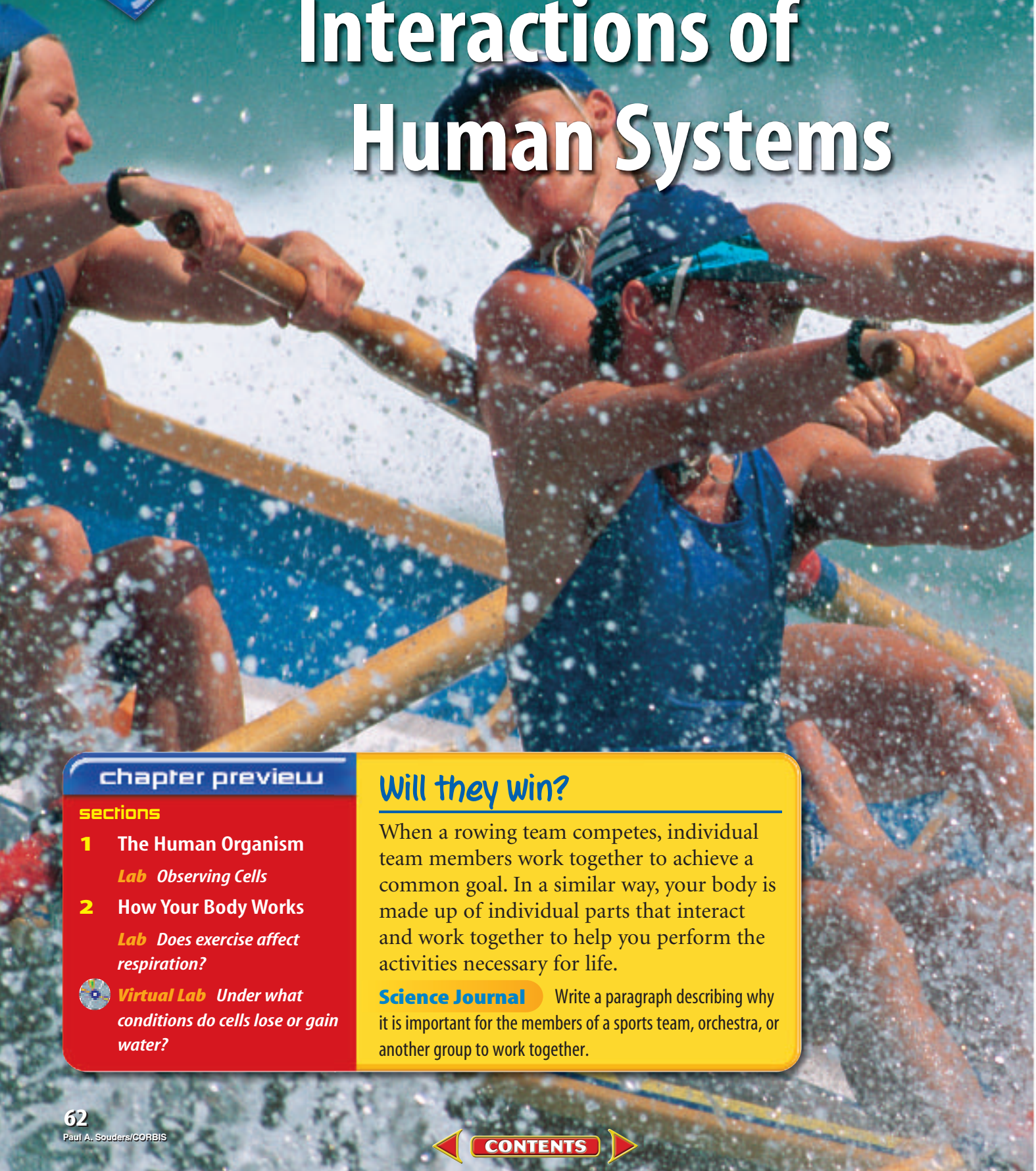




Interactions of Human Systems



chapter preview

sections

1 The Human Organism

Lab Observing Cells

2 How Your Body Works

Lab Does exercise affect respiration?



Virtual Lab Under what conditions do cells lose or gain water?

Will they win?

When a rowing team competes, individual team members work together to achieve a common goal. In a similar way, your body is made up of individual parts that interact and work together to help you perform the activities necessary for life.

Science Journal Write a paragraph describing why it is important for the members of a sports team, orchestra, or another group to work together.

Start-Up Activities



Model Blood Flow in Arteries and Veins

Your body's circulatory system is made up of a pumping heart and three types of blood vessels—arteries, veins, and capillaries. The blood flowing in your blood vessels is under constant pressure. However, the blood in your arteries has the highest pressure.



1. Fill a plastic sports bottle with water, leave the cap off, and squeeze it over a sink. Record the results in your Science Journal.
2. Refill the bottle, screw on the cap, and squeeze it over a sink. Record the results in your Science Journal.
3. Compare the results of step 1 and step 2.
4. **Think Critically** In your Science Journal, indicate which step modeled your veins and which step modeled your arteries. Explain.



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

FOLDABLES™ Study Organizer

Human Systems Make the following Foldable to ensure you have understood the content by defining the vocabulary terms on the interactions of human systems.

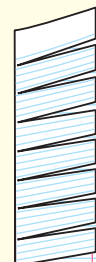
- STEP 1** **Fold** a sheet of notebook paper vertically from left to right.



- STEP 2** **Cut** along every third line of only the top layer to form tabs.



- STEP 3** **Label** each tab.



Read and Write Before you read the chapter, write the vocabulary words listed on the front page of each section on the front of the tabs. On the back of each tab, write what you think the word means. As you read the chapter, check your definitions and add to or change them as needed.



The Human Organism

as you read

What You'll Learn

- **Describe** the basic structure and function of a typical human cell.
- **Identify and describe** the five levels of organization in the body.

Why It's Important

Your body is a complex structure made up of many parts. Good health depends upon all of these parts functioning properly.

Review Vocabulary

matter: any substance that has mass and occupies space

New Vocabulary

- mineral
- organic compound
- cell
- tissue
- organ
- organ system

Organization in the Human Body

The next time you pass a building under construction, like the one in **Figure 1**, stop for a moment and think about how something so complex can be built. In the early stages of construction, the building lacks organization and looks different from the way it will look when it is finished. Some of the raw materials from which it will be built began as sand grains, clay particles, trees, and iron ore. Eventually, these materials are made into more useful structures, like concrete, plaster, wood beams, and steel supports. The separate pieces then are organized to form the basic framework of the building. When other finishing materials are added, the building is complete.

Although your body is not made of sand, clay, wood, and steel, it is composed of a series of building blocks that are different in size and complexity. As in a building, all of the things that your body is made up of are vital to your health.

Chemical Basis of Life

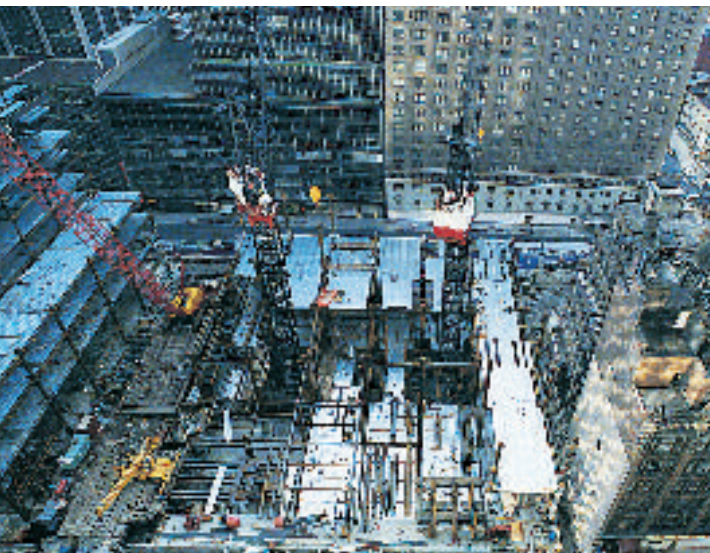


Buildings and people have much more in common than you might think. On the most basic level, a building and a person are made of matter. Matter is made up of particles called atoms. An atom is the smallest part of matter.

Elements and Compounds Matter that has the same composition and properties throughout is a substance. Substances are either elements or compounds. An element is made up of only one kind of atom. Scientists have discovered 90 natural elements on Earth.

Substances that are made of more than one element are called compounds. A compound is two or more elements that are chemically combined. What elements make up the compounds carbon dioxide (CO_2) and ammonia (NH_3)?

Figure 1 This building is in various stages of construction.





Inorganic Substances Chemicals in living things are classified as either inorganic or organic. Inorganic substances typically come from nonliving sources such as air, soil, or water.

Minerals are inorganic substances that are involved in many of the body's chemical reactions, as listed in **Table 1**. They are required in small amounts, yet your body must have them to maintain good health and fight disease.

Table 1 Important Minerals in Your Diet

| Mineral | Use | Dietary Source |
|------------|--|--|
| Calcium | Formation of bones and teeth, blood clotting, muscle and nerve functions | Dairy products, leafy green vegetables, nuts, whole grains |
| Chlorine | Fluid balance, pH balance | Table salt |
| Cobalt | Formation of red blood cells | Meat, dairy products |
| Copper | Development of red blood cells and respiratory enzymes | Kidney, liver, beans, whole-meal flour, lentils, raisins |
| Flourine | Formation of bones and teeth | Fluoridated water |
| Iodine | Part of thyroid hormone | Seafood, iodized table salt |
| Iron | Part of hemoglobin and some enzymes | Liver, egg yolk, peas, nuts, whole grains, red meat, raisins, leafy green vegetables |
| Magnesium | Muscle and nerve functions, bone formation, breakdown of proteins and carbohydrates, enzyme function | Potatoes, fruits, whole-grain cereal, vegetables, dairy products |
| Manganese | Growth of cartilage and bone; breakdown of carbohydrates, proteins, and fats | Wheat germ, nuts, bran, leafy green vegetables |
| Phosphorus | Bone formation, nerve function, regulation of blood pH, muscle contraction | Milk, whole-grain cereal, meats, vegetables, nuts |
| Potassium | Muscle and nerve function | Grains, fruits, vegetables, ketchup |
| Sodium | Muscle and nerve function, water balance, regulation of body fluid pH | Table salt, bacon, butter, vegetables |
| Sulphur | Builds hair, nails and skin; part of insulin | Nuts, dried fruits, oatmeal, eggs, beans |
| Zinc | Digestion, healing, taste, smell | Liver, seafood |



Topic: Water

Visit blue.msscience.com for Web links to information about the importance of water to living things.

Activity Design a label to place on the back of a bottle of water detailing the benefits of water to the human body.

Figure 2 Organic compounds needed by your body—carbohydrates, lipids, nucleic acids, and proteins—can be found in the foods you eat.

Identify four carbohydrates in this picture.



Inorganic Chemicals in Your Body Inorganic chemicals play many important roles in your body. Salt, an important chemical in your blood, is an example of an inorganic substance in the body. Chemically speaking, blood is mostly water (H_2O), but it also contains sodium ions (Na^+) and chlorine ions (Cl^-) in the form of dissolved sodium chloride (NaCl), also known as table salt. Water, for instance, makes up more than 70 percent of the body's tissues. It also plays a role in nearly every bodily function, such as digesting foods, muscle function, delivering oxygen to cells, and removing wastes from the body. Over long periods of time, a lack of water can lead to problems in digestion, circulation, and kidney function. On a daily basis, not getting enough water can cause dry skin, headaches, and fatigue.

Reading Check What are the roles of water in your body?

Organic Substances You probably have heard the expression “You are what you eat.” For most people, it means that a person's health is a reflection of the kinds of foods he or she eats. In another way, it means that your body is made up of the same kinds of chemicals that are found in the things that you eat every day.

Living things are made of **organic compounds**, which are compounds containing carbon, with a few exceptions. Two of the carbon-containing compounds that are not considered organic are carbon dioxide and carbon monoxide. The four groups of organic compounds are carbohydrates, lipids, nucleic acids, and proteins. Foods that contain these compounds are shown in **Figure 2**.



SEM Magnification: 1500×

Figure 3 This scanning electron micrograph shows a nucleic acid. Nucleic acids are made of carbon, hydrogen, oxygen, nitrogen, and phosphorus. DNA and RNA are examples of nucleic acids found in your body.

Life's Organic Compounds The next time you come home from school feeling tired and listless, do what many professional athletes do when they need an energy boost—eat some pasta. Maybe you would prefer a baked potato or a bowl of rice. These foods contain carbohydrates, which are the main source of energy for living things. Carbohydrates are made up of carbon (C), hydrogen (H), and oxygen (O).

Most of your energy comes from carbohydrates because they make up the largest part of your diet. But lipids contain more energy per molecule than carbohydrates do. Lipids, commonly called fats and oils, are stored in your body as energy reserves. When your supply of carbohydrates is low, your body turns to its fat reserves for energy.



Reading Check Which organic compound contains more energy than carbohydrates?

Nucleic acids, as shown in **Figure 3**, are large, complex organic compounds that store information in the form of a code. One type of nucleic acid called DNA often is called the blueprint for a living thing. DNA carries information that directs cell activities and instructions for making all proteins. Another nucleic acid called RNA is responsible for making proteins from amino acids.

Proteins serve many important functions in living things. Many of the structural parts of your body—hair, nails, skin, muscles, and blood vessels—are made, in part, of protein. Other proteins, such as enzymes, help your body carry out important processes, such as growth, repair, digestion, respiration, and the transmission of nerve impulses.

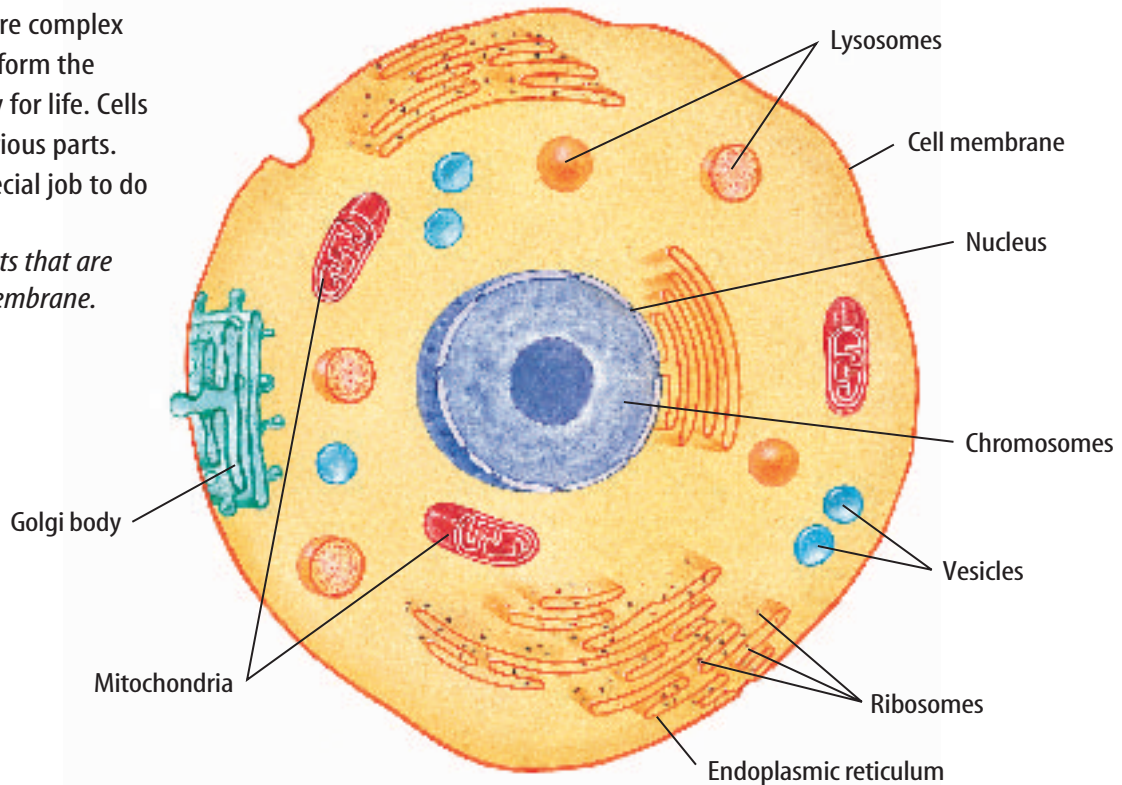


Body Elements Three of the chemical elements that make up the human body also are some that make up Earth's crust. The common elements are oxygen, calcium, and potassium. Earth's crust is 46.4 percent oxygen, 3.6 percent calcium and 2.6 percent potassium. What percentages of these elements are present in a typical human body?



Figure 4 Cells are complex structures that perform the activities necessary for life. Cells are made up of various parts. Each part has a special job to do in the cell.

Name four cell parts that are inside of the cell membrane.



Cells—Living Factories

Organic and inorganic chemicals combine in an organized way to form cells. A **cell** is the smallest functional unit in an organism. Every living thing is made up of one or more cells. **Figure 4** illustrates the basic structure of a human cell.

Most cells can't be seen with the unaided eye. You need a microscope to see human cells. Despite its size, the cell is the reason that living things can carry on all of the important activities of life, such as digestion, growth, and reproduction. Cells contain different parts that perform these activities necessary for life. Human cells, like the one shown in **Figure 5**, have a variety of shapes and sizes, but more similarities than differences can be identified.

In some ways, a living cell can be compared to a busy factory. Many factories have separate locations inside the building to complete the tasks of the production process. Raw materials are brought in, assembled into products, packaged, and delivered to customers. In a similar way, living cells take in raw materials from their surroundings, such as food, oxygen, water, and minerals. Cells then use these materials in chemical reactions to make proteins and other products necessary for life. During some of these chemical reactions, energy is released.

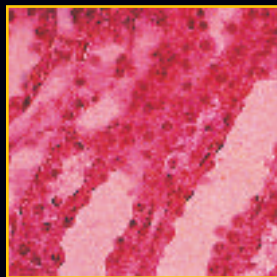
 **Reading Check** How is a cell like a factory?

NATIONAL GEOGRAPHIC VISUALIZING HUMAN CELLS

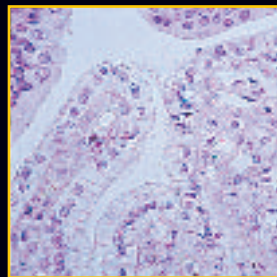
Figure 5

Throughout your body, many different types of cells carry out the complex processes that keep you alive and functioning at your best. A cell's size, shape, and structure are closely related to the tasks it performs, as shown here.

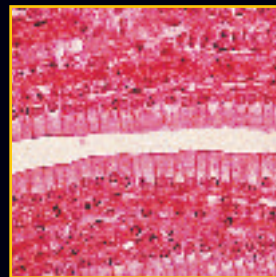
▼ **EPITHELIAL (ep uh THEE lee ul) CELLS** Humans have three types of epithelial cells, which protect or lubricate various parts of the body. Squamous (SKWAY mus) epithelial cells cover your body and line your mouth and esophagus. Cuboidal (kyew BOY dul) epithelial cells line your body cavities and glands. Columnar (kuh LUM nur) epithelial cells line your stomach, intestines, and respiratory passages.



Squamous epithelium, (125x)

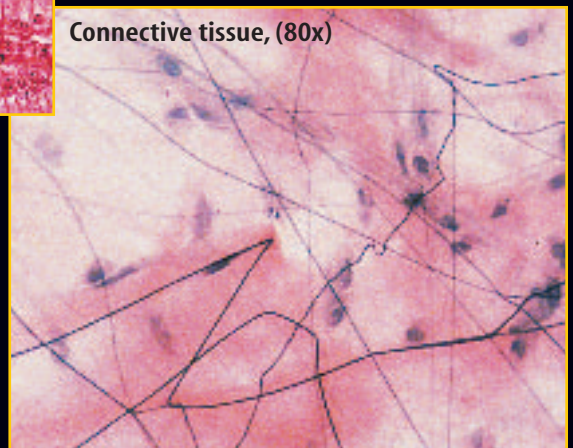


Cuboidal epithelium, (80x)



Columnar epithelium, (100x)

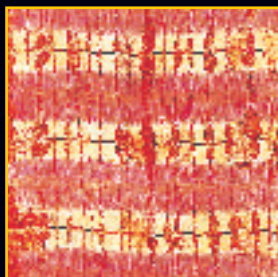
► **CONNECTIVE TISSUE CELLS** Like the cells in blood—a connective tissue—some connective tissue cells wander. Wandering connective tissue cells can protect, repair, and transport. Other connective tissue cells are fixed, like those in the photo to the right. These cells can insulate, maintain, store, support, or produce substances.



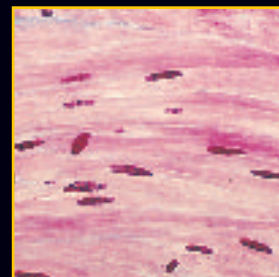
Connective tissue, (80x)

► **MUSCLE CELLS** Skeletal muscle cells move body parts such as arms and legs. Smooth muscle cells move substances within or through internal organs and vessels. Cardiac muscle cells are found only in the heart.

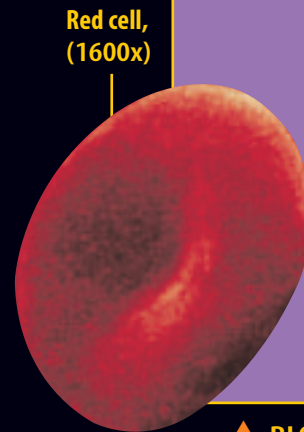
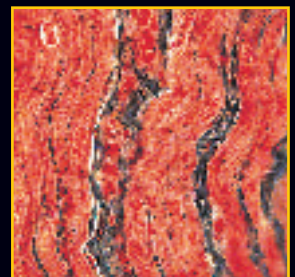
Skeletal muscle, (6000x)



Smooth muscle, (100x)



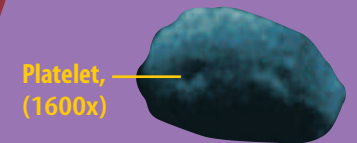
Cardiac muscle, (225x)



Red cell, (1600x)



White cell, (1600x)



Platelet, (1600x)

▲ **BLOOD CELLS** Red blood cells carry oxygen to your tissues and remove carbon dioxide. White blood cells protect your body from harmful, foreign substances or organisms. Platelets help form blood clots.

(top from top)Ken Eward/Science Source/Photo Researchers, Cabisco/Visuals Unlimited, Eric Grave/Science Source/Photo Researchers, Robert Krauff/Biology Media/Photo Researchers, Quest/Science Photo Library/Photo Researchers, Science Vu/Visuals Unlimited, Stan Elms/Visuals Unlimited, Cabisco/Visuals Unlimited



From Cell to Organism Your body is constructed from a variety of different types of cells. Are you no more than a collection of cells with each one doing its own thing?

Many-celled organisms are highly organized. Think about what it is like to be in a band. Each member plays the music written for his or her instrument. However, for the band to be successful, the members must work together. In a similar way, the cells in an organism need to perform their individual functions yet work together so the whole organism can function.

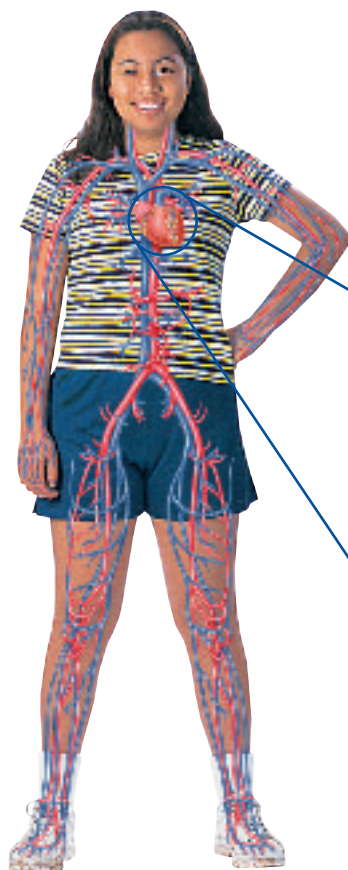
Levels of Organization The different levels of organization in the human body are shown in **Figure 6**. As stated earlier, cells represent the first level of organization in the body. Cells are organized into tissues. **Tissues** are groups of similar cells that do the same sort of work. In the human body, nerve tissue carries nerve impulses around the body. It helps different parts of the body communicate. Blood tissue transports oxygen and nutrients to and from cells.

Tissues are organized into larger structures called organs. An **organ** is a structure made up of different types of tissues that work together. For example, your heart is an organ made up of cardiac muscle tissue, nerve tissue, and blood tissue.

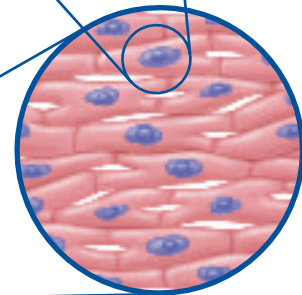
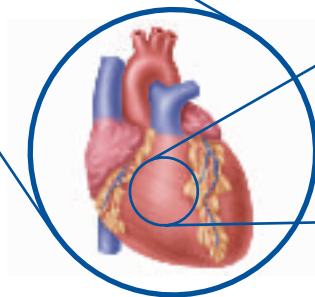
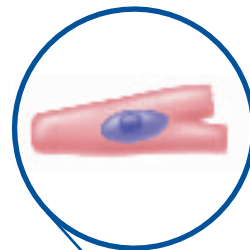
Figure 6 The human organism is made of small parts that work together and form larger, more complex parts.

Organ systems work together and form a whole organism.

Organs work with other organs to form organ systems.



Cells represent the first level of organization in the body. This cardiac cell is the smallest unit in the body that does "cardiac work."



Cardiac cells work together and make up cardiac tissues.

The heart is an organ. It is made up of cardiac tissue that works with other kinds of tissues, including blood tissue and nerve tissue.

**Table 2 The Systems of the Human Body**

| System | Main Organs | Function |
|---------------|----------------------------|---|
| Integumentary | Skin | Protects the body and prevents water loss |
| Muscular | Muscles | Movement of the body, attached to bones |
| Skeletal | Bones | Support and protection of soft body parts |
| Nervous | Brain, spinal cord, nerves | Controls mental and bodily functions |
| Endocrine | Pancreas, pituitary gland | Controls homeostasis by releasing hormones |
| Circulatory | Heart, blood vessels | Transport of materials to and from body cells |
| Lymphatic | Spleen, thymus, tonsils | Remove dead cells and foreign bodies from body fluids |
| Respiratory | Lungs, trachea | Exchange of gases between blood and the environment |
| Digestive | Stomach, small intestine | Break down food for absorption into the blood |
| Urinary | Kidneys, bladder | Control of water balance and chemical makeup of blood |
| Reproductive | Testes, ovaries | Production of sex cells |

Systems Organs in your body involved in the circulation of blood include your heart, arteries, veins, and capillaries. A group of organs that work together to do a certain job is called an **organ system**. Human body systems, as listed in **Table 2**, are interdependent and work together to perform life functions.

section 1 review

Summary

Organization in the Human Body

- The human body is complex, but organized.

Chemical Basis of Life

- Inorganic substances in the human body include minerals, salt, and water.
- Organic substances in the human body are carbohydrates, lipids, nucleic acids, and proteins.

Cells—Living Factories

- Cells perform the activities necessary for life.
- The human body has five levels of organization.

Self Check

1. **List**, in order, the levels of organization in the human organism.
2. **Explain** why your body needs minerals.
3. **Think Critically** Explain why cells are vital for life.

Applying Math

4. **Solve One-Step Equations** Every milliliter of blood has five million red blood cells. On average, a person has 3.3 L of blood. Calculate how many red blood cells are found in a typical human body.

Observing Cells

Cells come in a variety of shapes and sizes. They might look different and perform different functions, but they have some common structures.

Real-World Question

How do prepared human cheek cells and living onion cells compare?

Goals

- **Observe** the structure of human cheek cells.
- **Observe** the structure of onion cells.

Materials

compound light microscope
microscope slide
coverslip
prepared human cheek cell slide
small piece of onion
forceps
iodine solution
water
medicine dropper

Safety Precautions



WARNING: *These solutions can cause stains. Do not allow them to contact your skin or clothing.*

Procedure

1. Obtain a prepared slide of human cheek cells from your teacher.
2. **Examine** the cheek cells under low power of the microscope and then under high power. In your Science Journal, draw several cheek cells as they appear under high power.



3. Using forceps, remove a small section of paper-thin tissue from the onion. Prepare a wet-mount slide of the onion tissue. Before putting on the coverslip, place a drop of iodine on the onion tissue.
4. **Examine** the onion-tissue slide under low power, then under high power. In your Science Journal, draw several onion cells as they appear under high power.

Conclude and Apply

1. **Describe** the shape of human cheek cells.
2. **Describe** the shape of the onion cells.
3. **Name** the structure you saw in the onion cell but not in the human cheek cell.

Communicating Your Data

Make a colorful, poster-sized illustration of one of these cells. Label all visible parts of the cell. **For more help, refer to the Science Skill Handbook.**

How Your Body Works

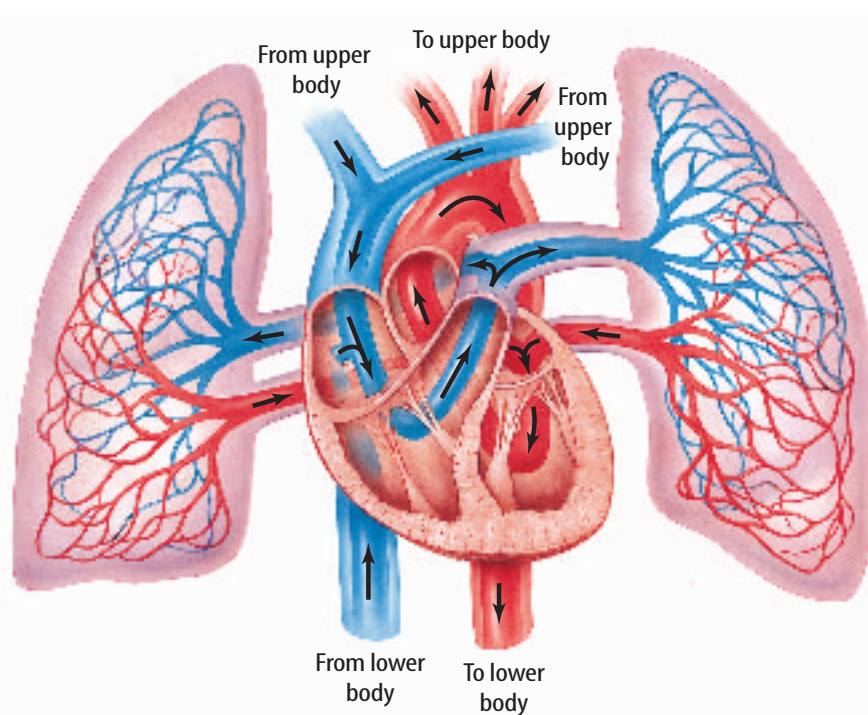
Body System Connections

The heart is the main organ of the circulatory system. Lungs carry out the most important role in the body's respiratory system. The heart and lungs are important organs working together to put oxygen into blood and take carbon dioxide out of it. This partnership of the heart and lungs, as shown in **Figure 7**, is one of the most important interactions in the body.

The heart also keeps blood moving so all the cells in the body can stay alive. Your heart and lungs work more quickly when you are active. When you rest or sleep, your heart and lungs slow down but never stop. In this section, you will read how other systems in your body interact and work together to carry out important life processes.

Feeding Cells

The foods you eat are filled with the chemicals that your body needs to grow strong and healthy. How are those chemicals distributed throughout your body for energy, growth, repair, and other important body functions?



as you read

What You'll Learn

- **Discuss** how body systems work together to carry out important life functions.
- **Explain** how negative feedback mechanisms in the body help maintain homeostasis.
- **Compare** negative feedback mechanisms and positive feedback mechanisms in the body.

Why It's Important

Systems in the body are interdependent—they depend on each other and work together.

Review Vocabulary

energy: the ability to cause change

New Vocabulary

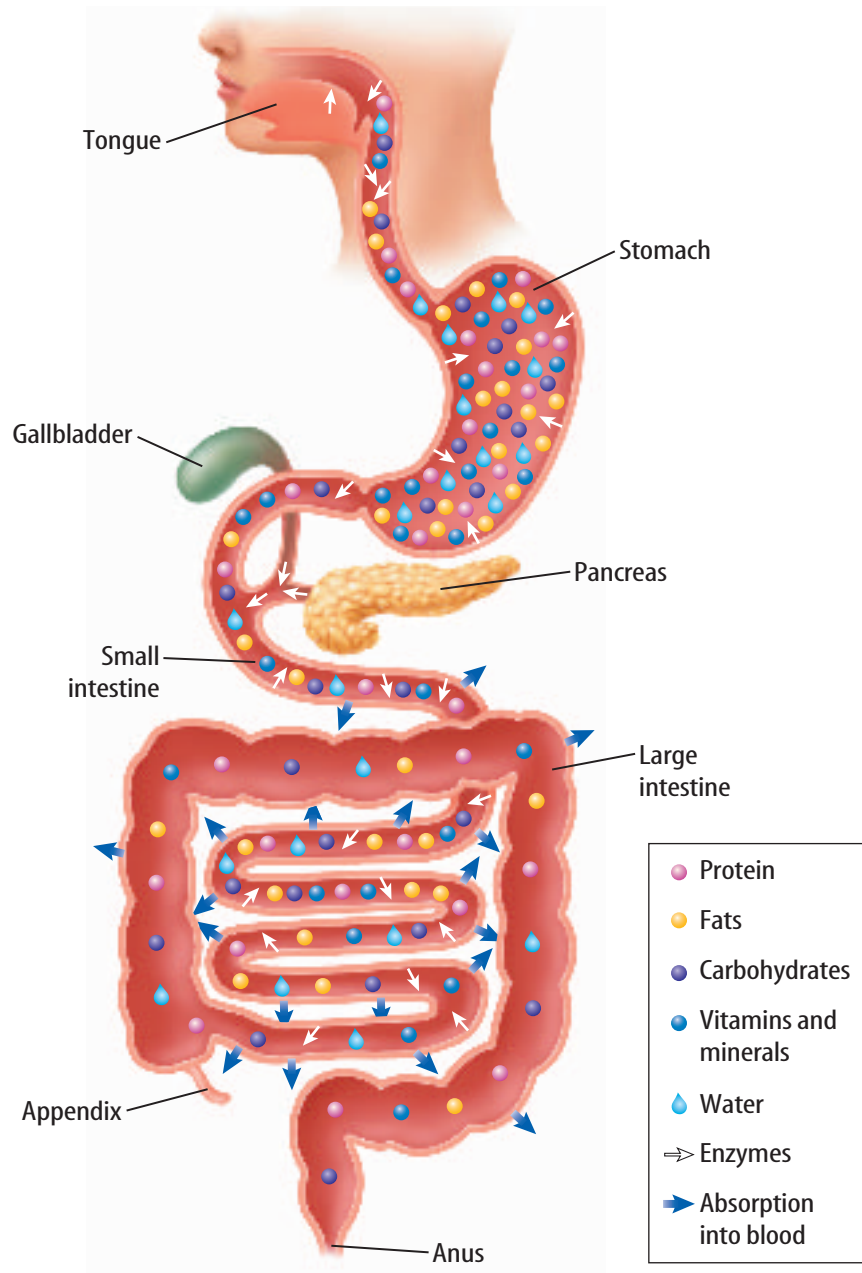
- digestion
- enzyme
- villi
- absorption
- cellular respiration
- alveoli
- excretion
- homeostasis
- negative feedback

Figure 7 The arrows show the direction of blood flow through the heart, lungs, and body.

Explain what occurs in the lungs.



Figure 8 During digestion, glucose, salt, vitamins, and water can be absorbed immediately into the bloodstream. All other foods must be broken down before they can pass through the walls of the small intestine and be absorbed by the blood.



Mini LAB

Observing the Gases That You Exhale

Procedure

1. Dry your hands with a towel.
2. Hold the palm of your hand up to your mouth, then exhale into it.
3. Feel your palm with your other hand.
4. Hold a **mirror** up to your mouth and exhale again. Observe what happens to the mirror.

Analysis

1. How did your hand feel after you breathed on it?
2. What happened to the mirror when you breathed on it?
3. Besides carbon dioxide, hypothesize what other things are exhaled.



Digestive System In the factory, an assembly line puts products together. Your digestive system works in reverse. It is a disassembly line. **Digestion** is the breakdown of the foods that you eat into smaller and simpler molecules that can be used by the cells in your body.

As shown in **Figure 8**, the digestive system is basically a long tube that runs through your body. Food is taken into the body through the mouth, where it is chewed and broken into smaller pieces. As the food passes through the digestion tube, it is broken down further.

Reading Check

Why can the digestive system be thought of as a disassembly line?



Helping Digestion Other body systems help the digestive system with this work. For instance, your brain signals some cells in your mouth to produce saliva when you see, smell, taste, or sometimes just think of food. Saliva softens and lubricates food and also contains an enzyme that helps the digestive process. An **enzyme** (EN zime) is a protein that helps the body carry out chemical reactions. When food reaches other parts of the digestive tract, such as the stomach and small intestine, the brain again directs the body to produce other enzymes that help break down the chemicals in food even further.

Circulation and Digestion The body's circulatory system transports blood that provides nutrients for the cells of the digestive system, just as it does for all the cells in the body. However, the most important connection between the circulatory system and the digestive system occurs in the small intestine, as shown in **Figure 9**.

Your small intestine is 2.5 cm to 5 cm in diameter but is 4 m to 7 m in length. Imagine a 7-m garden hose coiled up inside your abdomen. Unlike a garden hose, the small intestine is not smooth. It is lined with tiny fingerlike projections called **villi**. The many blood vessels in the villi are a clue to their function. By the time food reaches the small intestine, it has been broken down into molecules that can pass through the walls of the villi, then into the bloodstream. This process is known as **absorption**. After they are absorbed into the bloodstream, nutrients are carried to cells throughout the body. Materials that are not absorbed pass out of the body as wastes.



Antibiotics In 1928, Alexander Fleming discovered the first antibiotic—penicillin. This led to the discovery of other antibiotics and changed the way infections are treated. However, antibiotics that are used to kill disease-causing bacteria also can kill some helpful ones, like the bacteria that live in your digestive tract and help with the process of digestion. Killing these helpful bacteria upsets the digestive process. What is a common side effect of taking antibiotics?

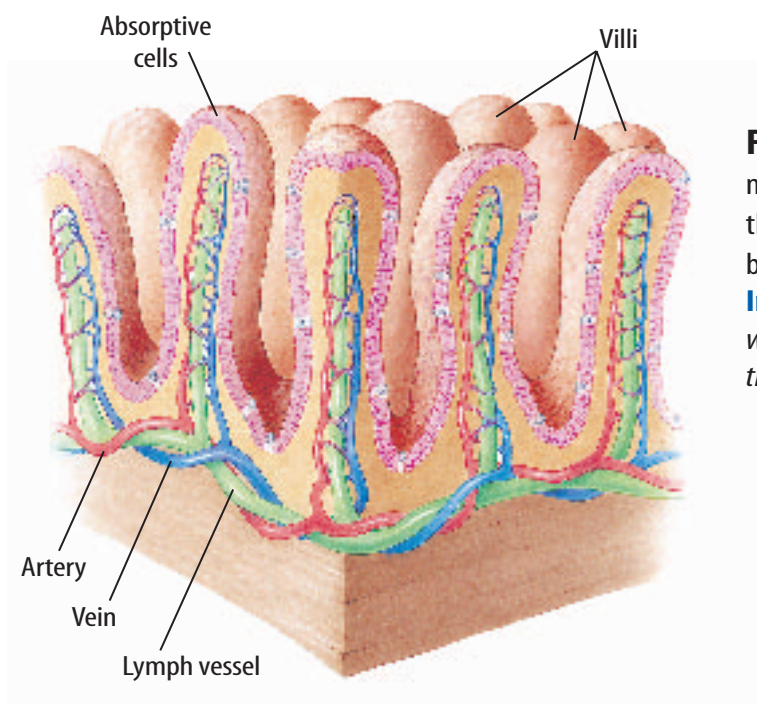


Figure 9 Villi make absorption more efficient because they increase the surface area of the small intestine by ten times.

Infer what might happen to a person's weight if the number of villi were drastically increased. Why?



Mini LAB

Observing a Chemical Reaction



Procedure

1. Pour a small amount of 3% hydrogen peroxide solution into a petri dish.
2. Use a thermometer probe to take the temperature of the peroxide solution.
3. Place a small chunk of fresh liver in the petri dish. Observe what happens.
4. Wait 1 min, then take the temperature of the solution a second time.

Analysis

1. Was energy released during this chemical reaction? How do you know?
2. How is this chemical reaction similar to the process of respiration in cells?

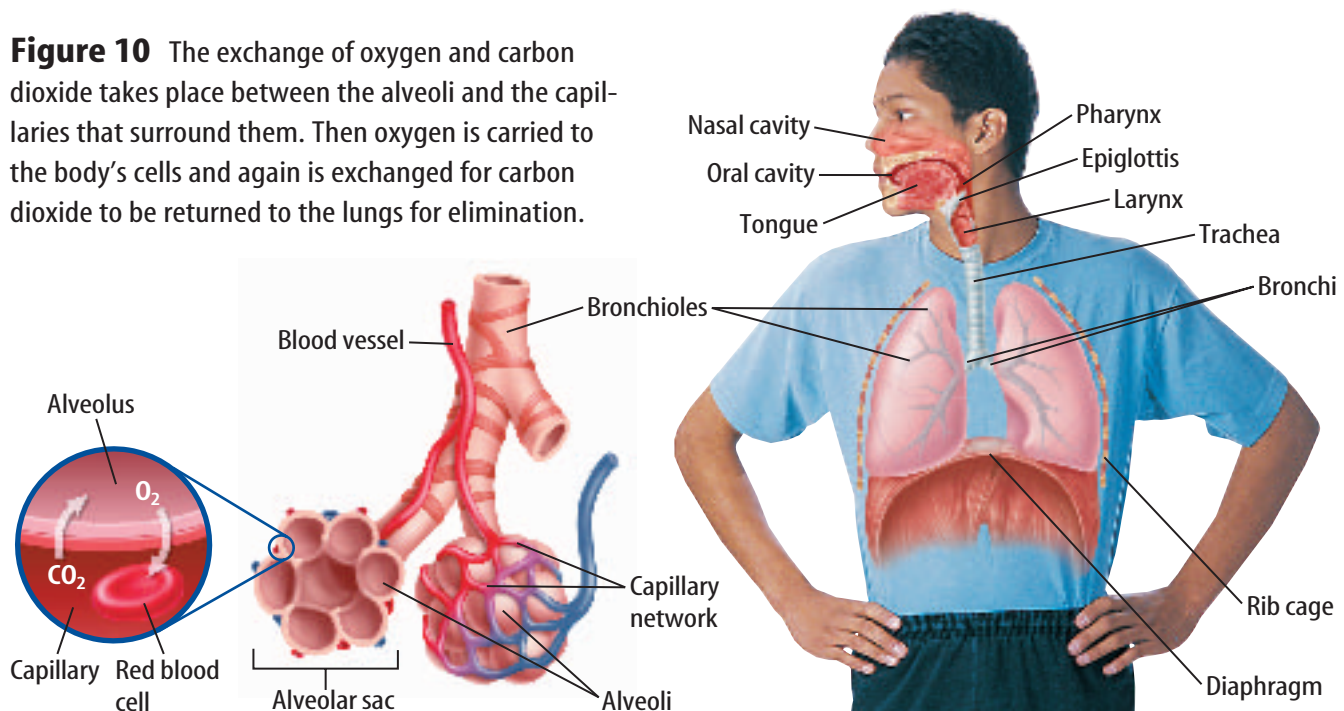
Energy for the Body

The body's cells release energy from food in the process of carrying out different activities. This important process occurs in the mitochondria of every cell. **Cellular respiration** is a series of chemical processes in which oxygen combines with food molecules and energy is released. A cell uses this released energy to perform all of its tasks. Carbon dioxide (CO₂) and water are given off as wastes.

For cellular respiration to occur, a constant supply of nutrients and oxygen must be available. When not enough oxygen is available, the cycle cannot be completed. In cells, hydrogen ions typically combine with oxygen molecules to produce water as a waste product. When the oxygen level is low, hydrogen combines with a compound that is produced when glucose is broken down to form lactic acid as a waste product. As lactic acid increases, muscle fatigue occurs, respiration is stimulated, and rapid breathing results.

Respiratory System Several body systems work together to remove wastes. Other body systems help the raw materials of cellular respiration—food and oxygen—get to your cells. You've read how the digestive and circulatory systems interact to break down food and transport it to cells. As shown in **Figure 10**, oxygen enters your body and carbon dioxide is released through your respiratory system.

Figure 10 The exchange of oxygen and carbon dioxide takes place between the alveoli and the capillaries that surround them. Then oxygen is carried to the body's cells and again is exchanged for carbon dioxide to be returned to the lungs for elimination.





Oxygen Absorption Recall how food molecules move into the bloodstream through the villi of the small intestine. A similar process of oxygen absorption occurs in the lungs, where your respiratory and circulatory systems interact. At the lower end of the trachea are two short branches, called bronchi, which carry air into the lungs. Within the lungs, the bronchi branch into smaller and smaller passageways. At the ends of the narrowest tubes are clusters of tiny, thin-walled sacs called **alveoli** (al VEE uh li). Lungs are made up of millions of alveoli. A network of tiny blood vessels called capillaries surrounds each cluster of alveoli.

Reading Check Compare food absorption and oxygen absorption in the body.

Applying Math Calculate Volume

LUNG VOLUME A person's lung capacity depends on their gender and overall physical condition. Using the table to the right, calculate the lung volume for a 5-ft-tall, nonathletic female.

| Body-Size Factor | |
|------------------|--------------------|
| Body | (cm ²) |
| Female | 20 |
| Female athlete | 22 |
| Male | 25 |
| Male athlete | 29 |

Solution

- This is what you know:*
 - height in inches = $12 \times 5 = 60$ inches
 - height in centimeters = $60 \times 2.54 \text{ cm} = 152.4 \text{ cm}$
 - body-size factor (from chart) = 20 cm^2
- This is what you need to find out:* What is the lung capacity of a 5-ft-tall, nonathletic female?
- This is the procedure you need to use:*
 - Use this equation:
height in centimeters \times body-size factor = volume of lungs
 - Substitute in the known values and solve:
 $152.4 \text{ cm} \times 20 \text{ cm}^2 = 3,048 \text{ cm}^3$ is the lung volume of a 5-ft-tall, nonathletic female
- Check your answer:* Divide $3,048 \text{ cm}^3$ by 20 cm^2 and you should get 152.4 cm .

Practice Problems

- Calculate your lung volume.
- Calculate the difference in the lung volumes of a male athlete who is 62 inches tall and a female athlete who is 56 inches tall.



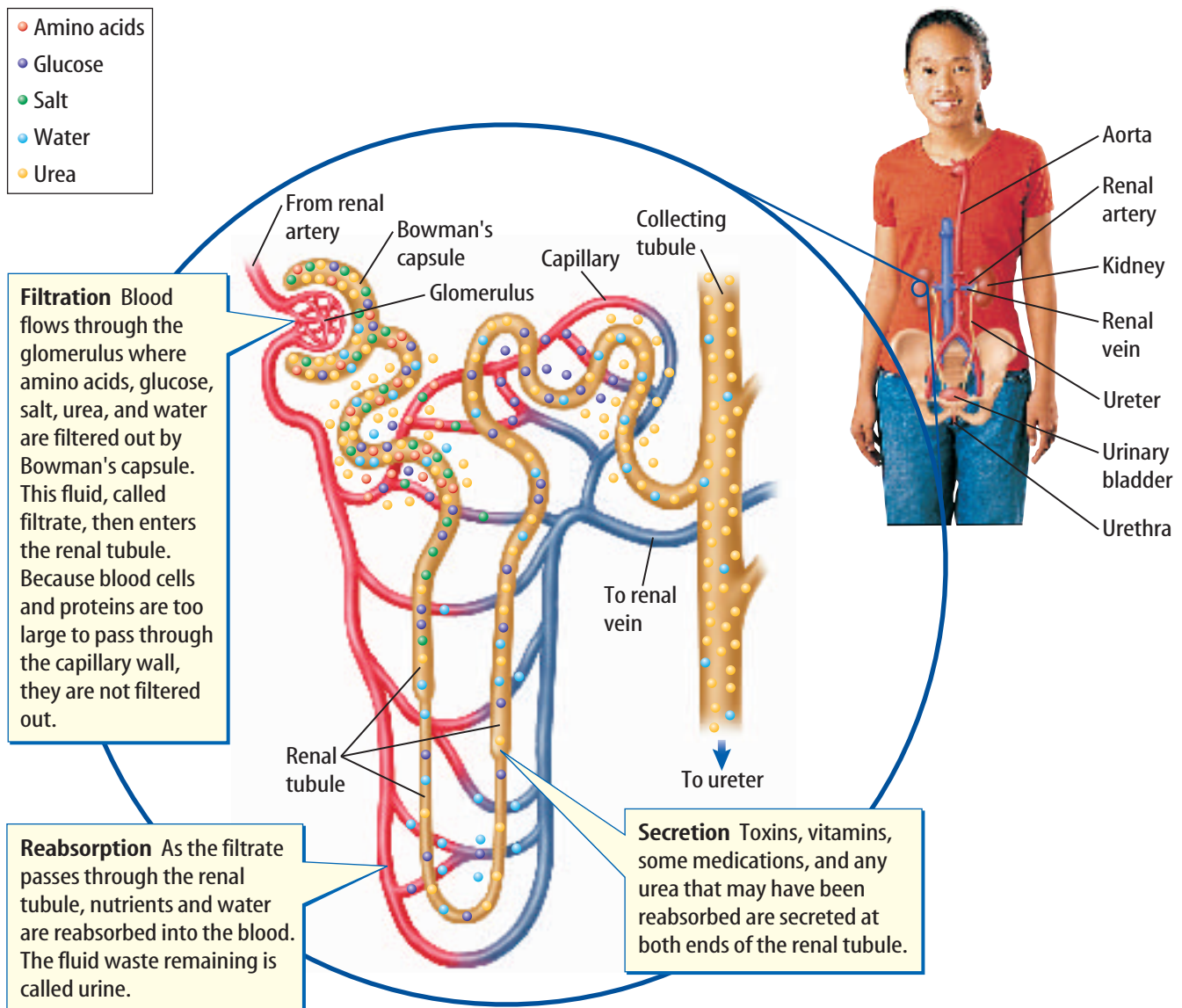
For more practice, visit
[blue.msscience.com/
math_practice](http://blue.msscience.com/math_practice)



Getting Rid of Wastes Carbon dioxide gas is released from your body through the combined efforts of the circulatory and respiratory systems. But CO₂ isn't the only waste product of the body. Earlier you read that undigested material is eliminated by your digestive system. Some salts also are given off when you sweat. All of these systems function together to make up your excretory system. The removal of waste products, or **excretion**, is an important life process in all organisms. If wastes aren't removed, they can build up to toxic levels and damage cells and eventually the whole organism.

Figure 11 Waste products are removed from blood in the kidneys by nephrons. Three processes occur in nephrons—filtration, secretion, and reabsorption.

Another body system that removes wastes is the urinary system, as shown in **Figure 11**. The main organs of the urinary system are two bean-shaped kidneys. All of your blood passes through the kidneys many times each day. The kidneys remove cell wastes and help control the amount of water in the blood.





Nephrons The kidney is made up of millions of tiny units, called nephrons, where the blood is filtered. Each nephron has a cuplike structure and a snakelike tubule. Water, salt, sugar, and wastes from your blood first pass into the cuplike structure and then into the tubule. Capillaries surrounding the tubule reabsorb most of the water, sugar, and salt and return them to the blood. Anything left behind is waste. The waste liquid, urine, contains excess water, salts, and other wastes, and eventually is eliminated from the body.

Interdependence of Body Systems

The human body has the remarkable ability to sense changes in its environment and to respond by making changes in body functions. As a result of the changes in functions, your body's internal environment is kept stable. The process by which the body maintains a stable internal environment is called **homeostasis**.

Reading Check *What is homeostasis?*

You probably know how your heart rate and breathing increase as you exercise. These bodily changes are direct responses to the increased level of activity. During exercise, your leg muscle cells use more and more oxygen and produce lots of carbon dioxide waste. You are not even aware that your brain responds to these internal changes and directs your heart and lungs to work harder. This delivers oxygen to your muscle cells and eliminates carbon dioxide at a faster rate.

When the body becomes overheated, as shown in **Figure 12**, it responds in a coordinated way to maintain homeostasis. The brain senses the increase in internal temperature and directs the body to make changes that will keep it from becoming too hot. Sweating, for example, is one response to an increase in temperature. As sweat evaporates, it cools the skin. Another response is the widening or dilation of blood vessels in the skin. Dilation helps release body heat.



Figure 12 The regulation of body temperature is a familiar example of homeostasis. **Describe** what happens when the body becomes too hot.



Topic: Negative Feedback

Visit blue.msscience.com for Web links to information about negative feedback.

Activity Make a model of a simple negative feedback system.

Negative Feedback Most body systems maintain homeostasis by the action of negative feedback mechanisms. In a **negative feedback** mechanism, the body changes an internal condition back to its normal state. The responses that occur when you exercise or your body becomes overheated are examples of negative feedback.

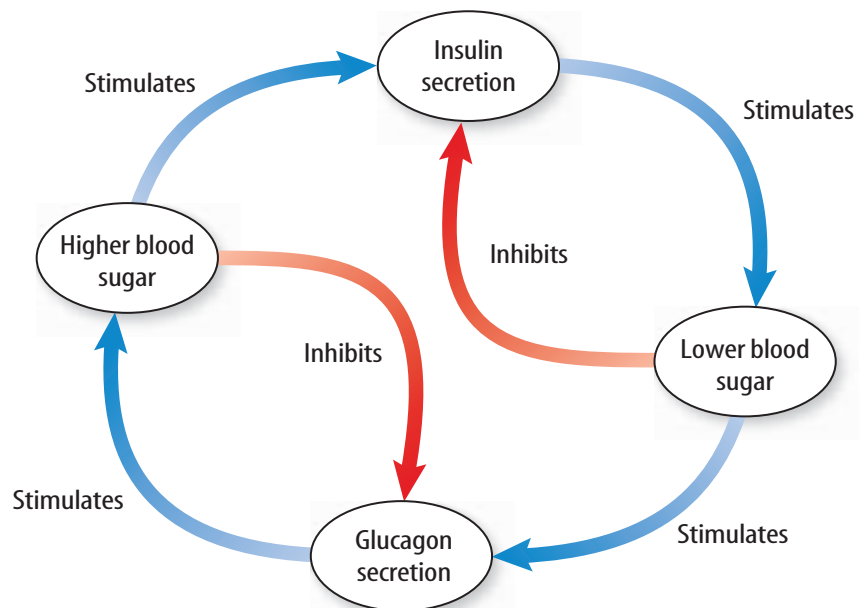
Reading Check *What type of mechanism is used by most body systems to maintain homeostasis?*

Blood pressure also is controlled by a negative feedback system. Specialized cells within the walls of major arteries are sensitive to changes in blood pressure. If blood pressure rises, a message is relayed to the brain signaling this internal change. The brain responds by sending a message to the heart to slow down—an action that decreases blood pressure.

Maintaining Chemical Balance Negative feedback is important for maintaining a proper chemical balance in the body. **Figure 13** shows what occurs when you eat and the glucose concentration in your blood rises above normal. Glucose is a type of sugar. When glucose levels are too high, a hormone called insulin is secreted by the pancreas. Insulin stimulates the absorption of glucose by cells and the liver's conversion of glucose into glycogen. Glycogen is a sugar that can be stored in the liver and muscle cells. As glucose levels decrease, less insulin is produced. A hormone called glucagon (GLEW kuh gahn) is produced when glucose levels are too low. Glucagon stimulates the liver's conversion of stored glycogen into glucose. Glucose is released into the blood. As glucose levels increase, less glucagon is produced.

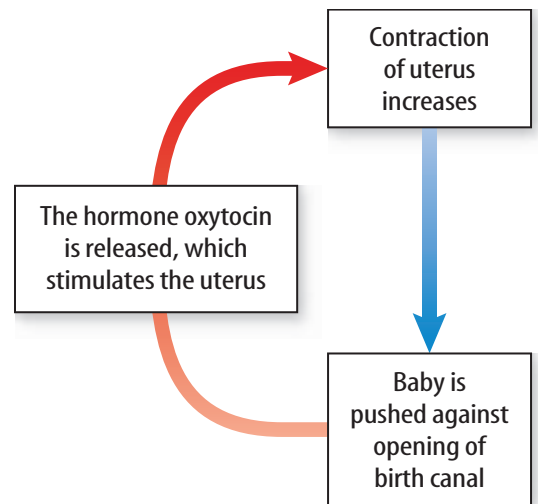
Figure 13 A negative-feedback response within the pancreas regulates blood sugar levels.

Describe *what would happen to blood sugar levels if the pancreas did not secrete enough insulin.*





Positive Feedback In a healthy body, positive feedback mechanisms are rare. The term *positive* means that when a change from the normal state occurs, the positive feedback mechanism does not restore the body to a normal state. It causes an even greater change. One example of positive feedback is the contraction of the uterus during childbirth, as shown in **Figure 14**. Contractions of the uterus push the baby against the opening of the birth canal. When the brain senses this change, it signals the uterus to increase contractions. The positive feedback mechanism continues until the baby passes through the birth canal.



Blood Clotting Another example of a positive feedback response is blood clotting. When a blood vessel is cut or torn, the vessel constricts and chemicals are released. The walls of the vessel also become sticky and adhere to each other. Platelets attach to the vessel walls. This causes more of the chemicals to be released. Therefore, more platelets become sticky and adhere to one another. When the hole is plugged, the process stops. The clot becomes hard, white blood cells destroy any bacteria, and skin cells begin to repair the hole.

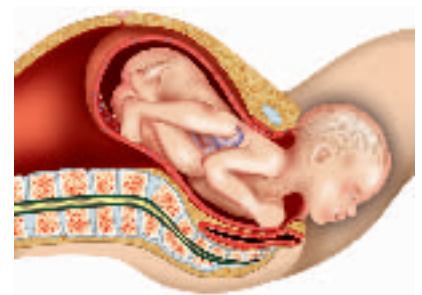


Figure 14 A positive feedback response within the uterus stimulates contractions during childbirth.

In this chapter, you've read that the human body is a complex, yet highly organized structure. It is a natural system made up of individual parts that carry out specific jobs. As in all large systems, proper functioning at all levels is necessary for the health of the entire system.

SECTION 2 REVIEW

Summary

Feeding Cells

- Your digestive and circulatory systems work together to feed cells.

Energy for the Body

- The process of cellular respiration combines food and oxygen to release energy for use by the cell.
- The circulatory, respiratory, and excretory systems remove wastes from the body.

Interdependence of Body Systems

- Your body systems work together to maintain homeostasis.
- Negative feedback systems help the body maintain homeostasis.

Self Check

1. **Discuss** how the digestive and circulatory systems work together to get food to cells.
2. **Compare and contrast** negative and positive feedback mechanisms.
3. **Infer** why a circulatory system disorder might be harmful to other body systems.
4. **Think Critically** Discuss the similarities between the villi of the small intestine and alveoli of the lungs.

Applying Skills

5. **Communicate** In your Science Journal, write a short paragraph that compares the structure and organization of the human body to a sports team.

Does exercise affect respiration?

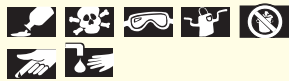
Goals

- **Observe** the effect of carbon dioxide on the bromthymol blue indicator solution.
- **Predict** how exercise will affect the amount of carbon dioxide that is exhaled by the body.

Possible Materials

- graduated cylinder
- large beakers (2)
- straws (2)
- balloons (2)
- bromthymol blue indicator solution (200 mL)
- stopwatch
- *clock with a second hand*
- glass-marking pencil
- *Alternate materials*

Safety Precautions



Real-World Question

When you exercise, muscle cells in your body use up a lot of energy. Carbon dioxide is a waste product of respiration, the energy-releasing process in your cells. Does exercise affect the amount of carbon dioxide exhaled by the lungs?

Form a Hypothesis

Make a hypothesis about how exercise affects respiration. Will exercise increase or decrease the amount of carbon dioxide you exhale?



Test Your Hypothesis

Make a Plan

1. As a group, predict how exercise will affect the amount of carbon dioxide exhaled by the lungs. Identify a way that you can test your hypothesis.
2. **List** the steps you will follow to test your hypothesis. Be sure to describe exactly what you will do in each step.
3. Make a data table in your Science Journal to record your observations.
4. Read over your entire experimental procedure. Do the steps make sense? Are they arranged in the correct order?

Follow Your Plan

1. Make sure your teacher approves your plan and your data table before you start.
2. Carry out the experiment according to the approved plan.
3. **Record** all of your observations in your data table.

Analyze Your Data

1. What caused the indicator solution to change color? Describe the color change.
2. **Compare** the time it took the bromthymol blue indicator solution to change color before exercising and after exercising.
3. **Compare** your results with the results of other groups in your class.

Conclude and Apply

1. **Explain** whether the results supported your hypothesis.
2. **Describe** how exercise affects the amount of carbon dioxide you exhale.

Communicating Your Data

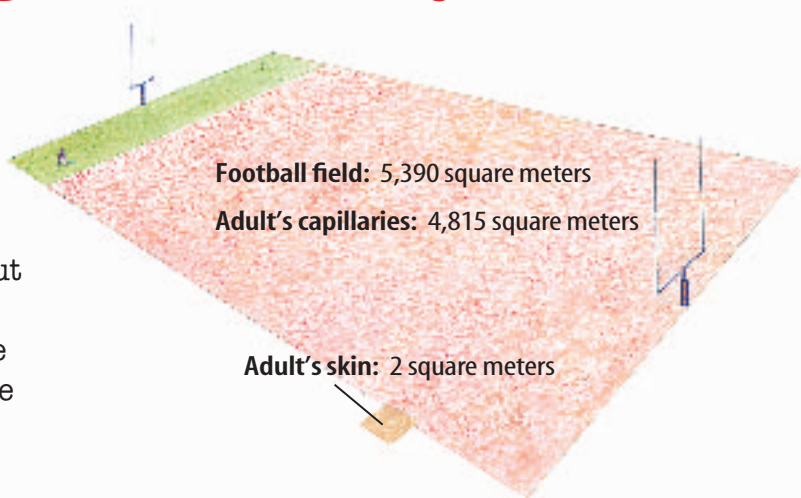
Prepare a poster project showing how increasing levels of activity affect the production of carbon dioxide. Include photos, a data table, and a step-by-step procedure.



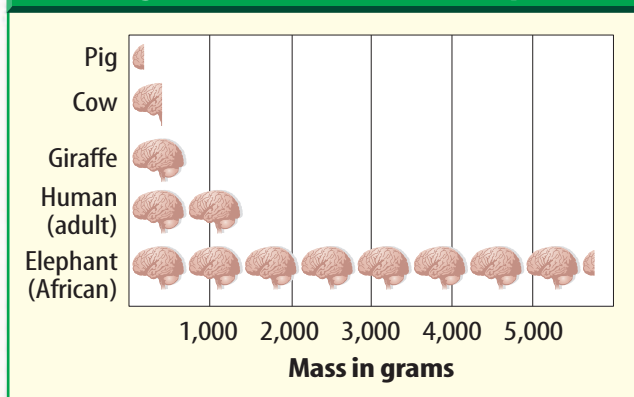
Astonishing Human Systems

Did you know...

...If all the capillaries in an adult's body were flattened, they would cover an area of about 4,815 m², or about 90 percent of the area of a football field. In comparison, the total surface area of the average adult's skin is only 2 m².



Average Brain Mass of Different Species



...More than half of the bones in your body are in your hands and feet. Your skeleton has 206 bones. There are 27 bones in each hand and 26 bones in each foot.

Applying Math Use a circle graph to show the percentages of bones in your hands, feet, and the rest of your body.

Find Out About It

Draw an events-chain concept map showing either the steps in the digestion process, excretory process, or process of respiration. For help, visit blue.msscience.com/science_stats.

Reviewing Main Ideas

Section 1 The Human Organism

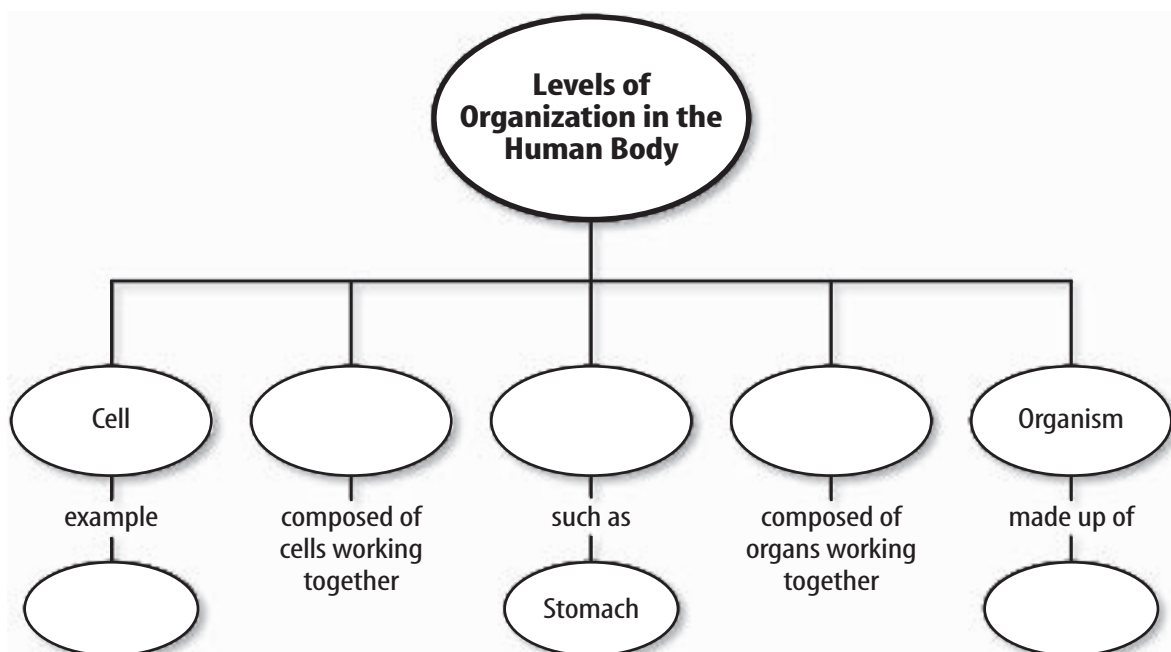
1. Your body is a complex, organized structure.
2. Minerals are inorganic substances that your body needs for good health and to fight disease.
3. Water plays a role in nearly every body function.
4. All living things are made up of four groups of organic chemicals—carbohydrates, lipids, nucleic acids, and proteins.
5. Cells are composed of organic and inorganic chemicals.
6. Complex organisms are made of organ systems, organ systems are made of organs, organs are made of tissues, tissues are made of cells, and cells are made of chemicals.

Section 2 How Your Body Works

1. Organ systems in your body do not work alone. They are interdependent and work together to perform all of the body's functions.
2. Energy is transported to your cells by the combined efforts of the digestive and circulatory systems.
3. Waste products are removed from your body by the combined efforts of the circulatory, respiratory, and excretory systems.
4. Body systems work together to maintain homeostasis.
5. Homeostasis is maintained through negative feedback mechanisms, which help return the body to a normal state.

Visualizing Main Ideas

Copy and complete the following concept map.



Using Vocabulary

| | |
|---------------------------|------------------------|
| absorption p.75 | mineral p.65 |
| alveoli p.77 | negative feedback p.80 |
| cell p.68 | organ p.70 |
| cellular respiration p.76 | organic compound p.66 |
| digestion p.74 | organ system p.71 |
| enzyme p.75 | tissue p.70 |
| excretion p.78 | villi p.75 |
| homeostasis p.79 | |

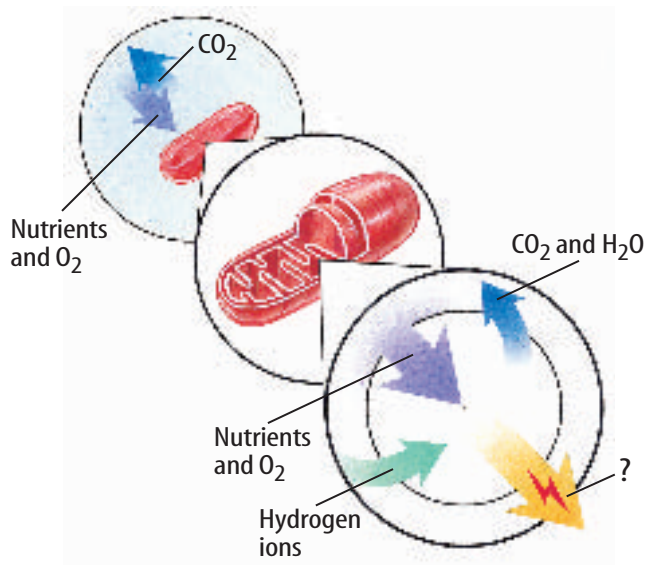
Use what you know about the vocabulary words to explain the differences in the following sets of words. Then explain how the words are related.

- homeostasis—negative feedback
- cell—tissue
- absorption—excretion
- alveoli—villi
- digestion—cellular respiration
- minerals—organic compounds
- organ system—organ
- organic compounds—enzymes
- digestion—absorption

Checking Concepts

- Which chemicals help you digest foods?
A) enzymes C) villi
B) nephrons D) cells
- What is the purpose of sweating?
A) digestion C) respiration
B) homeostasis D) positive feedback
- What is formed when similar types of cells work together?
A) organs C) organelles
B) organ systems D) tissues
- What kind of organic compound is DNA?
A) mineral C) lipid
B) carbohydrate D) nucleic acid

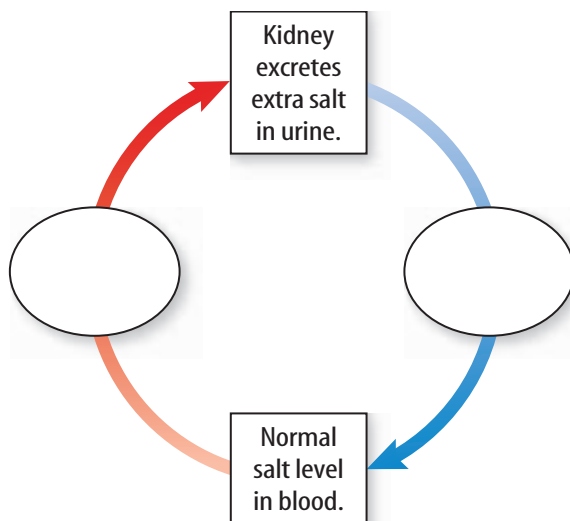
Use the illustration below to answer questions 14 and 15.



- What cell process is illustrated above?
A) excretion C) cellular respiration
B) absorption D) photosynthesis
- What is released at the end of the chemical process shown in the illustration above?
A) oxygen C) carbon dioxide
B) energy D) water
- What are groups of different tissues working together called?
A) organelles C) organs
B) organ system D) organisms
- Where in the lungs are oxygen and carbon dioxide exchanged?
A) nephrons C) villi
B) alveoli D) cells
- What are the filtering, reabsorption, and secretion units of the kidney called?
A) villi C) neurons
B) alveoli D) nephrons
- What type of mechanism helps return the body to a normal state?
A) digestive C) negative feedback
B) respiratory D) positive feedback

Thinking Critically

- 20. **Explain** why a kidney disorder could disrupt the chemical balance of the body.
- 21. **Explain** why food needs to be digested before cells can use it for energy.
- 22. **Infer** why muscle cells have more mitochondria than skin cells.
- 23. **Describe** what might happen if your body had no way of detecting internal temperature changes.
- 24. **Discuss** an example, not given in this chapter, of how two of your body systems work together.
- 25. **Classify** You're stranded on an island and equipped with only a microscope. Describe what you could do to determine whether an unknown object is from a living or a nonliving thing.
- 26. **Compare and contrast** the levels of organization in the human body to the organization of a book.
- 27. **Concept Map** Study the cycle concept map in **Figure 13**. Copy and complete this cycle concept map, which shows how salt levels are maintained in the body.



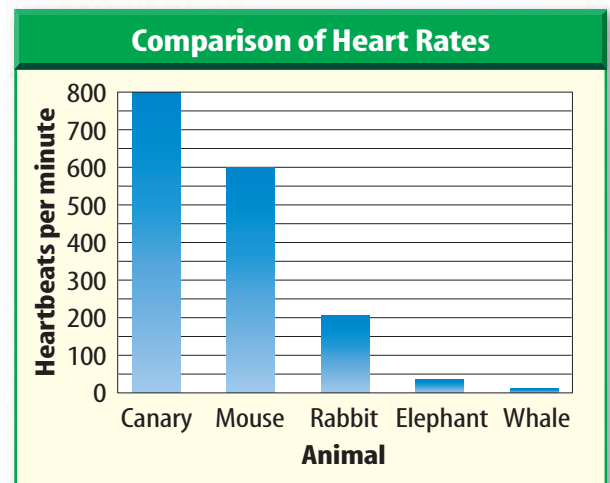
Performance Activities

- 28. **Experiment** Design an experiment to show that the process of respiration occurs in living yeast cells.
- 29. **Models** Using assorted household materials such as cardboard, foam, pipe cleaners, yarn, buttons, dry macaroni, or other small objects, construct a three-dimensional model of a human cell. On a separate sheet of paper, make a key to indicate which materials represent the different cell parts.

Applying Math

- 30. **New Skin** If the human body replaces the top layer of skin every 15 to 30 days, how many times per year does the body have a new top layer of skin?

Use the graph below to answer question 31.



- 31. **Heart Rate** Smaller animals have faster heart rates than larger animals. Using the graph above, estimate how many times faster a mouse's heart beats when compared to an elephant's heart. How many times faster does a canary's heart beat when compared to a rabbit's heart?

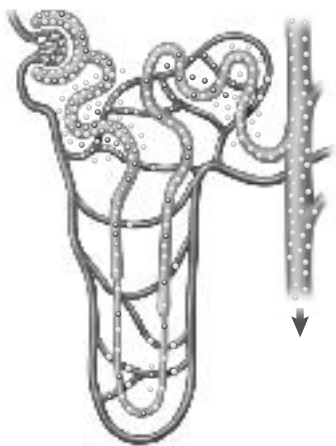
Part 1 Multiple Choice

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

1. Which of the following is a chemical compound?

- A. H₂
- B. CO₂
- C. O₂
- D. Cl

Use the illustration below to answer questions 2–4.



2. What structure is shown in the illustration?

- A. capillary
- B. alveolus
- C. nephron
- D. ureter

3. What is the function of the structure shown in the illustration?

- A. filtration
- B. digestion
- C. ingestion
- D. inspiration

4. If there are approximately one million of these structures in one kidney, approximately how many of these structures are present in your body?

- A. 1 million
- B. 0.5 million
- C. 2 million
- D. 10 million

Test-Taking Tip

Study Aid Do not “cram” the night before the test. It can hamper your memory and make you tired.

5. Which of the following is the main energy source for your body?

- A. protein
- B. lipids
- C. carbohydrates
- D. minerals

Use the table below to answer questions 6 and 7.

| 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 |

6. According to the information in this table, which of the following activities caused Ashley's pulse to be less than 100 beats per minute?

- A. Activity 2
- B. Activity 3
- C. Activity 4
- D. Activity 5

7. A reasonable hypothesis based on these data is that during Activity 2, Ashley was probably

- A. sprinting.
- B. marching.
- C. sitting down.
- D. walking slowly.

8. Which of the following is a function of protein in your body?

- A. direct cell activities
- B. provide energy
- C. make structural body parts
- D. store energy

9. Which of the following is NOT a type of human cell?

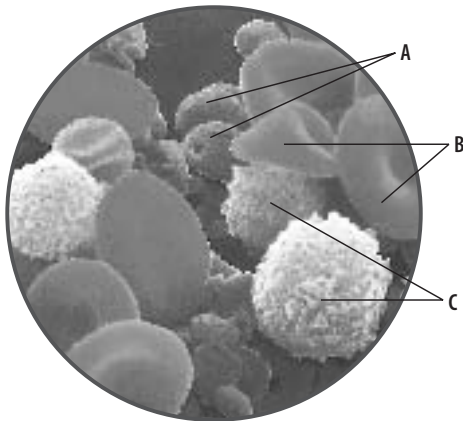
- A. epithelial cell
- B. muscle cell
- C. red cell
- D. cavity cell

Part 2 Short Response/Grid In

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

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

Use the photo below to answer questions 12 and 13.



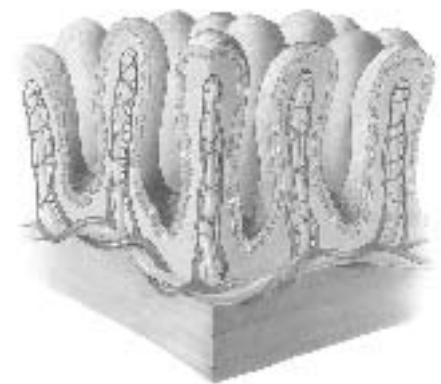
- Identify the blood components labeled A. How do they help your body maintain homeostasis?
- Thrombocytopenia is a condition in which the number of platelets in the blood is decreased. How would this affect the body?
- At birth, your skeleton has approximately 300 bones. Some bones fused together as you developed. Now you have 206 bones. How many fewer bones do you have now?
- If a cardiac muscle contracts about 70 times per minute, how many times does it contract in a day?

Part 3 Open Ended

Record your answers on a sheet of paper.

- Compare and contrast organic and inorganic substances. Give an example of each that is important for the human body.
- Smooth muscle, found in the walls of blood vessels, controls the narrowing and widening of these vessels. What might happen to your body temperature if blood vessels in the skin did not contain smooth muscle?
- Which body systems remove wastes? Discuss how these systems remove the wastes.
- Urine can be tested for any signs of a urinary tract disease. Mrs. Chavez had a urine test that showed protein in the urine. Is protein normally present in the urine? Explain. What might the results of this urine test mean?

Use the illustration below to answer questions 20 and 21.



- In which body system would you find these structures? Explain the function of these structures.
- If a person had fewer of these structures than normally present, how would the person be affected? Explain.