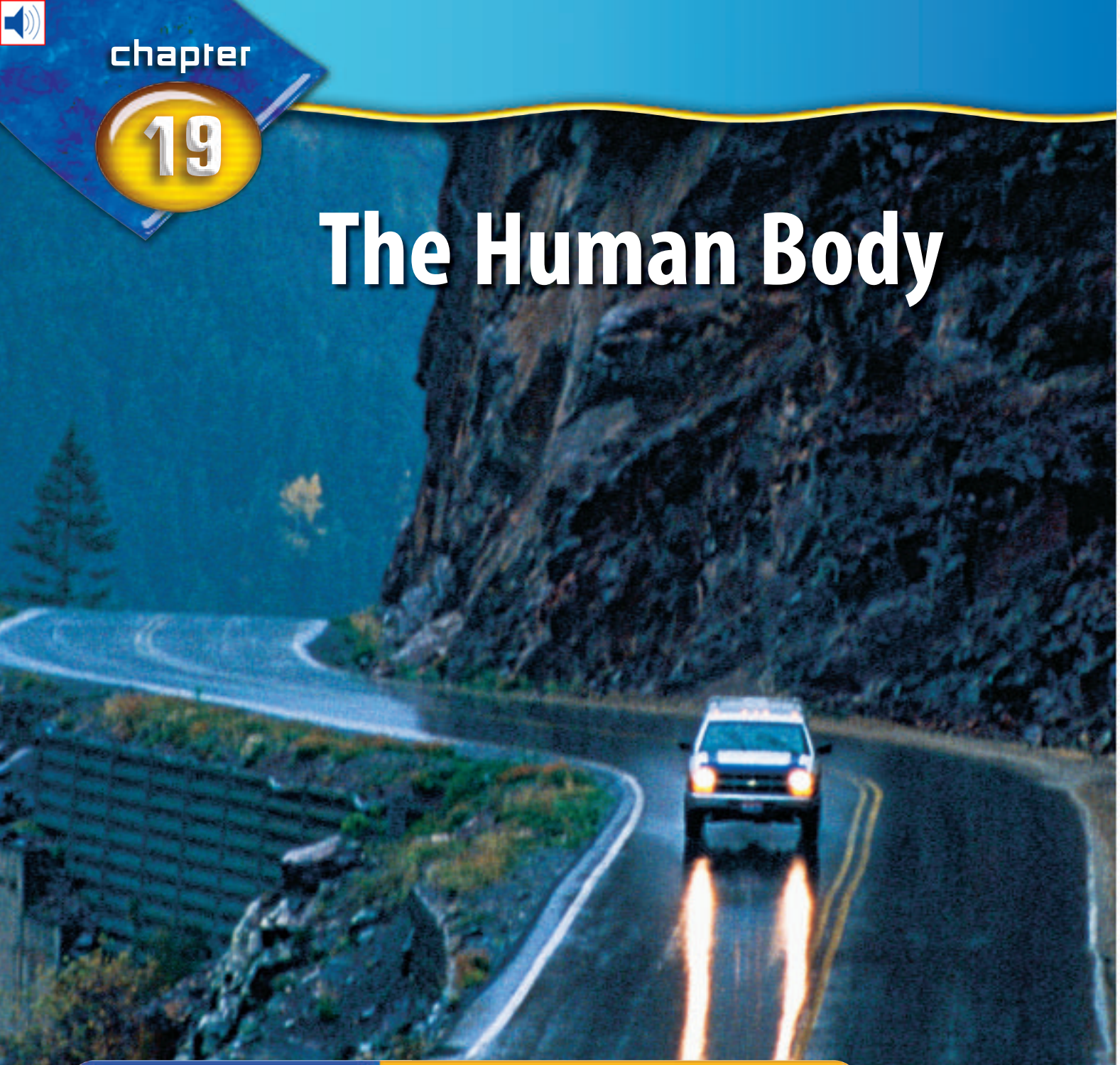
chapter 19

The Human Body



chapter preview

sections

1 Body Systems
Lab Improving Reaction Time

2 Human Reproduction
Lab Defensive Saliva

Virtual Lab What factors affect the likelihood of hypertension?

All Systems Ready

For a car to drive safely, many systems, such as headlights, brakes, and transmission, must be in working order. Your body also has many systems that work together to allow you to move, provide you with energy, defend you, and coordinate your body functions.

Science Journal Write three things your body needs to keep you healthy.

Eddie Hironaka/Getty Images

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Start-Up Activities

Launch Lab

Where does food go?

Imagine taking a bite of your favorite food. When you eat, your body breaks down food to release energy. How long does it take?

Organs of the Digestive System

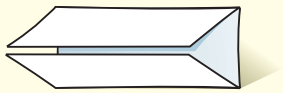
Organ	Length	Time
Mouth	8 cm	5 s to 30 s
Pharynx and esophagus	25 cm	10 s
Stomach	16 cm	2 h to 4 h
Small intestine	4.75 m	3 h
Large intestine	1.25 m	2 days

1. Make a label for each of the major organs of the digestive tract listed here. Include the organ's name, its length, and the time it takes for food to pass through it.
2. Working with a partner, place a piece of masking tape that is 6.5 m long on the classroom floor.
3. Beginning at one end of the tape, and in the same order as they are listed in the table, mark the length for each organ. Place each label next to its section.
4. **Think Critically** In your Science Journal, suggest reasons why the food that you eat spends a different amount of time in each of the organs.

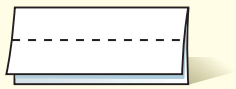
Foldables™ Study Organizer

Nutrients in Food Make the following Foldable to help you organize foods based on the nutrients that they contain.

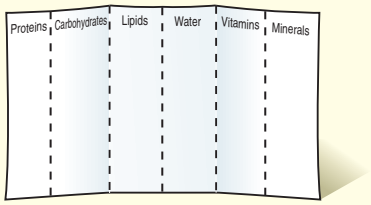
STEP 1 **Fold** the top of a vertical piece of paper down and the bottom up to divide the paper into thirds.



STEP 2 **Fold** the folded paper in half lengthwise.



STEP 3 **Unfold** the paper and draw a line on each fold line to form six columns. **Label** the columns as shown.



Read and Write As you read the chapter, list foods you eat that provide each of these nutrients in the appropriate columns.

Science Online

Preview this chapter's content and activities at red.msscience.com

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section 1

Body Systems

Español

as you read

What You'll Learn

- **Explain** how the skeletal and muscular systems provide structure and allow movement.
- **Identify** the functions of the digestive, respiratory, and circulatory systems.
- **Distinguish** between the nervous and endocrine system.
- **Explain** how your body systems provide defense.

Why It's Important

You can take better care of your body if you understand how your body works.

Review Vocabulary

organ: structure, such as the heart, made up of different types of tissues that work together

New Vocabulary

- skeletal system
- melanin
- muscle
- nutrient
- respiratory system
- alveoli
- capillary
- reflex

Structure and Movement

Have you ever seen a building under construction? First a framework of steel or wood is built, as shown in **Figure 1** on the left. Then the framework is covered by walls. Your body also has a framework, your bones, as shown in **Figure 1** on the right. Bones are covered by skin and muscle.

The Skeletal System All the bones in your body make up your **skeletal system.** Your skeletal system gives shape and support to your body. Without bones, your body would be a formless mass of tissue. Bones also protect your internal organs. For instance, your ribs surround and protect your heart and lungs, and your skull protects your brain.

You may think that bones are dead tissue, but bones are made of living cells. Like all the other cells in your body they need nutrients and use energy. Bones are hard because of the calcium and phosphorus that are deposited in them.

Reading Check *Are bones made of living or dead cells?*

Figure 1 When a building is put up, it needs a framework for support. Your body's framework is your skeleton, made up of 206 bones.

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Joints Unlike the framework of a building, which does not move, your bones can move. Joints make these movements possible. The place where two or more bones come together is called a joint, as shown in **Figure 2.** Muscles can move your bones by moving your joints.

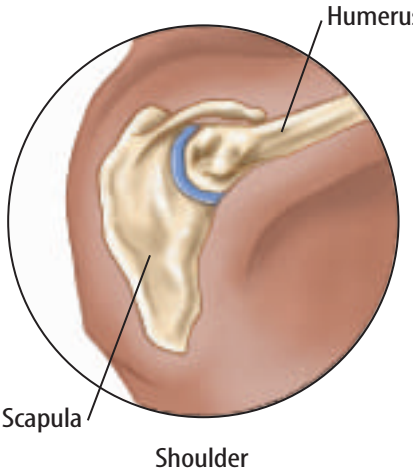

Figure 2 Joints enable your bones to move.

The Skin The largest human body organ is the skin. It helps your body in several important ways. First, skin forms a protective covering for your body. Unbroken skin can protect your body from disease-causing organisms. Sweat and oil glands in your skin secrete fluids that can slow the growth of or kill bacteria. The pigment, or coloring, in your skin protects it from damage by ultraviolet light. This pigment is called **melanin** (MEH luh nun). Humans have different skin colors because of the different amounts of melanin in their skin.

Second, skin is a sense organ. Because of special nerve cells in the skin, you can sense heat or cold, and you can feel the sharp prick of a pin or the smoothness of a polished rock.

Third, skin helps control your body temperature. Sweat glands in your skin produce sweat, as shown in **Figure 3,** that helps cool your body. As sweat evaporates from your skin, heat is lost and your skin is cooled.

Fourth, skin helps provide a nutrient for your body. Vitamin D, which is important for good health, is formed in your skin when your skin receives ultraviolet light from the Sun. This vitamin helps your body absorb calcium from food in your digestive tract.

Figure 3 Your skin helps control your body's temperature when you sweat.

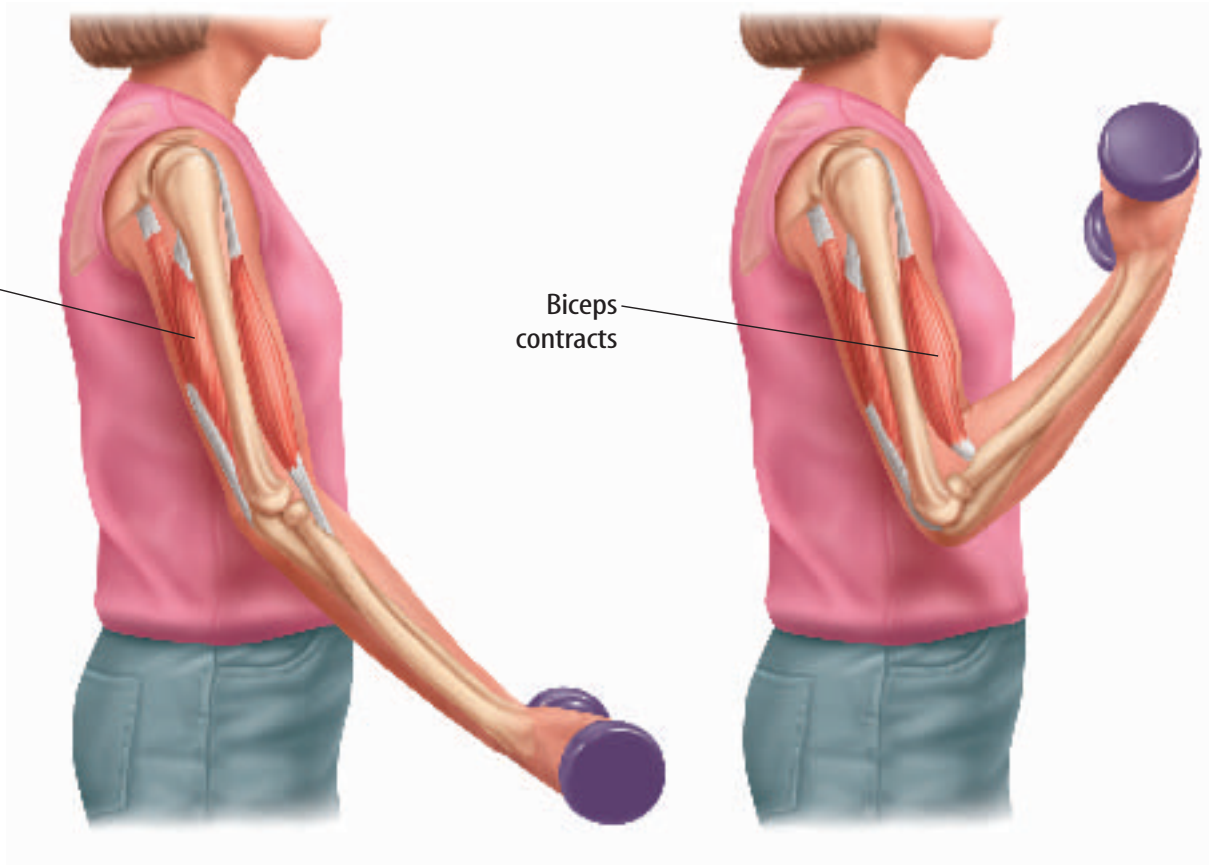

Figure 4 To lift a weight, one muscle in your arm contracts while another relaxes. **Identify** *another muscle pair in your body.*

The Muscular System Imagine that you are running down the street because you are late for school. How does your body perform all the movements to get you there? Remember that your bones provide a framework for your body. Muscles attach to bones and help them move. Your muscles make all your movements possible. A **muscle** is an organ that can relax, contract, and provide force to move you and your body parts.

All your movements require energy. Even when you are sitting in a chair, your muscles are still working. Some muscles are always moving, such as the muscles that help you breathe and your heart muscles.

Your body has some muscles that you can choose to move, as shown in **Figure 4,** called voluntary muscles. Other muscles, such as your heart and muscles in your digestive organs, are not controlled consciously. These are called involuntary muscles. Involuntary muscles work all day long, every day for your entire life.

Voluntary muscles work together in pairs to allow you to move your body. One muscle contracts or gets shorter, while another muscle relaxes or returns to its original length. Look again at **Figure 4.** You can see that one muscle contracts and another relaxes when you lift a weight.

Digestion and Excretion

How does your body supply you with the energy you need for activities such as a championship soccer game? Food enters your body's digestive system through your mouth, as shown in **Figure 5.** As food moves through each organ of your digestive system, some of it is broken down into smaller molecules. These smaller molecules are absorbed from your digestive system and enter your blood. From the blood, these molecules move into your cells where the food molecules are needed. Undigested food is eliminated from your digestive system.

Reading Check ***Why is food broken down into smaller molecules as it moves through your digestive system?***

Organs of the Digestive System

In **Figure 5,** trace the path of food as it travels through your digestive system. In your mouth, food is moistened by saliva and broken down into smaller particles by your teeth. From there, food enters your esophagus (ih SAH fuh gus), a long muscular tube, and moves to your stomach. In your stomach chemicals break down food. After breakdown in the stomach, food moves into the small intestine.

The small intestine is the longest organ in the digestive system. It is small in diameter, but not small in length. Most digestion and absorption of food take place in the small intestine. Here, food particles move from the digestive tract into the blood to be carried to all of the body's cells. Finally, food moves into the large intestine where water is absorbed. The remaining undigested food is now a semisolid and is excreted from the body.

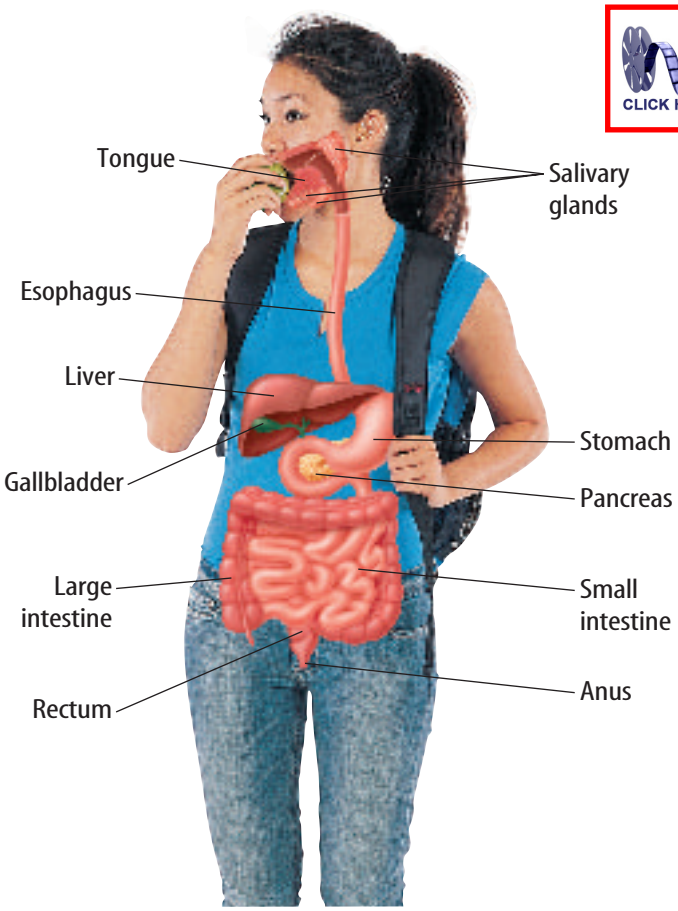

Figure 5 Your digestive system is designed to take in food and break it down so that the nutrients can be absorbed by your body. **Infer** *why food is important to your health.*

Aaron Haupt

INTEGRATE Social Studies

Protein and Carbohydrate Sources In South America and Africa, amaranth is a common source of protein and carbohydrates. Find out in which countries amaranth is grown and how it is prepared and eaten. Write a paragraph in your Science Journal to describe what you have discovered.

INTEGRATE Chemistry

Nutrients Although you might prefer to grab a candy bar or bag of chips when you feel hungry, your body needs certain foods to stay healthy. **Nutrients** (NEW tree unts) are the substances in food that provide for cell development, growth, and repair. There are six kinds of nutrients that are available in food—proteins, carbohydrates (kar boh HI drayts), lipids, vitamins, minerals, and water, as shown in **Figure 6.** Proteins, carbohydrates, lipids, and vitamins contain the element carbon. They are called organic nutrients. Minerals and water do not contain the element carbon and are called inorganic nutrients.

Proteins are found in meats, poultry, eggs, fish, peas, beans, and nuts. Proteins are used by your body for replacement and repair of body cells and for growth. Carbohydrates are the main energy source for your body. Foods that contain carbohydrates include sugar, honey, fruits, vegetables, breads, grains, and cereals. Lipids, or fats, provide energy, help your body absorb vitamins, and, when stored in the tissue, cushion your internal organs.

Figure 6 Six kinds of nutrients are available in food.

Laura Sifferlin

NATIONAL GEOGRAPHIC

VISUALIZING VITAMINS

Figure 7

Vitamins come in two groups—water soluble, which should be replaced daily, and fat soluble, which can be stored in the body. The sources and benefits of both groups are shown below.

Aids in growth, healthy nervous system, use of carbohydrates, and red blood cell production

B

(B_6, B_{12}, riboflavin, niacin, thiamine, etc.)

Aids in growth, healthy bones and teeth, wound recovery

C

WATER SOLUBLE

Need to be replenished every day because they are excreted by the body

Aids in growth, eyesight, healthy skin

A

Aids in absorption of calcium and phosphorus by bones and teeth

D

FAT SOLUBLE

Stored in the body in fatty tissue

Aids in formation of cell membranes

E

Aids in blood clotting and wound recovery

K

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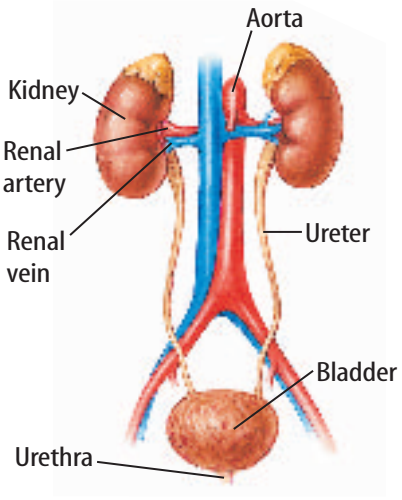
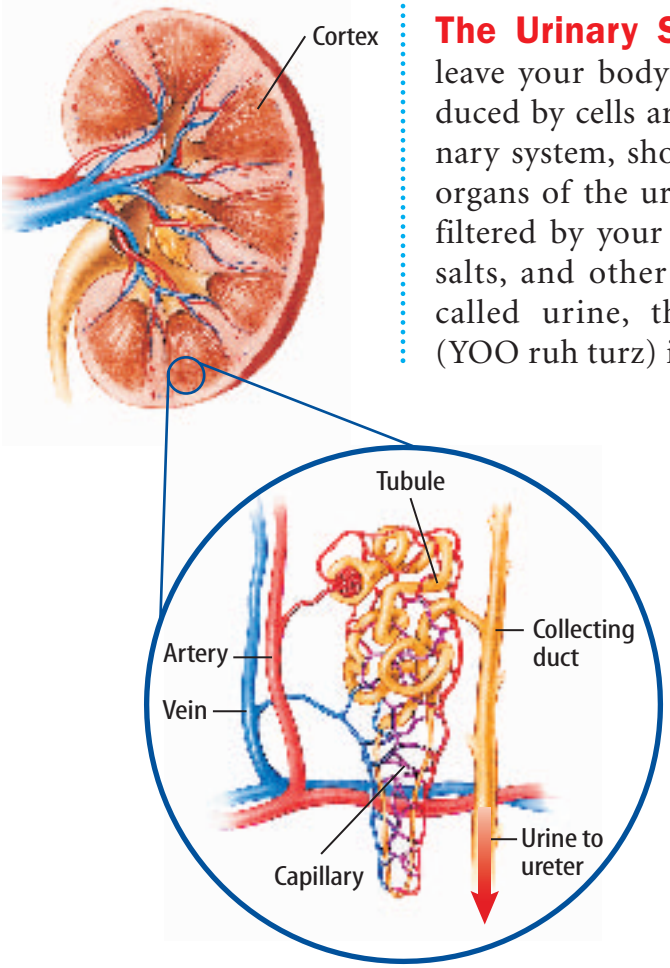
Figure 8 The kidneys filter wastes from the blood.
List *substances removed from the blood by the kidneys.*





Other Nutrients Vitamins and minerals are nutrients that are needed in small quantities by your body. Your body uses vitamins for many important functions, such as growth, regulating body functions, and preventing some diseases. Most foods have some vitamins, but no one food supplies them all. Vitamins are classified into two groups, as shown in **Figure 7** on the previous page. Vitamins that dissolve easily in water are called water-soluble vitamins. They are not stored in your body. Fat-soluble vitamins dissolve only in fat and can be stored by your body.

Your body uses minerals to control many chemical reactions. Calcium and phosphorus are two minerals that are used in the largest amounts by your body. One of their uses is in making and maintaining bone.

Water is important for your body. You cannot live for more than a few days without water. Most of the other nutrients can't be used by your body unless they are carried in water. Your cells need water to carry out the chemical reactions that are needed for you to live.

Reading Check ***Why is water important for your body?***

The Urinary System As you have learned, some wastes leave your body through the digestive system. Wastes produced by cells are removed from the blood through the urinary system, shown in **Figure 8.** Your kidneys are the main organs of the urinary system. All the blood in your body is filtered by your kidneys. The kidneys remove excess water, salts, and other wastes from your blood. The wastewater, called urine, then passes through tubes called ureters (YOO ruh turz) into the bladder. The bladder holds the urine until it is excreted from the body. The average-sized person produces about one liter of urine per day. Urine is carried from the bladder to outside of the body by another tube, the urethra (yoo REE thruh).

Other Organs of the Excretory System In addition to the wastes removed by the digestive and urinary systems, your body removes wastes in other ways. Your respiratory system removes waste gases, such as carbon dioxide and water vapor. Salt and some other wastes are lost through the skin.

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Respiration and Circulation

Besides food and water, you need a constant supply of air. Your body's cells need oxygen, a gas that is found in the air. Your body's cells produce carbon dioxide, a waste gas, that must be removed from the body.

The Respiratory System As shown in **Figure 9,** the **respiratory system,** is made up of structures and organs that help move oxygen into the body and waste gases out of the body. When you breathe in, or inhale, air enters through the mouth or nose and then travels through a series of passageways—the pharynx (FER ingks), larynx (LER ingks), and trachea (TRAY kee uh). Bronchi (BRAHN ki) then carry air into your lungs. In the lungs, bronchi branch into smaller and smaller tubes, somewhat like branches on a tree. The smallest tubes are called bronchioles (BRAHN kee ohlz). Grapelike clusters of air sacs called **alveoli** (al VEE uh li) (singular, *alveolus*) are at the end of each bronchiole. Microscopic blood vessels called **capillaries** (KAP uh ler eez) surround each alveolus. Air is carried through bronchioles and reaches the alveoli.

Oxygen leaves alveoli and enters capillaries. Then oxygen is carried to every cell in your body through the bloodstream. In a similar fashion, your body cells' waste gases, such as carbon dioxide, are carried to your lungs through the blood. Waste gases leave capillaries and enter alveoli. These waste gases are removed from your body when you exhale, as shown in **Figure 10.** Because capillaries have walls that are only one cell layer thick, oxygen and carbon dioxide can move easily between alveoli and capillaries.

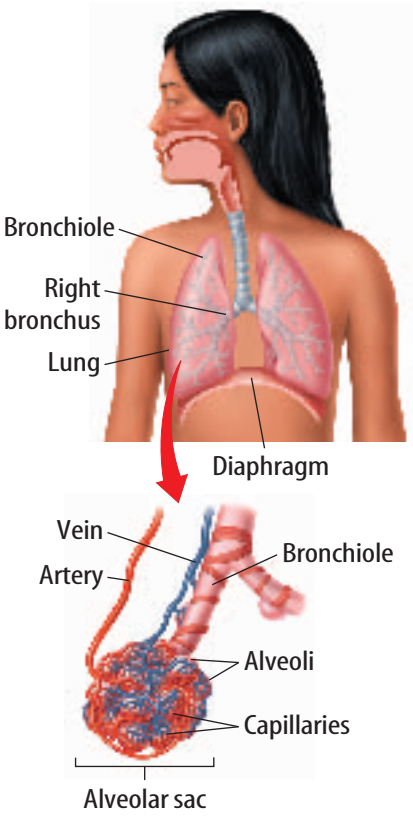
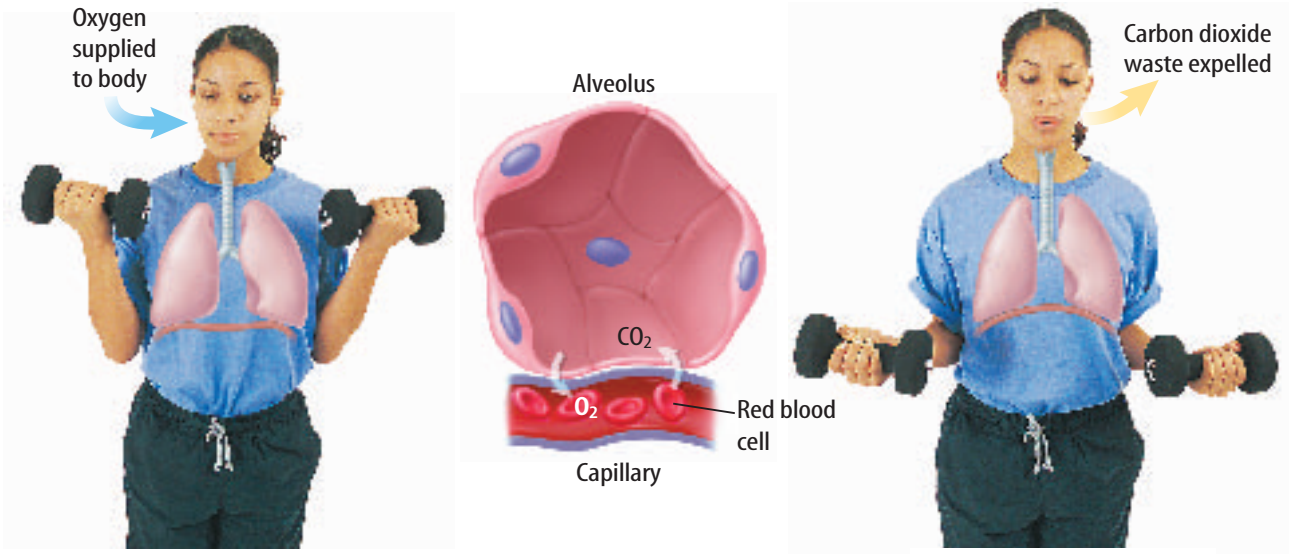


Figure 9 The respiratory system brings air into your body.

Figure 10 Gas exchange takes place in the lungs.



The Circulatory System All cells in your body need nutrients and oxygen and a way to remove wastes. This is the job of your circulatory system. As shown in **Figure 11,** it is made up of your heart, blood vessels, and blood. Your heart is the pump of your circulatory system that pumps blood to all the cells of the body. Then blood moves back to the heart. Blood moves throughout your body in a network of blood vessels.

As blood is pumped out of the heart, it travels through arteries (AR tuh reez), capillaries, and then veins. Arteries are blood vessels that carry blood away from the heart. Arteries have thick elastic walls. Veins carry blood back to the heart. Veins have thinner walls than arteries and one-way valves that prevent the backflow of blood. Capillaries connect arteries and veins. As you read earlier, capillary walls are one cell layer thick. Oxygen and nutrients can move easily from capillaries into the cells. Waste materials and carbon dioxide can leave body cells and enter the capillaries.

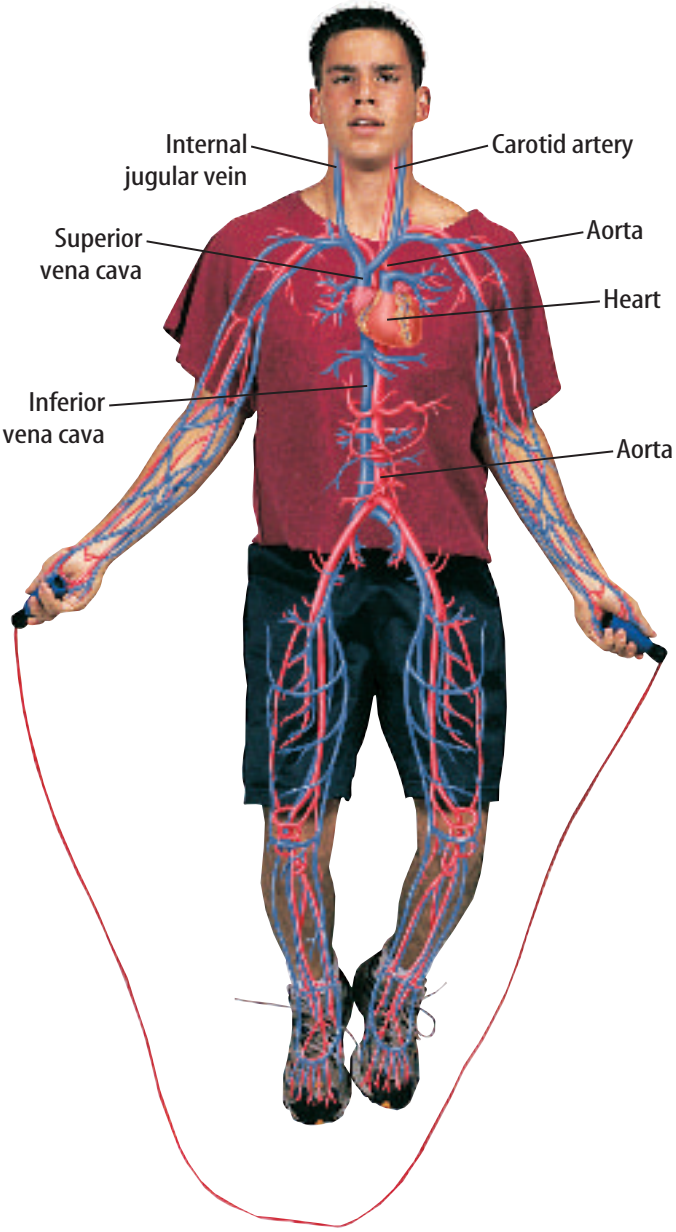


Figure 11 The circulatory system supplies your body with nutrients, oxygen, and a way to remove wastes. The heart pumps blood through blood vessels to all parts of your body.

Blood Without blood, your body's cells would die because they could not get the oxygen and nutrients necessary for life. Blood also removes wastes from your body cells. Your blood is tissue that is made up of liquid and cells. Oxygen is carried by red blood cells. Your blood also has cells, called white blood cells, that fight infections and heal wounds.

When you cut yourself, special chemicals and cell fragments, called platelets (PLAYT luts), in blood form a clot. This clot plugs the wounded blood vessels and acts somewhat like a bandage. Blood clots stop bleeding in minor wounds.

Sometimes, if a person has a serious wound, a large amount of blood can be lost. This person might need a blood transfusion. In a blood transfusion, a person receives donated human blood. Humans can donate blood to one another because of the similarities in human blood. However, the blood must be typed to be sure that the right kind is given. If the wrong type is given, the person may die.

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Table 1 Blood Transfusion Possibilities

Type	Can Receive	Can Donate To
A	O, A	A, AB
B	O, B	B, AB
AB	all	AB
O	O	all

Blood Types People can inherit one of four major blood types: A, B, AB, or O. Each blood type is different because of chemical identification tags, or antigens (AN tih junz), on red blood cells. Type A has A antigen, type B has B antigen, type AB has A and B antigens, and type O has no antigens.

Each blood type also has specific antibodies in the liquid part of the blood. Antibodies are proteins that destroy substances that are not part of your body. Because of these antibodies, certain blood types cannot be mixed. Only certain blood types can be given to certain other blood types in blood transfusions, as shown in **Table 1.**

Rh factor is another identification tag of red blood cells. If the Rh factor is present on the red blood cells, the person has Rh-positive (Rh+) blood. If the factor is absent, the person has Rh-negative (Rh−) blood. An Rh− person cannot receive Rh+ blood in a blood transfusion.

Reading Check *What prevents different blood types from being used successfully during blood transfusions?*

The Lymphatic System Between cells, there is tissue fluid. Some water and other substances become part of the tissue fluid. This tissue fluid is collected and returned to the blood through the lymphatic (lihm FA tihk) system. It has a network of vessels like the circulatory system. However, the lymphatic system does not have a heartlike organ that pumps the fluid. The movement of fluid depends on the contraction of muscles in the walls of the lymph vessel and skeletal muscles. Lymphatic vessels, like veins, have valves that keep the fluid from flowing backward.

In addition to water and dissolved substances, the lymphatic vessels also contain cells called lymphocytes. Lymphocytes help defend your body against disease-causing organisms.

Mini LAB

Inferring How Hard the Heart Works

Procedure

1. Make a fist and observe its size, which is approximately the size of your heart.
2. Place your fist in a **bowl of water.** Then clench and unclench your fist to cause water to squirt out between your thumb and forefinger.
3. Continue the squeezing action for 3 min. Determine the number of squeezes per minute.

Analysis

1. How many times did you squeeze your fist in 1 min? A resting heart beats approximately 70 times per minute.
2. What can you do when the muscles of your hand and arm get tired? Explain why cardiac muscle cannot do the same.

Try at Home

Immunity Your body has many ways to defend itself against disease-causing organisms. First-line defenses are your skin and your respiratory, digestive, and circulatory systems. Most disease-causing organisms cannot get through unbroken skin. Your respiratory system traps disease organisms with mucus and hairlike structures called cilia (SIH lee uh). Saliva, mucus, and chemicals in your digestive system also protect you. Your circulatory system has white blood cells that patrol your body to destroy invading disease-causing organisms.

A second-line of defense, called specific immunity, attacks disease organisms that get past these first-line defenses. In specific immunity, your body makes antibodies that can destroy disease-causing organisms. Recall that antibodies are proteins that destroy substances that are not part of your body. When you get a cold, for example, your body makes antibodies that attack that cold virus. This helps your body to fight off the infection.

You also can develop antibodies to fight off diseases when you receive vaccinations. Vaccinations can prevent diseases. You received vaccinations against many diseases, such as measles, tetanus, mumps, and polio before you started school. Your body formed antibodies against these diseases after you received the vaccinations.

Applying Science

Will there be enough blood donors?

Successful human blood transfusions began during World War II. This practice is much safer today due to extensive testing of the donated blood prior to transfusion. Health care professionals have determined that each blood type can receive certain other blood types as illustrated in **Table 1** on the previous page.

Blood Type Distribution

	Rh+ (%)	Rh− (%)
O	37	7
A	36	6
B	9	1
AB	3	1

Identifying the Problem

The table on the right lists the average distribution of blood types in the United States. The data are recorded as percents, or a sample of 100 people. By examining these data and the data in **Table 1,** can you determine safe donors for each blood type? Recall that people with Rh− blood cannot receive a transfusion from an Rh+ donor.

Solving the Problem

1. If a Type B, Rh+ person needs a blood transfusion, how many possible donors are there?
2. Frequently, the supply of donated blood runs low. Which blood type and Rh factor would be most affected in such a shortage? Explain your answer.

Control and Coordination

"10, 9, 8, 7, 6, 5, 4, 3, 2, 1…Blast off! We have lift off!" The NASA Mission Control Center monitors a space shuttle mission from takeoff to landing. Like the Mission Control Center for the space program, your body needs control systems to make all your body systems work together. Your nervous system and endocrine system are the control systems of the body. They coordinate your body functions.

The Nervous System Your brain, spinal cord, nerves, and nerve receptors make up your nervous system. The nervous system sends messages to and from your brain to all parts of your body. These messages are carried by nerves. The basic unit of the nervous system is the neuron (NOO rahn), or nerve cell, shown in **Figure 12.** The neuron has a cell body and branches called dendrites and axons (AK sahns). Messages travel from one neuron to another. Dendrites receive messages from other neurons and send them to the cell body. Axons carry messages away from the cell body.

If the brain sends a message to one of your leg muscles, for example, the message travels from one neuron to another until it reaches the muscle. Then, the muscle can respond by contracting. In a similar fashion, sensory information, such as the prick from a pin, can move from a skin nerve receptor to a neuron, then from one neuron to the next until the message reaches the brain. The brain coordinates all the activities of your body.

Have you ever coughed or touched something very hot and pulled your hand back quickly? If you have, you have experienced a reflex. A **reflex** is an involuntary, automatic response to a stimulus. You can't control reflexes. Reflexes help protect your body by allowing your body to respond without you having to think about what to do.

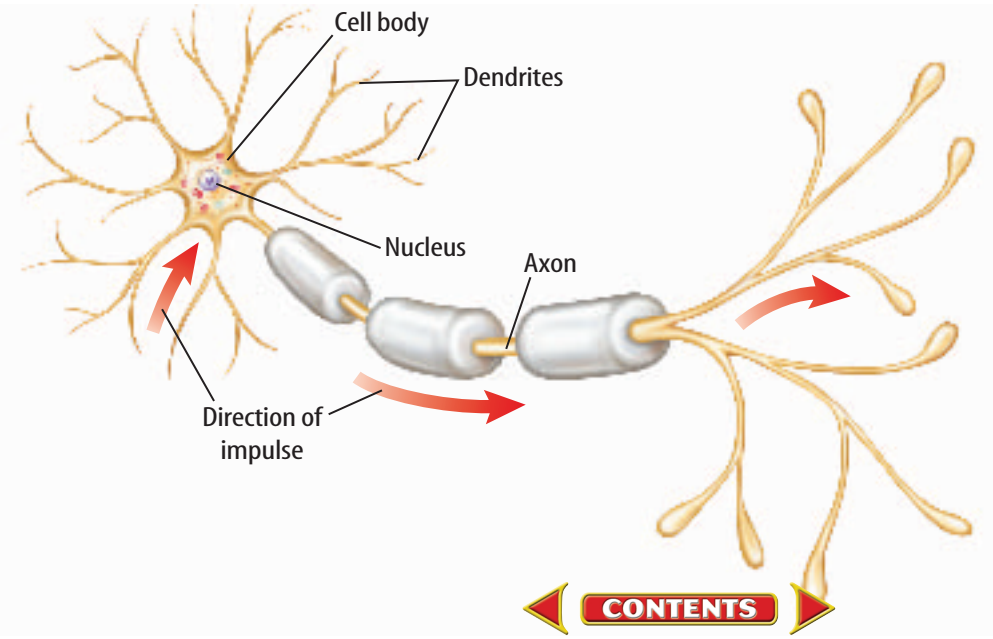

Figure 12 Messages travel from one neuron to another.
Infer *what kind of messages neurons send to each other.*

Science Online

Topic: Nervous System
Visit red.msscience.com for Web links to information about the nervous system.

Activity Make a brochure outlining recent medical advances.

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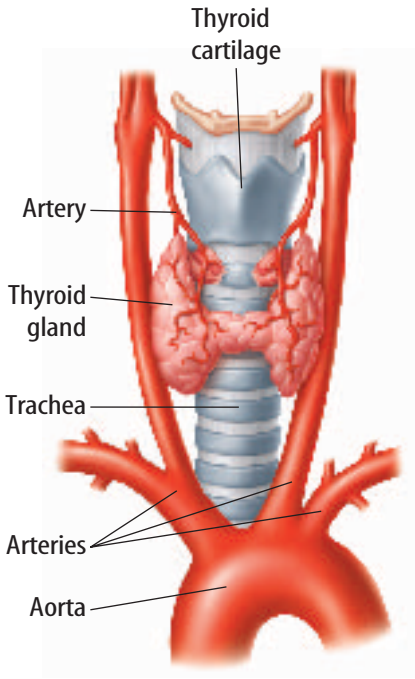

Figure 13 The thyroid gland secretes a hormone that helps increase the rate of chemical reactions in your body.

The Endocrine System The other control system in your body is the endocrine (EN duh krun) system. In the nervous system, messages travel quickly through nerves to and from all parts of your body. In the endocrine system, chemicals called hormones (HOR mohnz) carry messages throughout the body. Your body doesn't respond as quickly to messages from the endocrine system.

Saliva travels through a small tube called a duct, from the salivary gland to your mouth. Endocrine glands do not have ducts. Hormones are released by endocrine glands directly into your bloodstream, as shown in **Figure 13.** These hormones travel through the blood to reach target tissues.

Some endocrine glands are found in the brain—the pineal and pituitary glands. The pineal gland produces a hormone that controls your pattern of sleeping and waking. The pituitary gland makes several hormones that regulate many body activities including growth and reproduction. Other endocrine glands include the pancreas and adrenal glands, which are found in the abdomen. The pancreas makes a hormone that controls the amount of sugar that is present in your bloodstream. The adrenal glands make several hormones, including hormones that help your body respond in times of physical or emotional stress.

section 1 review

Summary

Structure and Movement

- The skeletal system gives shape and support to your body.
- Skin is the largest organ in your body.
- Your body has both voluntary and involuntary muscles.

Digestion and Excretion

- Your digestive system breaks down food into smaller molecules.
- The urinary system removes wastes from your blood.

Respiration and Circulation

- Your body's cells need oxygen.
- Your heart pumps blood through vessels.

Control and Coordination

- Reflexes help protect your body.
- Hormones are chemical messengers.

Self Check

1. **Describe** how the skeletal and muscular systems provide structure and allow movement.
2. **Explain** why a person may not be able to donate blood to another person.
3. **Identify** the blood type—A, B, AB, or O—that can donate to all other blood types.
4. **Infer** how the digestive, circulatory, and respiratory systems help meet the needs of your body.
5. **Compare and contrast** the nervous and endocrine systems.
6. **Think Critically** What might happen to your body if it could not make antibodies?

Applying Skills

7. **Concept Map** Make a network-tree concept map to show how your body defends you against disease-causing organisms. Begin with the words *Lines of Defense.*

Science Online red.msscience.com/self_check_quiz
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LAB

IMPROVING REACTION TIME

Your reflexes allow you to react quickly without thinking. Sometimes you can improve how quickly you react. Complete this lab to see if you can decrease your reaction time.

Real-World Question

How can reaction time be improved?

Goals

- **Observe** reflexes.
- **Identify** stimuli and responses.

Materials

metric ruler

Procedure

1. Make a data table in your Science Journal to record where the ruler is caught during this lab. Possible column heads are *Trial, Right Hand,* and *Left Hand.*
2. Have a partner hold the ruler as shown.
3. Hold the thumb and index finger of your right hand apart at the bottom of the ruler. Do not touch the ruler.
4. Your partner must let go of the ruler without warning you.
5. Catch the ruler between your thumb and finger by quickly bringing them together.
6. Repeat this lab several times and record in a data table where the ruler was caught.
7. Repeat this lab with your left hand.

Conclude and Apply

1. **Identify** the stimulus, response, and variable in this lab.
2. Use the table on the right to determine your reaction time.
3. **Calculate** the average reaction times for both your right and left hand.
4. **Compare** the response of your writing hand and your other hand for this lab.
5. Draw a conclusion about how practice relates to stimulus-response time.

Reaction Time

Where Caught (cm)	Reaction Time(s)
5	0.10
10	0.14
15	0.17
20	0.20
25	0.23
30	0.25

KS Studios

Communicating Your Data

Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**

section 2

Human Reproduction

as you read

What You'll Learn

- **Identify** the organs of the male and female reproductive systems.
- **List** the stages in the menstrual cycle.
- **Describe** the stages of development before birth.
- **Sequence** the life stages of humans.

Why It's Important

Human reproduction is necessary to ensure that human life continues on Earth.

Review Vocabulary

hormone: chemical produced by the endocrine system; released directly into the bloodstream

New Vocabulary

- sperm
- semen
- ovulation
- menstrual cycle
- pregnancy
- embryo
- fetus

Male Reproductive System

Unlike other human body systems, reproductive systems are different in males and females. They are made up of different organs, have different roles in reproduction, and have different sex hormones. These hormones are needed for the development of sexual characteristics.

The male reproductive system is made up of several organs and structures, as shown in **Figure 14.** The scrotum contains two testes (TES teez) that produce the male hormone testosterone and **sperm,** the male reproductive cells. Testosterone and sperm are not produced until the male begins to mature sexually.

Each sperm has a head and a tail. The head contains genetic information in the nucleus and the tail moves the sperm. After sperm are produced in the testes, they travel through the sperm ducts. Fluid from the seminal vesicles, organs behind the bladder, is mixed with the sperm. This mixture of fluid and sperm is called **semen** (SEE mun). Semen leaves the body through the urethra—the same tube that carries urine from the body. However, urine and semen never mix. A muscle at the back of the bladder does not allow urine to enter the urethra when sperm leave the body.

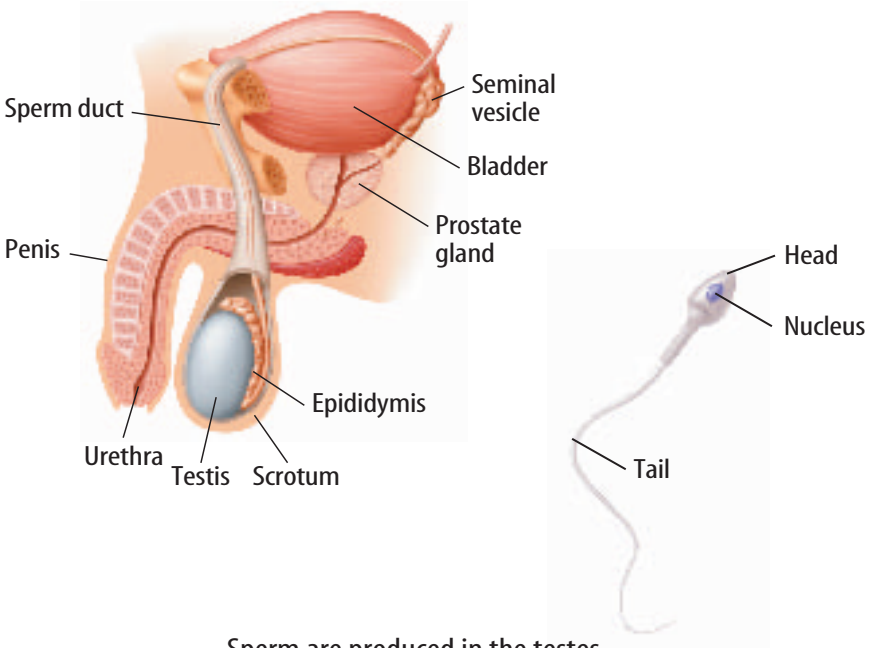

Figure 14 Some structures of the male reproductive system extend outside the body.

Sperm are produced in the testes.

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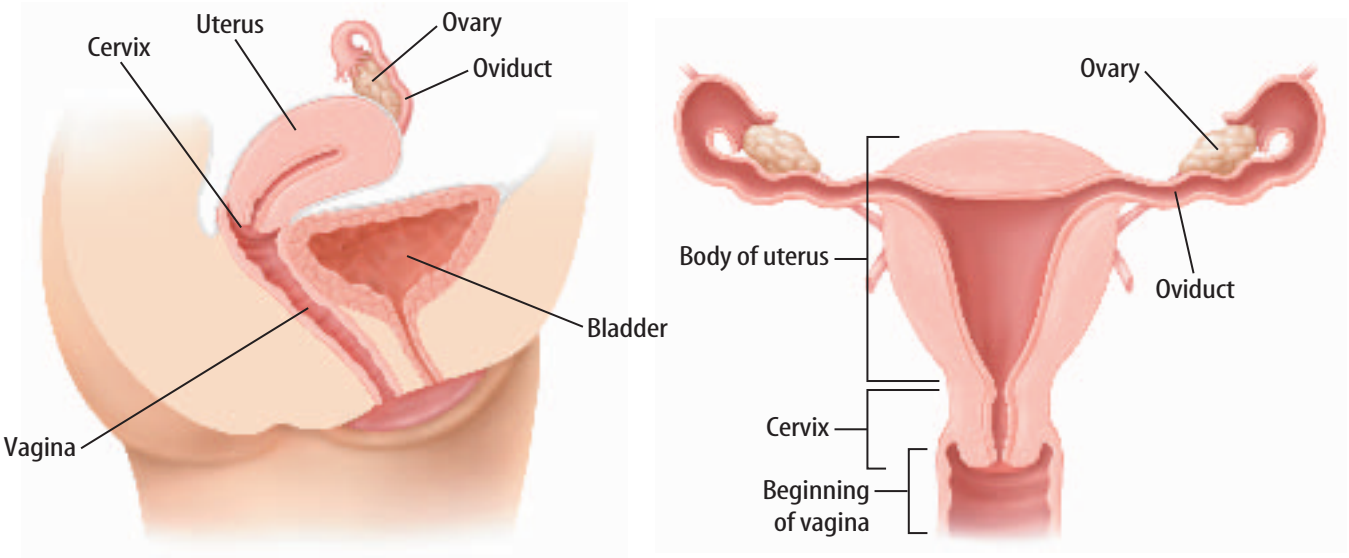

Figure 15 These are diagrams of the female reproductive system. **Identify** *where a fertilized egg grows and develops.*

Female Reproductive System

Most of the organs of the female reproductive system, as shown in **Figure 15,** are inside of a female's body and are called internal. Ovaries are the female sex organs that produce eggs and the female sex hormones, estrogen (ES truh jun) and progesterone (proh JES tuh rohn), when a female matures sexually. These hormones help prepare the female body for having a baby.

The ovaries contain certain cells that eventually develop into eggs. When a female is born, her ovaries already contain all of the cells that can develop into eggs. The female sex hormones control the development and release of eggs from the ovaries. Every 28 days on average, an egg is released from one of the ovaries. This process is called **ovulation** (ahv yuh LAY shun). The ovaries usually release eggs on alternating cycles.

Reading Check ***What controls the development and release of eggs?***

A discharged egg moves into the oviduct, which is lined with hairlike cilia. The coordinated wavelike movement of the cilia sweeps the egg along the oviduct to the uterus, a muscular, pear-shaped hollow organ. If the egg is fertilized by a sperm while in the oviduct, the fertilized egg can grow and develop in the uterus. The lower end of the uterus is called the cervix and connects the uterus to the vagina. The vagina is a muscular tube and is known as the birth canal. During birth, a baby moves from the uterus through the vagina to outside the mother's body.

Science Online

Topic: Menstrual Cycle

Visit red.msscience.com for Web links to information about the monthly changes in the female reproductive system.

Activity Make a table of the changes organized by day, starting with day 1 and ending with day 28.

The Menstrual Cycle

The monthly cycle of changes in a sexually mature female reproductive system is the **menstrual cycle.** The average length of a menstrual cycle is 28 days. However, the cycle can vary in length from 20 to 40 days.

Each month, the female undergoes changes that help prepare her body for having a baby. These changes include maturing of the egg, producing female sex hormones, and preparing the uterus for the fertilized egg. Hormones from the pituitary gland start the development of an egg and production of sex hormones in the ovary. The menstrual cycle is divided into three phases, as shown in **Figure 16.**

Phase one is the phase of menstrual flow, or menstruation (men STRAY shun). Menstrual flow is made of tissue cells from the thickened lining of the uterus and blood. This flow usually lasts from four to six days.

In phase two, an egg develops in the ovary and the lining of the uterus thickens. Ovulation occurs about 14 days before menstrual flow begins.

The last phase, phase three, is the phase between ovulation and menstruation. The lining of the uterus continues to thicken. If the egg is fertilized, it can attach to the wall of the uterus and begin to develop while hormones continue to be produced. If the egg is not fertilized, the hormone levels decrease, the lining of the uterus breaks down, and menstruation begins.

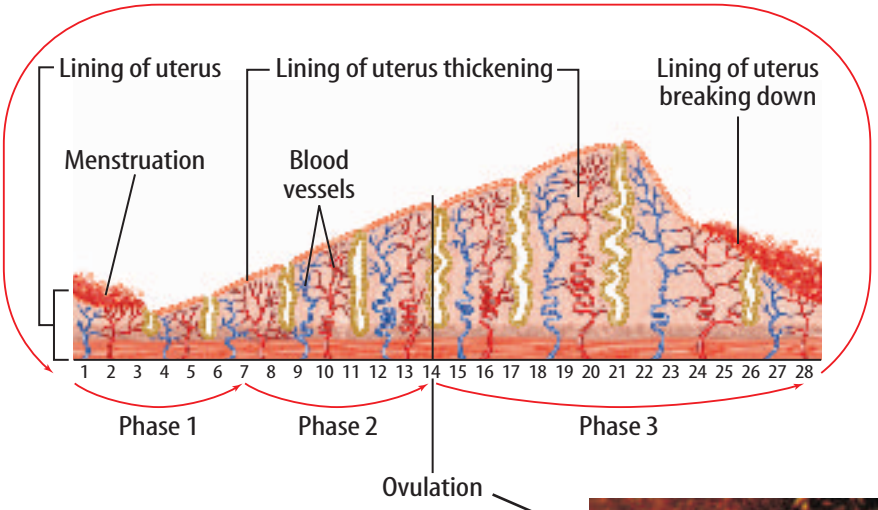

Figure 16 The menstrual cycle has three phases. Phase one—menstrual flow; phase two—development and release of egg and thickening of lining of the uterus; phase three—breakdown of lining if egg is not fertilized.

Claude Edelmann/Photo Researchers

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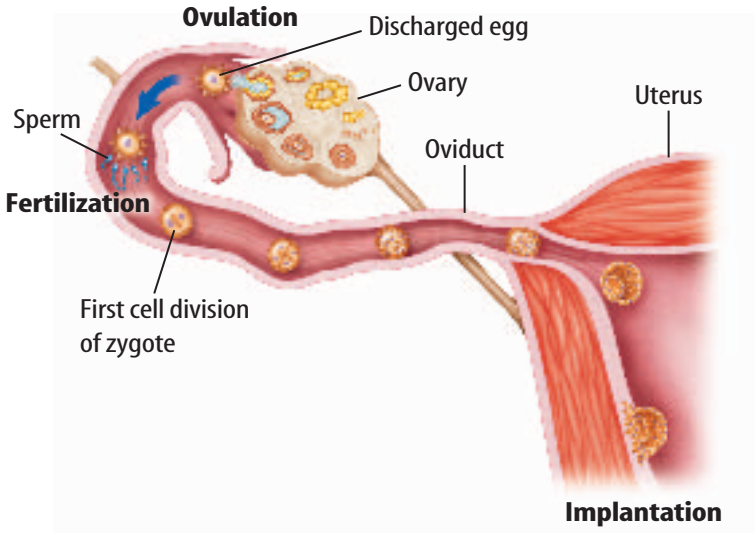
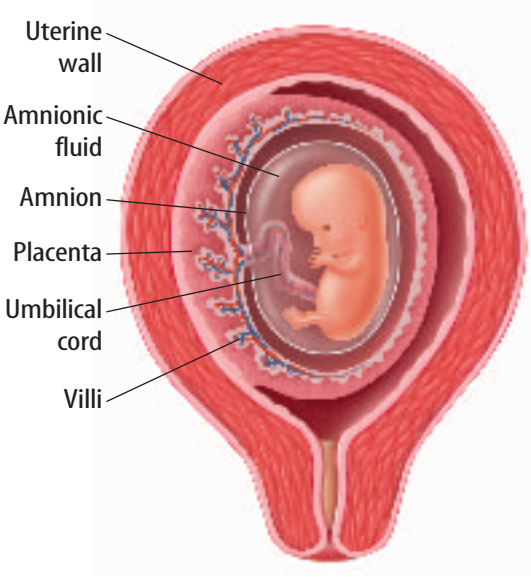


Figure 17 Human development begins when an egg is fertilized by a sperm.

By two months, the developing embryo is about 2.5 cm in size.



Life Stages

Human development begins when an egg from the female is united with a sperm from the male. This process is called fertilization. Fertilization usually takes place in the oviduct, as shown in **Figure 17.**

The nucleus of the sperm and the nucleus of the egg join together creating a fertilized cell called the zygote, as shown above. This cell undergoes many cell divisions as it moves along the oviduct to the uterus. If the zygote successfully attaches to the wall of the uterus, the zygote will develop into a baby in about nine months. This period of development from fertilized egg to birth is called **pregnancy.**

Development Before Birth After attachment to the wall of the uterus, the zygote is called an **embryo.** During the embryo period, which is the first two months of pregnancy, the major organs develop and the heart begins to beat. At first, the embryo receives nutrients from the fluids in the uterus. Then, a placenta (pluh SEN tuh) develops from tissues of the uterus and tissues of the embryo. The umbilical cord connects the embryo to the placenta. The placenta carries nutrients and oxygen from the mother and removes wastes from the embryo.

Reading Check ***What is the first way that the embryo receives nutrients?***

After the first two months of pregnancy, the developing embryo is called a **fetus.** At three months, the fetus measures 8 cm to 9 cm in length and the mother may feel the fetus move. The fetus continues to grow and develop during the pregnancy. At nine months, the fetus weighs about 2.5 kg to 3.5 kg and measures about 50 cm. By this time, the fetus is usually in a head-down position in the uterus.

INTEGRATE Physics

Fetal Ultrasonography Ultrasonic waves are sound waves that are beyond the upper limit of human hearing. In medicine, these sound waves of frequencies of 1 million Hz to 10 million Hz are used to "see" structures inside the human body. Why would ultrasonography be useful during pregnancy? Research to find this answer and then record it in your Science Journal.

Mini LAB

Interpreting Infant Development

Procedure

Make a bar graph of the following data.

Infant Development

Age (in months)	Skill
5 to 7	Sits with support
5 to 8	Gets on hands and knees; stands with support
8 to 9	Sits alone
8 to 10	Crawls
9 to 12	Pulls to standing
9 to 13	Walks around furniture
9 to 14	Stands with no support
10 to 15	Walks

Analysis

1. Name two skills an infant develops before walking.
2. List four skills that may develop during the same time period.

Try at Home

Birth The process of childbirth begins with labor, the muscular contractions of the uterus. As these contractions increase in strength and frequency, the opening to the uterus widens, and the baby is pushed out through the vagina.

After birth, the umbilical cord is clamped and cut. The scar that forms where the umbilical cord was attached to the body is called the navel. The placenta also is pushed out of the mother's body after the baby is born by the contractions of the uterus.

Stages After Birth Just as there were stages of development before birth, humans have stages of development after birth. These stages are infancy, childhood, adolescence, and adulthood, as shown in **Figure 18.**

Infancy is the time from birth to around 18 months of age. During this time, the infant must adjust to a new environment. The infant's nervous and muscular systems develop rapidly and the infant interacts with the world.

Childhood lasts from 18 months of age until around 12 years of age. During childhood, growth is rapid but not as rapid as it was during infancy. The child learns many new skills including control of the bladder and bowels between the ages of two and three, and dressing and undressing by about age four. Children also develop their skills in speaking, reading, writing, and reasoning. Each child develops at a different rate.

Figure 18 After birth, human development has four stages—infancy, childhood, adolescence, and adulthood.

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Adolescence begins around age 12 to 13 years. Puberty occurs during adolescence. During puberty the human body matures sexually. This means that the person becomes physically able to reproduce. In girls, puberty usually begins between ages nine and 13. Puberty in boys occurs between ages 13 and 16. Some of the changes in girls include breast development and the growth of pubic and underarm hair. In boys, the voice deepens, muscles increase in size, and facial, pubic, and underarm hair grow. During adolescence, there is usually a final spurt of growth as well, as shown in **Figure 19.**

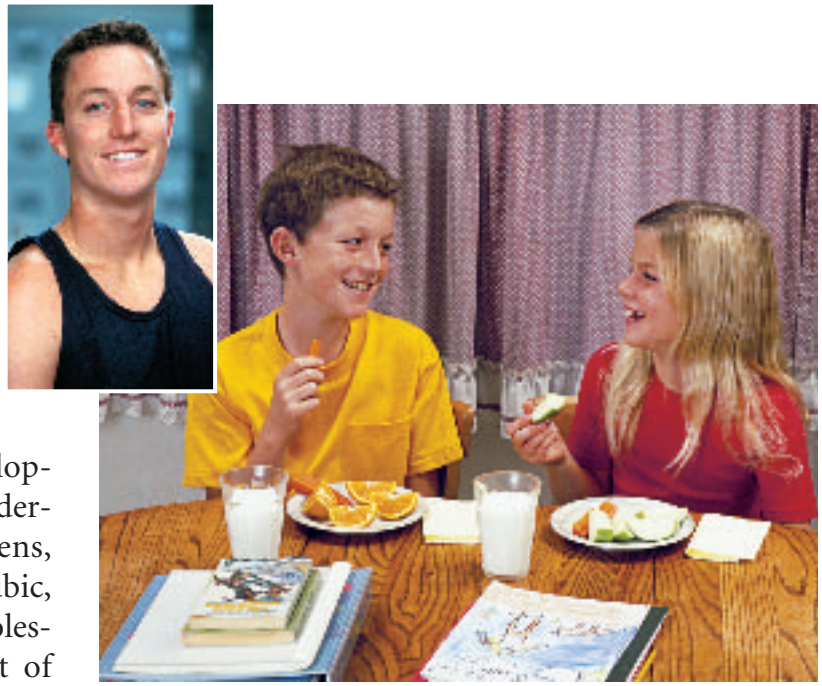

Figure 19 During adolescence, humans have their final growth spurt. For girls, this final growth phase begins at about 11 years and ends around age 16. For boys, the growth spurt begins around age 13 and ends around age 18.

Adulthood is the final stage of human development. It begins at the end of adolescence and continues through the rest of the human's life. During this time, the muscular and skeletal systems stop growing. The average human life span—from birth to death—is about 75 years. But some people live much longer. As body systems age, however, they break down, eventually resulting in death.

section 2 review

Summary

Male Reproductive System

- The male reproductive system has both external and internal organs.
- Sperm travel through the sperm duct and are released from the male through the urethra.

Female Reproductive System

- Most of the female reproductive organs are internal.
- The menstrual cycle is a cycle of monthly changes in the female reproductive system.

Life Stages

- Human development before birth occurs in three stages—zygote, embryo, and fetus.
- Development after birth occurs in four stages—infancy, childhood, adolescence, and adulthood.

Self Check

1. **Compare and contrast** the major organs and structures of the male reproductive system and female reproductive system.
2. **Identify** the organ of the female reproductive system that produces the female reproductive cell.
3. **Think Critically** Why does a placenta develop to provide nutrients to the developing embryo?

Applying Skills

4. **Concept Map** Make an events-chain concept map to sequence the stages of the menstrual cycle.
5. **Use a Spreadsheet** Make a spreadsheet for the stages of development both before and after birth. Title the columns with the stage name. Include information about each stage such as major skills developed and changes in body systems.

LAB

Design Your Own

Defensive Saliva

Goals

- **Design** an experiment to test the reaction of a bicarbonate to acids and bases.
- **Test** the reaction of a bicarbonate to acids and bases.

Possible Materials

head of red cabbage
cooking pot
coffee filter
drinking glasses
clear household ammonia
bicarbonate of soda
water
spoon
white vinegar
lemon juice
orange juice

Safety Precautions

WARNING: *Never eat or drink anything used in an investigation. Ammonia fumes are irritating to the eyes and nose.*

Real-World Question

What happens when you think about a juicy cheeseburger or smell freshly baked bread? Your mouth starts making saliva. Saliva is the first line of defense for fighting harmful bacteria, acids, and bases entering your body. Saliva contains salts and chemicals known as bicarbonates. An example of a bicarbonate found in your kitchen is baking soda. Bicarbonates help to maintain normal pH levels in your mouth. When surfaces in your mouth have normal pH levels, the growth of bacteria is slowed and the effects of acids and bases are reduced. How do the bicarbonates in saliva work to protect your mouth from harmful bacteria, acids, and bases?

Form a Hypothesis

Based on your reading in the text, form a hypothesis to explain how the bicarbonates in saliva react to acids and bases.

Test Your Hypothesis

Make a Plan

1. List the materials you will need for your experiment. Red cabbage juice can be used as an indicator to test for acids and bases. Vinegar and citrus juices are acids, ammonia is a base, and baking soda (bicarbonate of soda) is a bicarbonate.

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Matt Meadows

2. Describe how you will prepare the red cabbage juice and how you will use it to test for the presence of acids and bases.
3. Describe how you will test the effect of bicarbonate on acids and bases.
4. List the steps you will take to set up and complete your experiment. Describe exactly what you will do in each step.
5. Prepare a data table in your Science Journal to record your observations.
6. Examine the steps of your experiment to make certain they are in logical order.

Follow Your Plan

1. Ask your teacher to examine the steps of your experiment and data table before you start.
2. Conduct your experiment according to the approved plan.
3. Record your observations in your data table.

Analyze Your Data

1. **Compare and contrast** the color change of the acids and bases in the cabbage juice.
2. **Describe** how well the bicarbonate neutralized the acids and bases.
3. **Identify** any problems you had while setting up and conducting your experiment.

Conclude and Apply

1. **Determine** whether or not your results support your hypothesis.
2. **Explain** why your saliva contains a bicarbonate based on your experiment.
3. **Predict** how quickly bacteria would grow in your glass containing acid compared to another glass containing acid and the bicarbonate.
4. **Infer** how saliva protects your mouth from bacteria.
5. **Predict** what would happen if your saliva were made of only water.

Communicating Your Data

Using what you learned in this experiment, create a poster about the importance of good dental hygiene. Invite a dental hygienist to speak to your class.

Overcoming the Odds

Overcoming the odds—especially when the odds seem stacked against you—is a challenge that many people face. Dr. Samuel Lee Kountz, Jr. (right) had the odds stacked against him. Thanks to his determination, however, he beat them.

Samuel Kountz decided at age eight to become a doctor. He faced his first challenge when he failed the entrance exam to his local Arkansas college. That didn't stop him, though. He asked the college president to give him another chance, and the president did. Kountz got into school and earned As and Bs. He went on to get a graduate degree in biochemistry and was admitted to the University of Arkansas's medical school. Kountz was especially interested in a process that was still brand new in the 1950s—the kidney transplant. At that time, a kidney transplant added months or a year to the lives of many patients. But then, a patient's body would reject the kidney, and the patient would die. Dr. Kountz was determined to see that kidney transplants saved lives and kept patients healthy for years.

Fixing the Problem

Kountz discovered the root of the problem—why and how a patient's body rejected the transplanted kidney. He and others at Stanford University developed a way for doctors to watch the flow of the kidney's blood supply following surgery. As a result, doctors can give patients the right kinds of drugs at the right time, so that their bodies can overcome the rejection process.

In 1959, Kountz performed the first successful kidney transplant. He went on to develop a procedure to keep body organs healthy for up to 60 hours after being taken from a donor. He also set up a system of organ donor cards through the National Kidney Foundation. And in his career, Dr. Kountz transplanted more than 1,000 kidneys himself—and paved the way for thousands more.

Research **What kinds of medical breakthroughs has the last century brought? Locate an article that explains either a recent advance in medicine or the work that doctors and medical researchers are doing. Share your findings with your class.**

ScienceOnline
For more information, visit red.msscience.com/time

Reviewing Main Ideas

Section 1 Body Systems

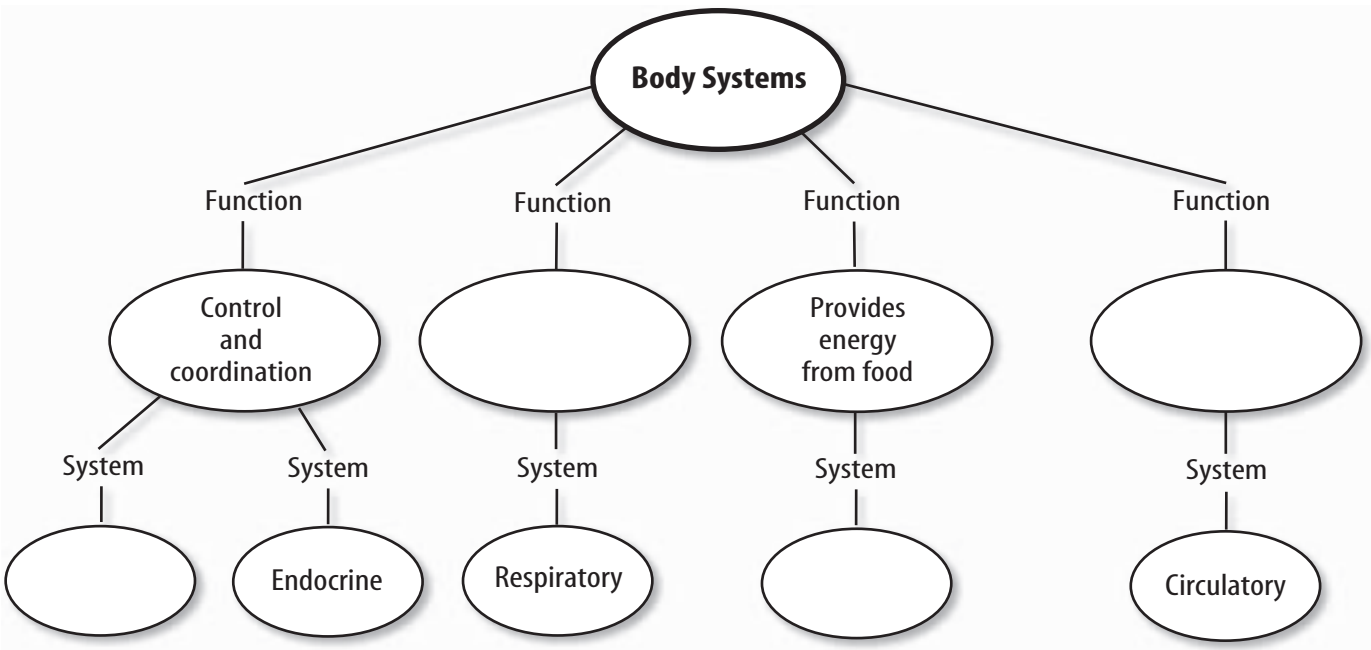
1. Energy needs of the body are provided by the digestive and circulatory systems.
2. Oxygen is taken into the body, and waste gases are removed from the body through the respiratory system.
3. Your body's first-line defenses are your skin and respiratory, digestive, and circulatory systems. Your second-line defenses make antibodies to destroy disease-causing organisms.
4. The nervous and endocrine systems control and coordinate all body activities.
5. Blood provides oxygen and nutrients to body cells and removes wastes.

Section 2 Human Reproduction

1. Reproductive organs and structures are different in males and females.
2. Male testes produce sperm. The female ovary produces eggs.
3. If the egg is fertilized by a sperm, it becomes a zygote and then develops to become an embryo and finally a fetus.
4. Infancy, the first life stage after birth, is a time of rapid growth. During childhood, which lasts until age 12, many skills are developed. Adolescence is the stage in which a person becomes able to physically reproduce. Adulthood is the last stage of development.

Visualizing Main Ideas

Copy and complete the following concept map on body systems.



chapter 19 Review

Using Vocabulary

alveoli p. 567
capillary p. 567
embryo p. 577
fetus p. 577
melanin p. 561
menstrual cycle p. 576
muscle p. 562
nutrients p. 564
ovulation p. 575
pregnancy p. 577
reflex p. 571
respiratory system p. 567
semen p. 574
skeletal system p. 560
sperm p. 574

Fill in the blanks with the correct word or words.

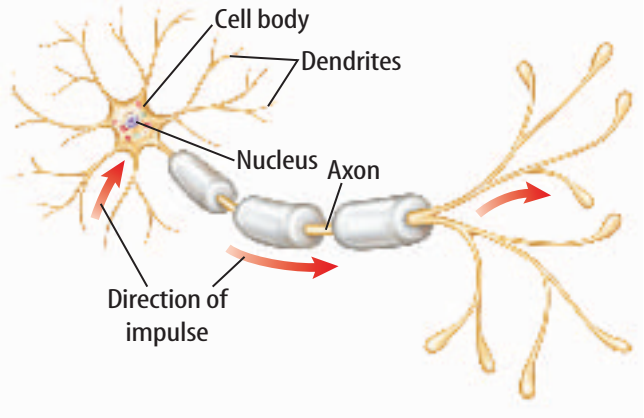
1. _____ is a mixture of sperm and fluid.
2. Grapelike clusters of air sacs are called _____.
3. _____ are substances in food.
4. The period of development from fertilized egg to birth is called _____.
5. The _____ is the name used for the unborn child after the first two months of pregnancy.
6. A(n) _____ is an involuntary response.

Checking Concepts

Choose the word or phrase that best answers the question.

7. Which is the largest organ in your body?
   A) heart **C)** skin
   B) skeletal muscle **D)** brain
8. To which body system do joints belong?
   A) skeletal system
   B) muscular system
   C) nervous system
   D) digestive system
9. Which is a stage of development before birth?
   A) embryo **C)** ovulation
   B) infancy **D)** childhood

Use the illustration below to answer question 10.

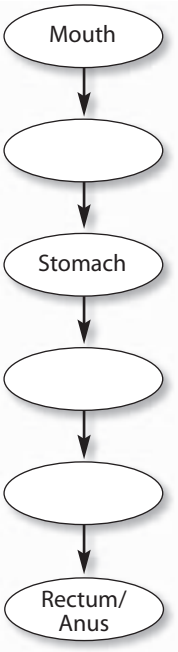


10. What body system contains the cell type shown in the drawing above?
    A) nervous system
    B) endocrine system
    C) digestive system
    D) circulatory system
11. Which two body systems are the control systems for your body?
    A) circulatory and respiratory
    B) endocrine and circulatory
    C) nervous and endocrine
    D) skeletal and nervous
12. Which of the following is an organ in the male reproductive system?
    A) bladder **C)** embryo
    B) ovary **D)** testes
13. How often does ovulation usually occur?
    A) once a year
    B) once a month
    C) twice a month
    D) once every two months
14. What is the union of an egg and a sperm?
    A) fertilization **C)** menstruation
    B) ovulation **D)** puberty
15. During which stage of development does the final growth spurt occur?
    A) infancy **C)** childhood
    B) adulthood **D)** adolescence

Thinking Critically

16. Compare and contrast arteries, veins, and capillaries.

17. Concept Map Copy and complete the following concept map of the path of food through the digestive system.



18. Sequence the flow of gases through the respiratory system.

19. Draw Conclusions Reflexes are involuntary responses, such as coughing or moving away from a hot object. Why are reflexes involuntary?

20. Classify each of the following structures according to the body system to which it belongs: stomach, lung, esophagus, heart, trachea, blood vessels, kidney, brain, pituitary gland, large intestine, and ribs.

21. Form a hypothesis about what might happen to the fertilized egg if it remained in the oviduct instead of attaching to the wall of the uterus.

Performance Activities

22. Poem Create a poem that includes the names, functions, and organs of at least two of the following body systems: respiratory system, circulatory system, nervous system, endocrine system, skeletal system, or muscular system.

23. Model Use clay, construction paper, or other art materials to make a model showing the human life stages before or after birth. Label each stage.

Applying Math

24. Water Loss Every day your body loses water through the skin and in urine, feces, and exhaled air. If the total body water loss in one day is 2,500 mL and the water loss through the skin, feces, and urine combined is 2,150 mL, how much water is lost through exhaled air in one day?

25. Amount of Blood Blood makes up about eight percent of your body's total mass. If you weigh 50 kg what is the weight of the blood in your body?

Use the table below to answer question 26.

Number of Bicycle Deaths per Year

Year	Male	Female
1996	654	107
1997	712	99
1998	658	99
1999	656	94
2000	605	76

Data from Insurance Institute for Highway Safety

26. Bicycle Helmets Head injuries are the most serious injuries of people who die in bicycle accidents. In 90 percent of the deaths, people were not wearing bicycle helmets. Using the data in the table, about how many of the people (male and female) who died in bicycle accidents in 2000 were wearing bicycle helmets?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the table below to answer question 1.

Results of Folic Acid on Development of Neural Tube Defect		
Group	**Babies with Neural Tube Defect**	**Babies without Neural Tube Defect**
Group I Folic Acid	6	497
Group II No Folic Acid	21	581

(From CDC)

Researchers have found that the B-vitamin folic acid can prevent a type of birth defect called neural tube defect. In a study done in Europe in 1991, one group of pregnant women was given extra folic acid, and the other group did not receive extra folic acid.

1. Which of the following statements is true regarding the data in this table?
- **A.** Folic acid had no effect on the percentage of babies with neural tube defect.
- **B.** Women who took the extra folic acid had a decreased percentage of babies with neural tube defect.
- **C.** Extra folic acid increased the percentage of babies with neural tube defect.
- **D.** Group I and Group II had the same percentage of babies born with neural tube defect.

Test-Taking Tip

Detect Data Patterns When analyzing data in a table or graph, try to detect a pattern. Questions about the pattern may use words like hypothesis, generalization, summary, or trend.

Questions 3 and 4 When looking for a pattern, compare data for two or more variables.

2. Which of the following is a function of blood?
- **A.** carries saliva to the mouth
- **B.** excretes urine from the body
- **C.** transports nutrients and oxygen to body cells
- **D.** collects tissue fluid from around cells

Use the table below to answer questions 3 and 4.

Results from Ashley's Activities			
Activity	**Pulse Rate (beats/min)**	**Body Temperature**	**Degree of Sweating**
1	80	98.6°F	None
2	90	98.8°F	Minimal
3	100	98.9°F	Little
4	120	99.1°F	Moderate
5	150	99.5°F	Considerable

3. According to the information in this table, which of the following activities indicates that Ashley was exercising vigorously?
- **A.** Activity 2
- **B.** Activity 3
- **C.** Activity 4
- **D.** Activity 5

4. A reasonable hypothesis based on these data is that during Activity 2, Ashley was probably
- **A.** sprinting.
- **B.** marching.
- **C.** resting.
- **D.** walking slowly.

5. Which of the following events does NOT happen during a female's monthly menstrual cycle?
- **A.** maturing of egg
- **B.** production of female sex hormones
- **C.** menstruation
- **D.** menopause

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

6. If red blood cells are made at the rate of two million per second in the center of long bones, how many red blood cells are made in one hour?

7. If a cubic milliliter of blood has 10,000 white blood cells and 400,000 platelets, how many more platelets than white blood cells are present in a cubic milliliter of blood?

Use the table below to answer questions 8 and 9.

Blood Transfusion Possibilities		
Type	**Can Receive**	**Can Donate To**
A	O, A	A, AB
B	O, B	B, AB
AB	All	AB
O	O	All

8. Infer what would happen if type A blood was given to a person with type O blood.

9. Which blood type could be called the "universal recipient"?

10. How does your skin help defend your body from diseases?

11. Explain the difference between organic and inorganic nutrients. Name a class of nutrients for each.

12. Compare and contrast voluntary and involuntary muscles.

13. The brain is made up of approximately 100 billion neurons, which is about 10% of all neurons in the body. Approximately how many neurons are there in the human body?

Part 3 Open Ended

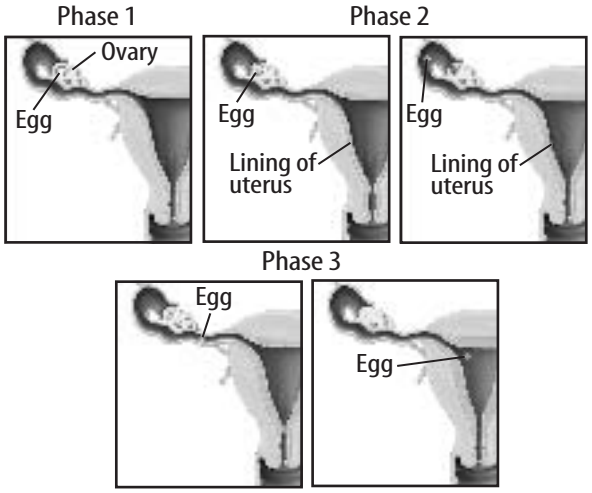
Record your answers on a sheet of paper.

14. A virus causes the disease rubella, also known as "German measles." If a pregnant woman becomes infected with rubella, the virus can affect the formation of major organs such as the heart in her baby. During which stage of development before birth would a rubella infection be most dangerous? Why?

15. How do the lymphatic and circulatory systems work together?

16. Explain why blood sometimes is called "the tissue of life?"

Use the illustration below to answer questions 17 and 18.



17. Describe the changes that occur in phase 2.

18. Compare and contrast the changes that occur in phase 3 if fertilization does take place and if fertilization does not take place.

19. Describe your body's first line and second-line defenses.

20. How do water-soluble and fat-soluble vitamins differ? Name the vitamins in each group and give examples of how they help the body.