesis of hemoglobin
Thiamine	• Metabolism of carbohydrates		Zn	• Healing of wounds
Niacin (B_3)	• Metabolism		Cl	• Balance of water
Pyridoxine (B_6)	• Metabolism of amino acids		I	• Synthesis of thyroid hormone
B_{12}	• Formation of red blood cells		Na	• Nerve conduction • Balance of pH
C	• Formation of collagen		K	• Nerve conduction • Contraction of muscle

(t to b) D. Hurst/Alamy; Ingram Publishing; 4kodiak/E+/Getty Images; Brittany Herbert/McGraw-Hill Education; © Foodcollection; Frans Rombout/iStock/Getty Images; Suzannah Skelton/E+/Getty Images; filmfoto/iStock/Getty



Figure 12 When you read a nutrition label, notice how many servings are in each food container. The percent daily values are based on an individual serving, not the entire package.

Nutrition Labels

Nutrition labels are provided on commercially packaged foods like those shown in **Figure 12**. These labels are based on a 2000 Calorie per day diet. Labels can be especially useful for monitoring fat and sodium intake, which are two nutrients that need to be consumed in moderation. The FDA requires that food labels list the following information:

- name of the food
- the net weight or volume
- the name and address of manufacturer, distributor, or packager
- the ingredients
- nutrient content

Get It?

Explain why nutrition labels are important.

Check Your Progress

Summary

- The energy content of food is measured in Calories.
- Carbohydrates, fats, and proteins are three major groups of nutrients.
- Carbohydrates are a major source of energy for the body.
- Fats and proteins provide energy and are important building blocks for the body.
- Vitamins and minerals are essential for proper metabolic functioning.
- MyPlate and food labels are tools that you can use to eat healthfully.

Demonstrate Understanding

1. **Explain** the roles of vitamins and minerals in the process of maintaining homeostasis.
2. **Describe** what proteins, carbohydrates, and fats are used for in the body.
3. **Recommend** what nutrients a vegetarian should add to his or her diet.
4. **Explain** why keeping a count of Calories consumed and Calories used is important in maintaining proper functioning of the body.

Explain Your Thinking

5. **Summarize** how many Calories you consume during one day by recording everything you eat or drink. Compare this to how many Calories you burn in an average day.
6. **WRITING Connection** Write a short article for your school newspaper describing what is needed for a well-balanced diet.

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LESSON 3

THE ENDOCRINE SYSTEM

FOCUS QUESTION

What are the structures and functions of the endocrine system?

Actions of Hormones

The endocrine system is composed of glands and functions as a communication system. **Endocrine glands** produce hormones, which are released into the bloodstream and distributed to body cells. A **hormone** is a substance that acts on certain target cells and tissues to produce a specific response. Hormones are classified as steroid hormones and nonsteroid or amino acid hormones, based on their structure and mechanism of action.

Steroid hormones

Estrogen and testosterone are two examples of steroid hormones. All steroid hormones work by causing the target cells to initiate protein synthesis, as illustrated in **Figure 13**.

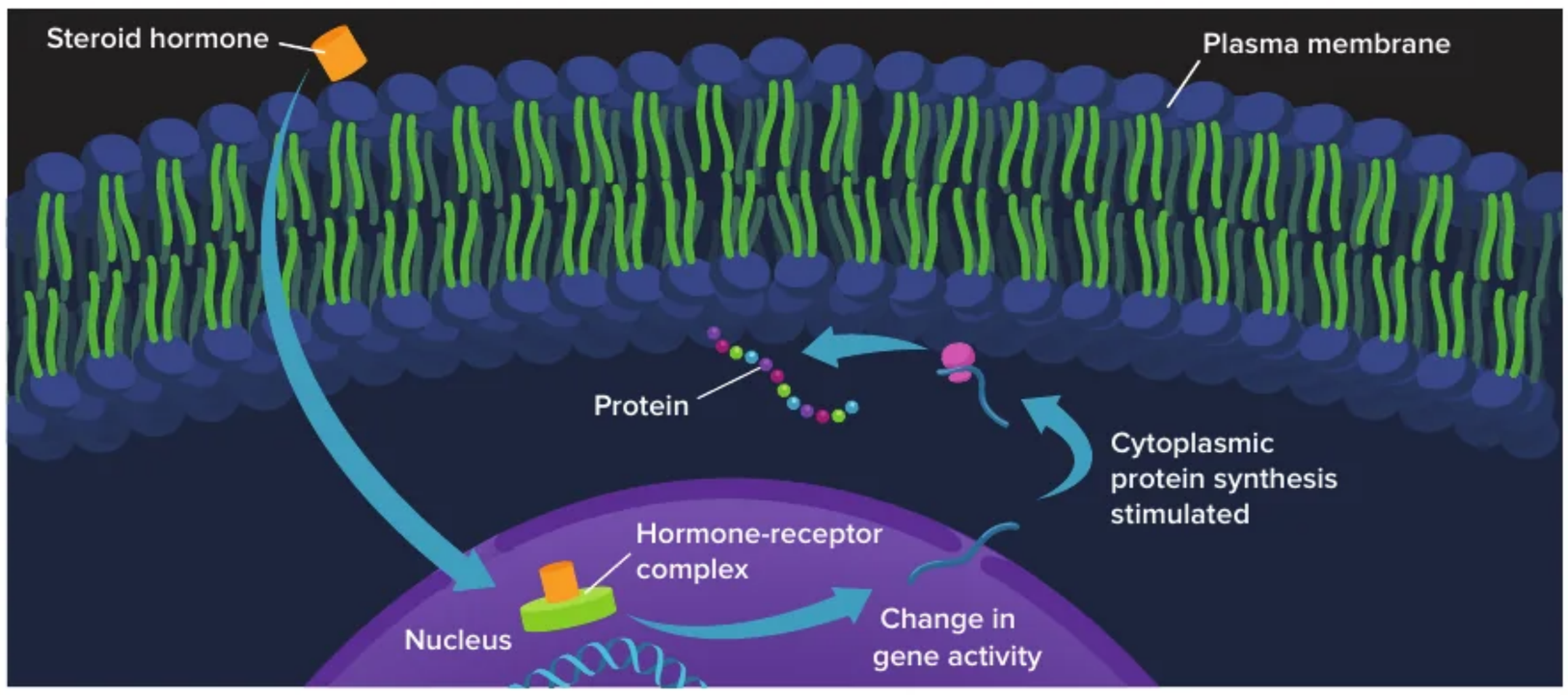


Figure 13 A steroid hormone passes through a cell membrane, binds to a receptor within the cell, and stimulates protein synthesis.

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COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Applying Practices: Investigate Homeostasis in the Human Body

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Steroid hormones are soluble in lipids and therefore can diffuse through the plasma membrane of a target cell. Once inside a target cell, they bind to a receptor in the cell. The hormone and the receptor that are bound together bind to DNA in the nucleus, which activates specific genes.

Amino acid hormones

Insulin and growth hormones are two examples of nonsteroid, or amino acid, hormones. As the name implies, these hormones are composed of amino acids. Amino acid hormones must bind to receptors found on the plasma membrane of a target cell because they cannot diffuse through the plasma membrane. Once the hormone binds to the receptor, the receptor activates an enzyme found on the inside of the membrane. This usually initiates a biochemical pathway, eventually causing the cell to produce the desired response, as illustrated in **Figure 14**.

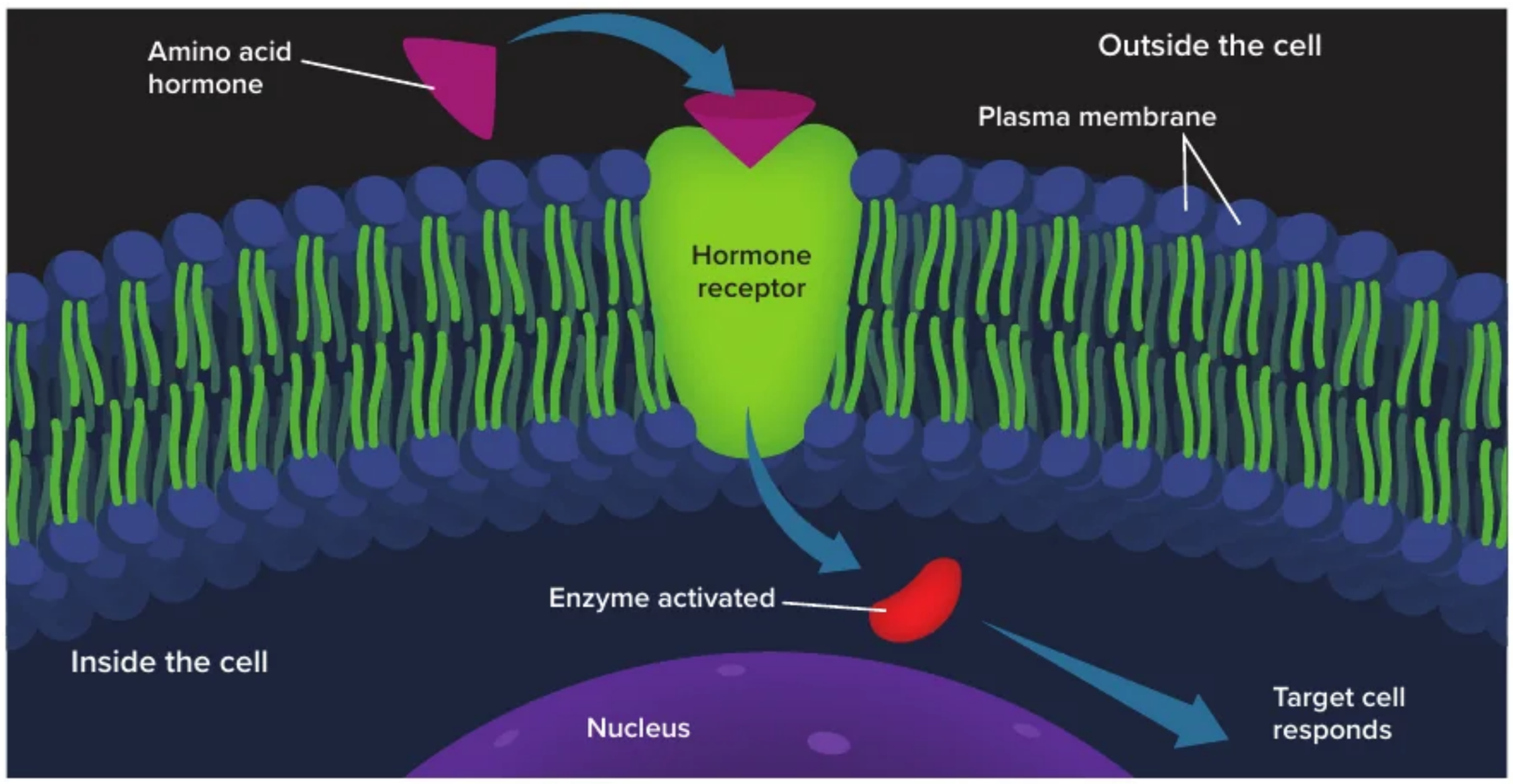


Figure 14 An amino acid hormone binds to a receptor on the plasma membrane before entering the cell.
Explain *the difference between amino acid hormones and steroid hormones.*

Negative Feedback

Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system. Negative feedback systems usually control conditions that remain in a steady state over long periods of time, stabilizing a system. You might be familiar with an example of a negative feedback system in your own home—the thermostat that controls temperature.

Get It?
Explain how feedback can stabilize a system.

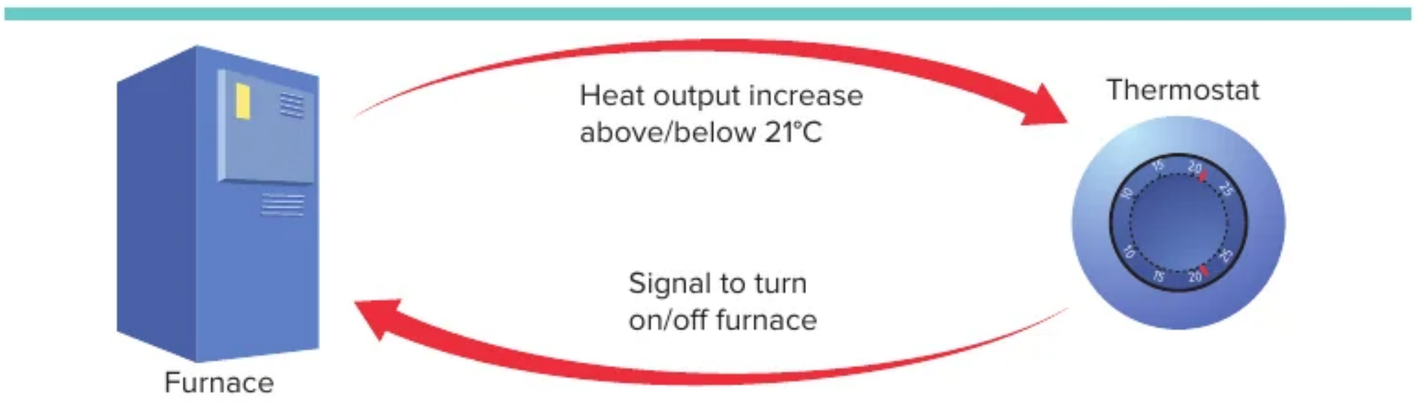


Figure 15 A furnace turns on or off based on the relationship of the detected room temperature and the set point.

Study **Figure 15**. In this example, the temperature in a house is maintained at 21˚C. The thermostat in the house detects the temperature, and when the temperature drops below 21˚C, the thermostat sends a signal to the heat source, which turns it on and produces more heat. Soon the temperature rises above 21˚C, and the thermostat sends a signal to the heat source to shut off. The heat source will not turn on again until the room temperature drops below 21˚C and is detected by the thermostat. Because this process can go on indefinitely, negative feedback often is described as a loop.

Endocrine Glands and Their Hormones

The endocrine system includes all the glands that secrete hormones—pituitary, thyroid, parathyroid, adrenal glands, pancreas, ovaries, testes, pineal gland, and the thymus gland. Some of these glands are shown in **Figure 16**.

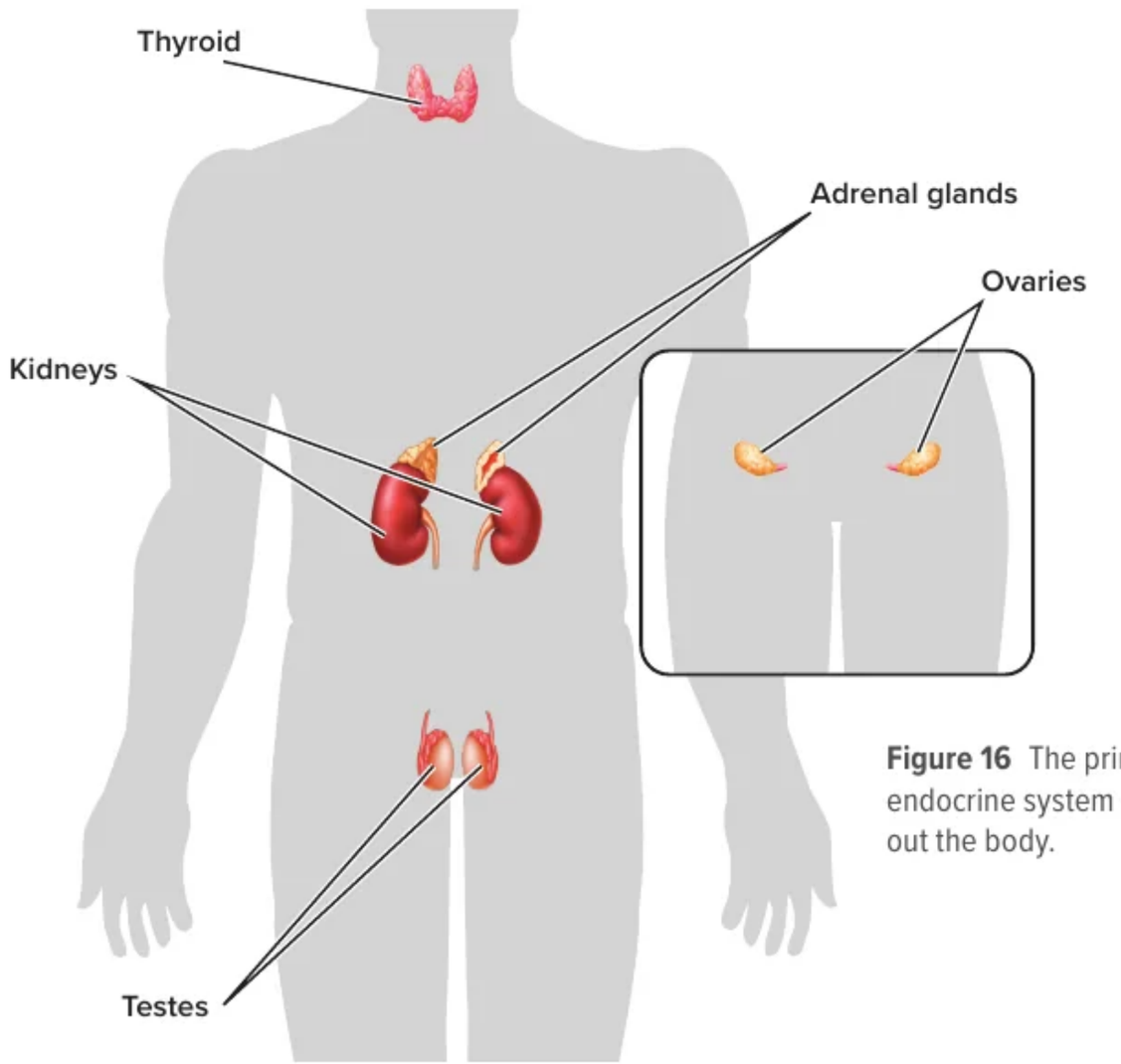


Figure 16 The principal glands of the endocrine system are located throughout the body.

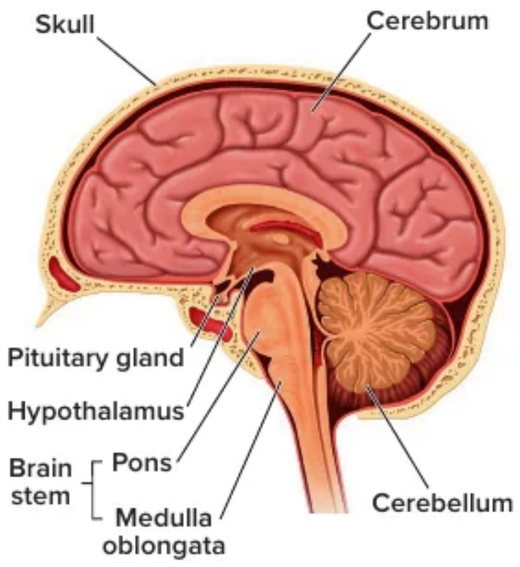


Figure 17 The pituitary gland is located at the base of the brain.

Pituitary gland

The pituitary gland is situated at the base of the brain, as illustrated in **Figure 17**. This gland is sometimes called the "master gland" because it regulates so many body functions. Despite its small size, it is the most important endocrine gland. The **pituitary gland** secretes hormones that regulate many body functions. It also regulates other endocrine glands, such as the thyroid gland, adrenal glands, testes, and ovaries.

Several pituitary hormones act on tissues in the body rather than on specific organs. Human growth hormone (hGH) regulates the body's physical growth by stimulating cell division in muscle and bone tissue. This hormone is especially active during childhood and adolescence.

Thyroid and parathyroid glands

Identify the thyroid and parathyroid glands in **Figure 18**. One hormone produced by the thyroid gland is thyroxine. Like hGH, **thyroxine** does not act on specific organs; rather, it causes cells of the body to have a higher rate of metabolism. The thyroid gland also produces calcitonin. **Calcitonin** (kal suh TOH nun) is a hormone that is partly responsible for the regulation of calcium, an important mineral for bone formation, blood clotting, nerve function, and muscle contraction. Calcitonin lowers blood calcium levels by signaling bones to increase calcium absorption and also signaling the kidneys to excrete more calcium.

When blood calcium levels are too low, the parathyroid glands increase production of parathyroid hormone. **Parathyroid hormone** increases blood calcium levels by stimulating the bones to release calcium. The action of this hormone also causes the kidneys to reabsorb more calcium and the intestines to absorb more calcium from food. The thyroid and parathyroid glands have opposite effects on blood calcium levels. However, as they work together, they maintain homeostasis.

Get It?

Explain how negative feedback is important in maintaining homeostasis.

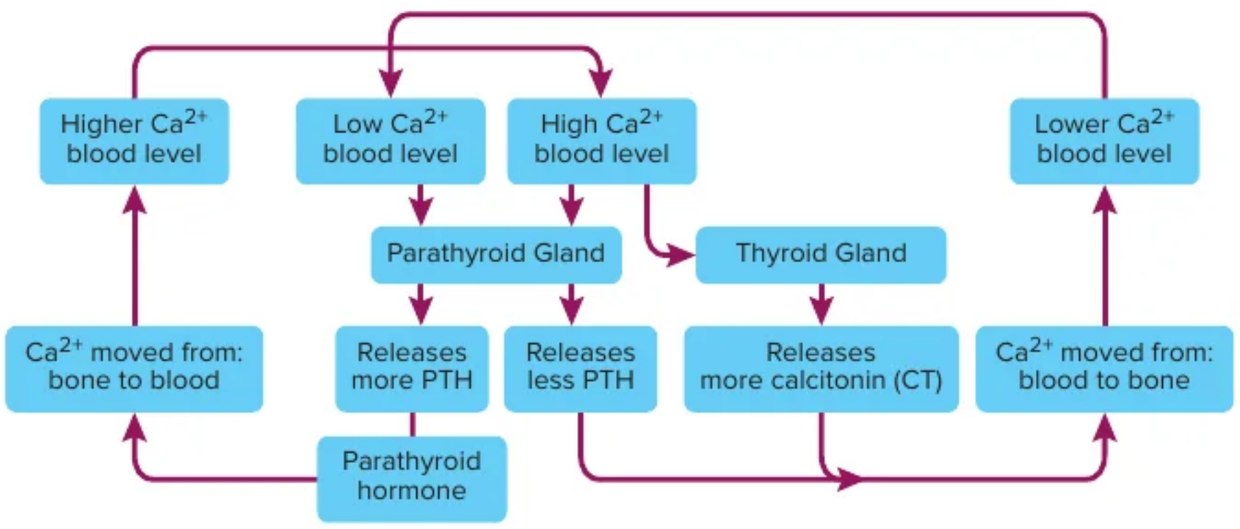


Figure 18 Parathyroid hormone (PTH) and calcitonin (CT) regulate the level of calcium in the blood.

Explain *how PTH and CT illustrate negative feedback.*

Pancreas

As discussed in Lesson 1, the pancreas has a crucial role in the production of enzymes that digest carbohydrates, proteins, and fats. The pancreas also secretes the hormones insulin and glucagon, which work together to maintain homeostasis, as illustrated in **Figure 19**. When blood glucose levels are high, the pancreas releases insulin. **Insulin** signals body cells, especially liver and muscle cells, to accelerate the conversion of glucose to glycogen, which is stored in the liver. When blood glucose levels are low, glucagon is released from the pancreas. **Glucagon** (GLEW kuh gahn) binds to liver cells, signaling them to convert glycogen to glucose and release the glucose into the blood.

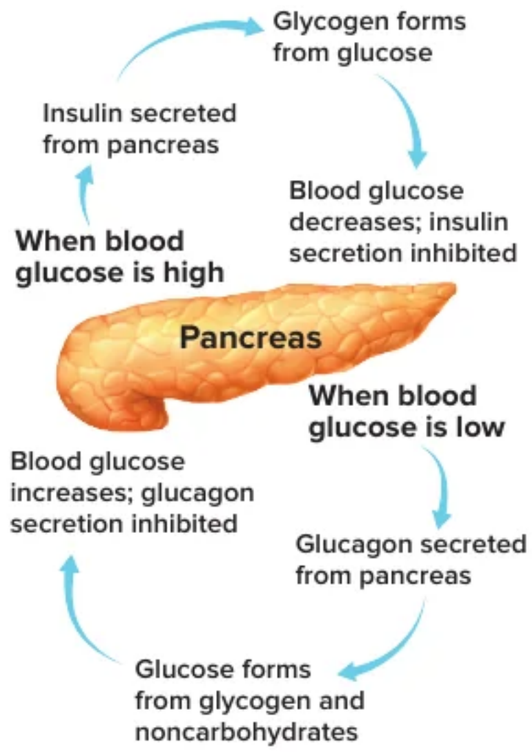


Figure 19 Glucagon and insulin work together to maintain the level of sugar in the blood.

Diabetes is a disease that results from the body not producing enough insulin or not properly using insulin. Type 1 diabetes, which usually appears in people by the age of 20, occurs when the body cannot produce insulin. Type 2 diabetes occurs in 70–80 percent of people diagnosed with diabetes, and usually occurs after the age of 40. It results from the cells of the body becoming insensitive to insulin. In both types of diabetes, the blood glucose levels must be monitored and maintained to prevent complications from the disease.

Adrenal glands

Refer again to **Figure 16**. The adrenal glands are located just above the kidneys. The outer part of the adrenals is called the cortex, which manufactures the steroid hormone aldosterone and a group of hormones called glucocorticoids. **Aldosterone** (al DAWS tuh rohn) primarily affects the kidneys and is important for reabsorbing sodium. **Cortisol,** another glucocorticoid, raises blood glucose levels and also reduces inflammation.

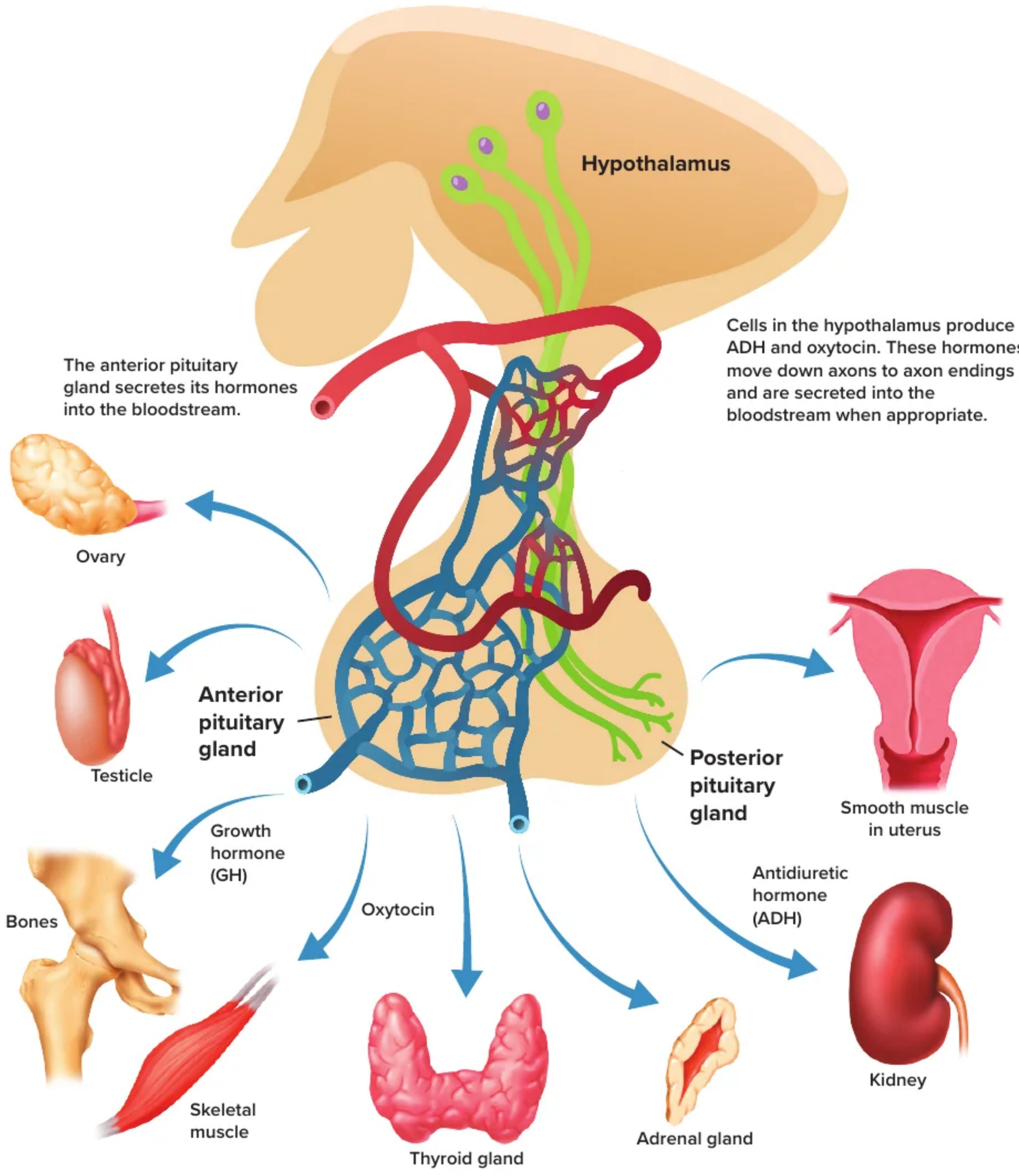
The body has different mechanisms for responding to stress, such as the role of the nervous system and the "fight or flight response." The endocrine system also is involved with these types of responses. During a stressful situation the inner portions of the adrenal glands secrete epinephrine (eh puh NEH frun) and norepinephrine. Together, these hormones increase heart rate, blood pressure, breathing rate, and blood sugar levels, all of which are important in increasing the activity of body cells.

CCC CROSSCUTTING CONCEPTS

Stability and Change Write a paragraph that provides evidence that negative feedback stabilizes blood glucose levels, helping the body maintain homeostasis. Cite specific information from **Figure 19** in your paragraph.

Figure 20 Visualizing the Endocrine System

The hypothalamus maintains homeostasis by serving as a link between the nervous system and the endocrine system. The pituitary gland releases growth hormone, ADH, and oxytocin as needed by the body. The pituitary gland also manufactures and secretes hormones that regulate the testes, the ovaries, and the thyroid and adrenal glands.



Link to the Nervous System

The nervous and endocrine systems are similar in that they both are involved in regulating the activities of the body and maintaining homeostasis. Refer to **Figure 20** on the previous page to study the role of the hypothalamus in homeostasis. Recall that this part of the brain is involved with many aspects of homeostasis. The hypothalamus produces two hormones, oxytocin (ahk sih TOH sun) and antidiuretic hormone (ADH).

The **antidiuretic** (AN ti DY yuh REH tic) **hormone** (ADH) functions in homeostasis by regulating water balance. As illustrated in **Figure 21**, ADH travels in the blood to the kidneys, where it binds to receptors on certain kidney cells. This causes the kidneys to reabsorb more water and decrease the amount of water in the urine, increasing the water level in the blood. If there is too much water in a person's blood, the hypothalamus decreases the release of ADH, and the urine tends to be more dilute. ADH production is stimulated by nausea and vomiting, both of which cause dehydration. Blood loss of 20 percent by hemorrhage results in the release of ADH.

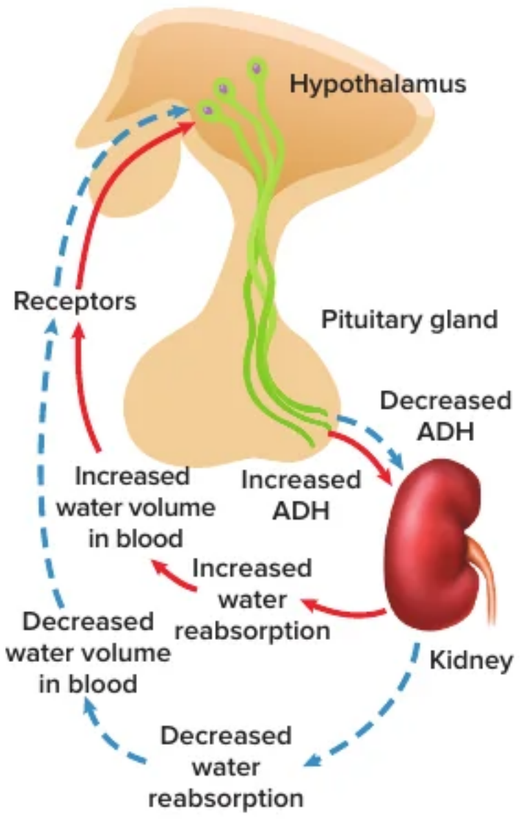


Figure 21 Antidiuretic hormone (ADH) helps to control the concentration of water in the blood.

Check Your Progress

Summary

- Endocrine glands produce substances called hormones.
- Hormones travel throughout the body in the bloodstream.
- Hormones are classified as steroid hormones or amino acid hormones.
- Hormone levels are influenced by feedback systems.
- The endocrine system helps to maintain homeostasis with signals from internal mechanisms called negative feedback.

Demonstrate Understanding

1. **Explain** the reasons why a feedback system would be referred to as "negative feedback."
2. **Predict** when high levels of insulin would be found in a person's blood and when high levels of glucagon would be found in a person's blood.
3. **Explain** how the endocrine and nervous systems work together to maintain homeostasis.
4. **Identify** and describe the functions of pituitary, thyroid, parathyroid, pancreas, and adrenal glands.

Explain Your Thinking

5. **Research** Iodine is essential for thyroid gland function. Fetal and childhood iodine deficiency is a major cause of mental retardation in the world, yet the deficiency is preventable. Predict how iodine deficiency might lead to mental retardation or other health issues. Research what has been and what is being done to alleviate this concern. Include information about sources of iodine in your response.

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SCIENCE & SOCIETY

By the Skin of Your Teeth

Teeth are an important part of the digestive system. Mechanical digestion begins as teeth break down food into smaller pieces. Chewing allows amylase to begin the process of chemical digestion. Tooth decay can have a negative impact on the process of digestion.

The chemistry of tooth decay

The surface of teeth is made of enamel, which consists mostly of a solid, called hydroxyapatite, composed of calcium and phosphate ions. Ions move in and out of hydroxyapatite, depending on pH. When ions are added, it is called mineralization. Demineralization is the process of ions leaving the enamel. Ideally, the rates of mineralization and demineralization are the same, resulting in no net loss of enamel.

Bacteria produce acids in the mouth in the presence of sugar or starch. Acidity causes demineralization. Cavities result when demineralization destroys tooth enamel and acids start destroying dentin, the layer under the enamel.

The consequences of tooth decay

Tooth decay can cause significant pain and tooth loss, which can impact the ability to thoroughly chew food. If unchecked, tooth decay can affect an individual's ability to get the nutrition they need.



Dental care can help prevent tooth decay.

Preventing and treating tooth decay

A variety of strategies help prevent tooth decay. Consuming fluoride in drinking water and having sealants applied are effective ways to slow tooth decay. Regular brushing and dental visits are also key factors in the prevention of tooth decay. Reducing the amount of sugar and starch consumed can also contribute to healthy teeth.

Traditional treatment for tooth decay includes filling cavities with metal or porcelain. However, some new techniques are being developed that can reverse tooth decay. For example, a treatment is being developed that uses stem cells to stimulate the tooth to repair damaged areas. Another treatment being developed uses electric currents to stimulate remineralization of a damaged area. Other researchers are exploring the use of aspirin to stimulate the gene that codes for the production of new dentin.

COMMUNICATE SCIENTIFIC INFORMATION

Work with a small group to develop a plan for communicating the importance of healthy teeth to other students in the school. Be sure to relate the health of the teeth to digestion, nutrition, and overall health.

Fuse/Getty Images

MODULE 25
STUDY GUIDE

GO ONLINE to study with your Science Notebook.

Lesson 1 THE DIGESTIVE SYSTEM

- The digestive system has three main functions.
- Digestion can be categorized as mechanical or chemical.
- Most nutrients are absorbed in the small intestine.
- Accessory organs provide enzymes and bile to aid digestion.
- Water is absorbed from chyme in the colon.

- mechanical digestion
- chemical digestion
- amylase
- esophagus
- peristalsis
- pepsin
- small intestine
- liver
- villus
- large intestine

Lesson 2 NUTRITION

- The energy content of food is measured in Calories.
- Carbohydrates, fats, and proteins are three major groups of nutrients.
- Carbohydrates are a major source of energy for the body.
- Fats and proteins provide energy and are important building blocks for the body.
- Vitamins and minerals are essential for proper metabolic functioning.
- MyPlate and food labels are tools you can use to eat healthfully.

- nutrition
- Calorie
- vitamin
- mineral

Lesson 3 THE ENDOCRINE SYSTEM

- Endocrine glands produce substances called hormones.
- Hormones travel throughout the body in the bloodstream.
- Hormones are classified as steroid hormones or amino acid hormones.
- Hormone levels are influenced by feedback systems.
- The endocrine system helps to maintain homeostasis with signals from internal mechanisms called negative feedback.

- endocrine gland
- hormone
- pituitary gland
- thyroxine
- calcitonin
- parathyroid hormone
- insulin
- glucagon
- aldosterone
- cortisol
- antidiuretic hormone

THREE-DIMENSIONAL THINKING

Module Wrap-Up



REVISIT THE PHENOMENON

Why do we need a variety of foods in our diet?

CER Claim, Evidence, Reasoning

Explain your Reasoning Revisit the claim you made when you encountered the phenomenon. Summarize the evidence you gathered from your investigations and research and finalize your Summary Table. Does your evidence support your claim? If not, revise your claim. Explain why your evidence supports your claim.

STEM UNIT PROJECT

Now that you've completed the module, revisit your STEM unit project. You will summarize your evidence and apply it to the project.

GO FURTHER

SEP Data Analysis Lab

How reliable are food labels?

In a study conducted at the U.S. Department of Agriculture Human Nutrition Research Center, scientists measured the mass of 99 single-serving food products.

Data and Observations The table compares the mass listed on the food package label with the actual mass of the food in five single-serving packages.

Food (1 serving)	Label Mass (g)	Actual Mass (g)
Cereal, bran flakes with raisins (1 box)	39	54.2
Cereal, toasted grains with supplement (1 box)	23	39.6
Cookie, chocolate sandwich	57	67.0
Mini danish, apple (1 per serving)	35	44.8
Mini donut, chocolate covered (4 per serving)	100	116.5

*Data obtained from: Conway, J.M., D.G. Rhodes, and W.V. Rumpler. 2004. Commercial portion-controlled foods in research studies: how accurate are label weights? *Journal of the American Dietetic Association* 104: 1420–1424.

CER Analyze and Interpret Data

1. **Calculate** the percent difference in mass between the label mass and the actual mass of the cookies.
2. **Evidence, Reasoning** Compare the trend in the percent differences.

Makoto Watanabe/MIXA Co. Ltd./Alamy

Credits

1. Module 24 Circulatory, Respiratory, and Excretory Systems: *Chapter from UAE Inspire Science Biology, Student Edition, 2024-25 by Biggs, 2024* 1
2. Module 25 Digestive and Endocrine Systems: *Chapter from UAE Inspire Science Biology, Student Edition, 2024-25 by Biggs, 2024* 26

Student Notes

Student Notes

Student Notes