INTEGRATING

SECTION 1

Body Organization and Homeostasis

MR. PIERRO

DISCOVER

ACTIVITY

How Do You Lift Books?

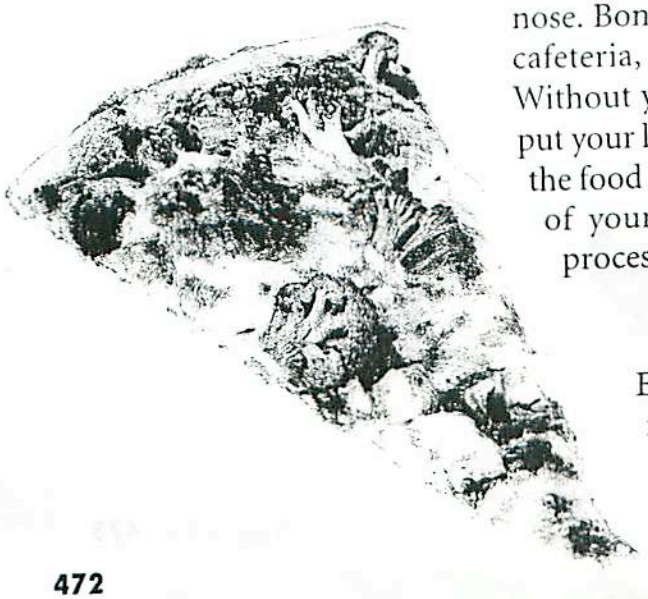
1. Stack one book on top of another one.
2. Lift the two stacked books in front of you so the lowest book is about level with your shoulders. Hold the books in this position for 30 seconds. While you are performing this activity, note how your body responds. For example, how do your arms feel at the beginning and toward the end of the 30 seconds?
3. Balance one book on the top of your head. Walk a few steps with the book on your head.

Inferring List all the parts of your body that worked together as you performed the activities in Steps 1 through 3.

GUIDE FOR READING

- What are the levels of organization in the body?
- What are the four basic types of tissue in the human body?
- What is homeostasis?

Reading Tip Before you read, preview *Exploring Levels of Organization in the Body.* Write down any unfamiliar words. Then, as you read, write their definitions.



The bell rings—lunchtime at last! You hurry down the noisy halls toward the cafeteria. The unmistakable aroma of hot pizza makes your mouth water. At last, after waiting in line, you pick up a plate with a slice of pizza and some salad. When you get to the cashier, you dig in your pocket for lunch money. Then, carefully balancing your tray, you scan the crowded cafeteria for your friends. You spot them, walk to their table, sit down, and begin to eat.

Think for a minute about how many parts of your body were involved in the simple act of getting and eating your lunch. You heard the bell with your ears and smelled the pizza with your nose. Bones and muscles worked together as you walked to the cafeteria, picked up your food, and sat down at the table. Without your brain, you couldn't have remembered where you put your lunch money. Once you began to eat, your teeth chewed the food and your throat muscles swallowed it. Then other parts of your digestive system, such as your stomach, began to process the food for your body to use.

Every minute of the day, whether you are eating, studying, playing basketball, or even sleeping, your body is busily at work. Each part of the body has a specific job to do, and all the different parts work together. This

smooth functioning is due partly to the way in which the human body is organized. **The levels of organization in the human body consist of cells, tissues, organs, and organ systems.** The smallest unit is the cell, and the largest is the organ system.

A cell is the basic unit of structure and function in a living thing. Complex organisms are composed of many cells in the same way a building is composed of many bricks. The human body contains about 100 trillion cells. Cells are quite tiny, and most cannot be seen without a microscope.

Most animal cells, including those in the human body, have a structure similar to the cell in Figure 1. The **cell membrane** forms the outside boundary of the cell. Inside the cell membrane is a large structure called the **nucleus.** The nucleus is the control center that directs the cell's activities and contains information that determines the cell's characteristics. When the cell divides, or reproduces, this information is passed on to the newly formed cells. The area between the cell membrane and the nucleus is called the **cytoplasm.** The cytoplasm contains a clear, jellylike substance in which many important cell structures, called organelles, are found.

Cells carry on the processes that keep organisms alive. Inside cells, for example, molecules from digested food undergo chemical reactions that provide energy for the body's activities. Cells also get rid of waste products, grow, and reproduce. For more information on cells, look back at Chapters 1 and 2.

Checkpoint *What is the function of the nucleus?*

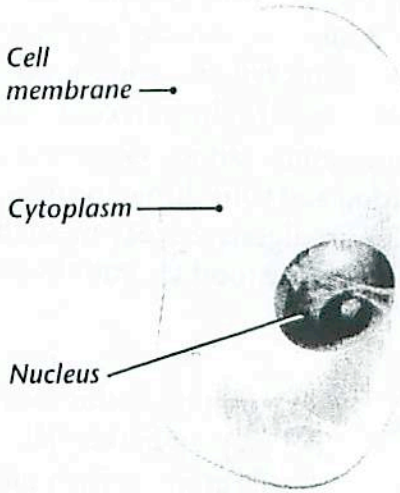


Figure 1 The cells in your body are surrounded by a cell membrane, and most have a nucleus. The cytoplasm is the area between the cell membrane and the nucleus.

In this activity, you will analyze the levels of organization in a book.

1. Examine this textbook to see how it is subdivided—into chapters, sections, and so on.
2. Make a concept map that shows this pattern of organization. Place the largest subdivision at the top of the map and the smallest at the bottom.
3. Compare the levels of organization in this book to those in the human body.

Making Models Which level of organization in the book represents cells? Which represent tissues, organs, and organ systems?

Tissue is the next largest unit of organization in your body. A **tissue** is a group of similar cells that perform the same function. **The human body contains four basic types of tissue: muscle tissue, nerve tissue, connective tissue, and epithelial tissue.** To see examples of each of these tissues, look at Figure 2.

Like the muscle cells that form it, **muscle tissue** can contract or shorten. By doing this, muscle tissue makes parts of your body move.

While muscle tissue carries out movement, nerve tissue directs and controls it. **Nerve tissue** carries messages back and forth between the brain and every other part of the body. Your brain is made up mostly of nerve tissue.

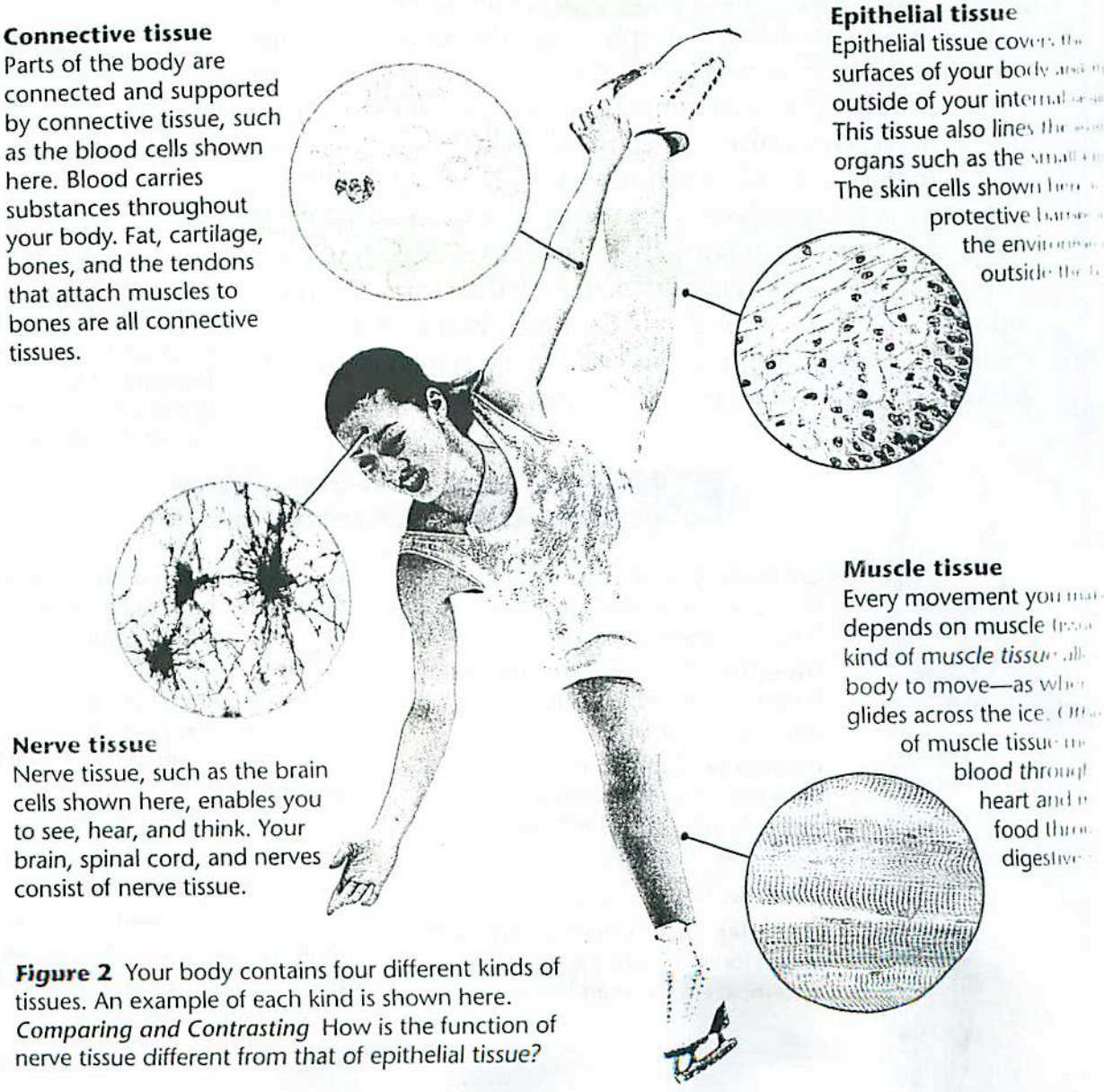


Figure 2 Your body contains four different kinds of tissues. An example of each kind is shown here. *Comparing and Contrasting* How is the function of nerve tissue different from that of epithelial tissue?

Connective tissue provides support for your body and connects all its parts. Bone is one kind of connective tissue; its strength and hardness support your body and protect its internal structures. Fat is also a connective tissue. It pads parts of your body, provides insulation from cold, and stores energy.

Epithelial tissue (ep uh THEE lee ul) covers the surfaces of your body, inside and out. Some epithelial tissue, such as the outermost layer of your skin, protects the delicate structures that lie beneath it. Other kinds of epithelial tissue absorb or release substances. The lining of your digestive system consists of epithelial tissue that releases chemicals used in digestion.

gans and Organ Systems

Your stomach, heart, brain, and lungs are all organs. An **organ** is a structure that is composed of different kinds of tissue. Like a tissue, an organ performs a specific job. The job of an organ, however, is generally more complex than that of a tissue. The heart, for example, pumps blood throughout your body, over and over again. The heart contains all four kinds of tissue—muscle, nerve, connective, and epithelial. Each tissue type contributes to the overall job of pumping blood.

Each organ in your body is part of an **organ system**, a group of organs that work together to perform a major function. Your heart is part of your circulatory system, which carries oxygen and other materials throughout the body. Besides the heart, blood vessels are organs in the circulatory system. Figure 3 describes the major organ systems in the human body.

Figure 3 The human body is made up of eleven organ systems. *Interpreting Charts* Which two systems work together to get oxygen to your cells?

Organ Systems in the Human Body

Circulatory Carries needed materials to the body cells; carries wastes away from body cells; helps fight disease.

Digestive Takes food into the body, breaks food down, and absorbs the digested materials.

Endocrine Controls many body processes—such as intake of sugar by cells—by means of chemicals.

Excretory Removes wastes.

Immune Fights disease.

Muscular Enables the body to move; moves food through the digestive system; keeps the heart beating.

Nervous Detects and interprets information from the environment outside the body and from within the body; controls most body functions.

Reproductive Produces sex cells that can unite with other sex cells to create offspring; controls male and female characteristics.

Respiratory Takes oxygen into the body and eliminates carbon dioxide.

Skeletal Supports the body, protects it, and works with muscles to allow movement; makes blood cells and stores some materials.

Skin Protects the body, keeps water inside the body, and helps regulate body temperature.

The different organ systems work together and depend on one another. You can compare the functioning of the human body to the work it takes to put on a school play. A play needs actors, of course, but it also needs a director, someone to make the costumes, and people to sell tickets. Similarly, when you ride a bike, you use your muscular and skeletal systems to steer and push the pedals. But you also need your nervous system to direct your arms and legs to move. Your respiratory, digestive, and circulatory systems work together to fuel your muscles with the energy they need. And your excretory system removes the wastes produced while your muscles are hard at work.

The systems of the body work together to maintain **homeostasis** (hoh mee oh STAY sis), the body's tendency to keep an internal balance. **Homeostasis is the process by which an organism's internal environment is kept stable in spite of changes in the external environment.**

To see homeostasis in action, all you have to do is take your temperature when the air is cold. Then take it again in an overheated room. No matter what the temperature of the air around you, your internal body temperature will be close to 37 degrees Celsius, as long as you are healthy. If you get sick, your body temperature may rise. But when you get well again, it returns to 37 degrees.

Figure 4 The air is cold and the ground is covered with snow. In spite of the chill, the body temperatures of these sledders remain fairly constant at about 37° Celsius.
Applying Concepts What is the term for the body's tendency to maintain a stable internal environment?

Your body has various ways of maintaining homeostasis. For example, you need food and water to stay alive. When your body is low on either of these substances, your brain sends signals that result in your feeling hungry or thirsty. When you eat or drink, you maintain homeostasis by providing your body with substances that it needs.

Stress and Homeostasis

The school play is about to begin. Nervously, you walk out on stage. Your heart is beating rapidly and your breathing quickens. Your body's reactions are signs of stress. **Stress** is the reaction of your body and mind to threatening, challenging, or disturbing events. Many things can act as stressors, or events that cause stress. A snarling dog, an argument with a friend, or an upcoming oral report can all be stressors. Stress upsets homeostasis, and your body reacts in specific ways.

Physical Responses to Stress Figure 5 shows what happens in your body within seconds after you experience stress. During this stage, which is called the alarm stage, your body releases a chemical called adrenaline into your bloodstream. Adrenaline gives you a burst of energy and causes many other changes in your body. These changes prepare you to take quick action.

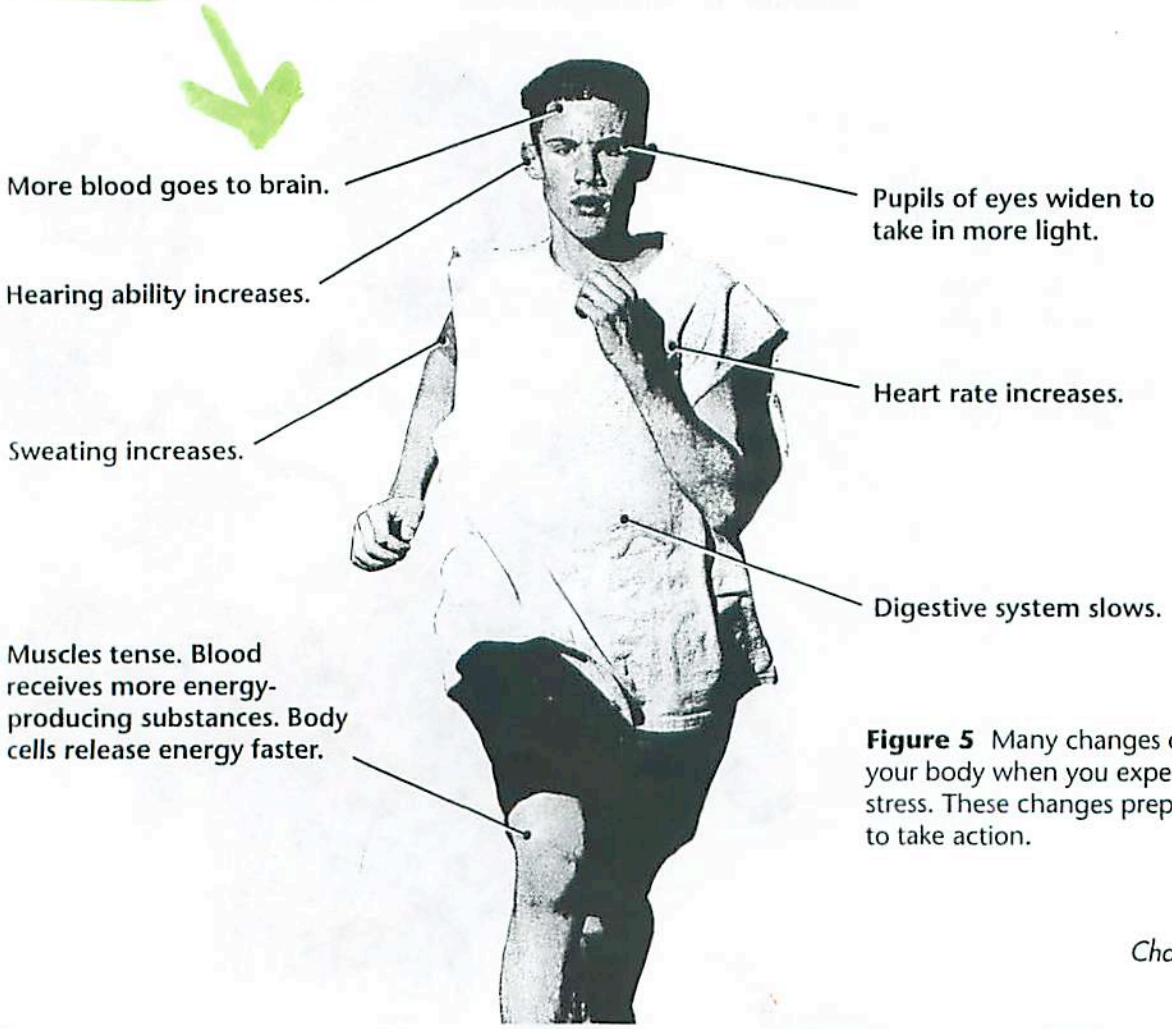


Figure 5 Many changes occur in your body when you experience stress. These changes prepare you to take action.

Language Arts CONNECTION

In Edgar Allan Poe's story, "The Pit and the Pendulum," the author's detailed descriptions paint a vivid picture of a person's physical reactions to a stressor. The character was frightened by a razor-sharp pendulum swinging overhead. "I at once started to my feet, trembling compulsively in every fibre....Perspiration burst from every pore, and stood in cold, big beads upon my forehead."

In Your Journal

Create a situation in which a character faces an extremely stressful situation. Describe the character's physical reactions and feelings. Make sure to use vivid and precise descriptive words that clearly convey the character's reactions.

The effects of adrenaline, which take only a few seconds, are dramatic. Your breathing quickens, sending more oxygen to your body cells to provide energy for your muscles. That extra oxygen gets to your cells rapidly because your heart begins to beat faster. The faster heartbeat increases the flow of blood to your muscles and some other organs. In contrast, less blood flows to your skin and digestive system, so that more is available for your arms and legs. The pupils of your eyes become wider, allowing you to see better.

Fight or Flight The reactions caused by adrenaline are sometimes called the "fight-or-flight" response, because they prepare you either to fight the stressor or to take flight and escape. Scientists think that the fight-or-flight response was important for primitive people who faced wild-animal attacks and similar dangers. Today, the same reactions still occur with any stressor, whether it is a snarling dog or a social studies test.

During the fight-or-flight response, your body systems work together to respond to the stressor. For example, your respiratory system provides you with extra oxygen, which your circulatory system delivers to the parts of your body that need it. Your muscular system, in turn, works with your skeletal system to help you move—fast.

☑ *Checkpoint During the alarm stage, how do your eyes and ears respond?*

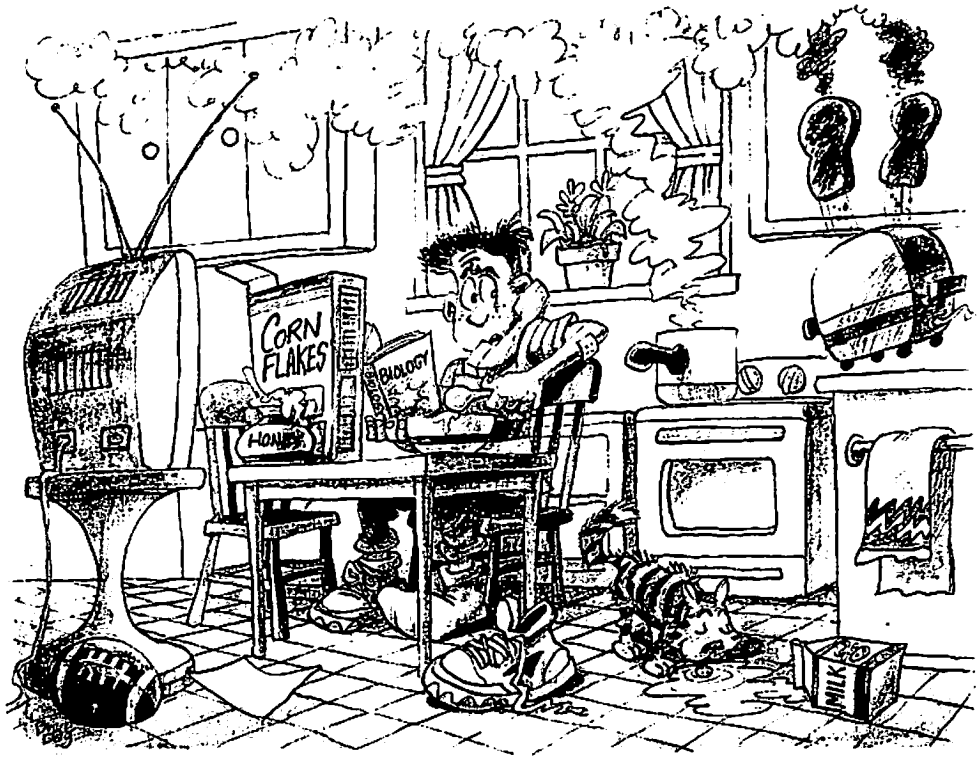


Figure 6 Oops! One sure way to cause stress is to do too many things at once. *Relating Cause and Effect How does stress affect a person's heartbeat and breathing rates?*

The alarm stage of stress only lasts for a short time. If the stress is over quickly, your body soon returns to its normal state. Some kinds of stressors, however, continue for a long time. Suppose, for example, you are stressed because you are moving to a new community. You cannot fight the stressor, and you cannot run away from it either. When a stressful situation does not go away quickly, your body cannot restore homeostasis. If you do not deal with the stress, you may become tired, irritable, and have trouble getting along with others. In addition, you may be more likely to become ill.

Dealing With Stress

Stress is a normal part of life. No one can avoid stress entirely. When you are in a stressful situation, it is important that you recognize it and take action to deal with it, rather than pretending that the stressor doesn't exist. For example, suppose you aren't doing well in math class. If you accept the problem and deal with it—perhaps by asking your teacher for help—your stress will probably decrease.

In addition, when you are experiencing long-term stress, physical activity can help you feel better. Riding a bike, skating, or even raking leaves can take your mind off the stress. It is also important to talk about the situation and your feelings with friends and family members.

Figure 7 When you are under stress, it is important to find ways to relax.

Section 1 Review

1. List the four levels of organization in the human body. Give an example of each level.
2. Name the four types of tissue in the human body. Give an example of where each is located.
3. What is homeostasis?
4. Describe what happens during the alarm stage of stress.
5. **Thinking Critically Applying Concepts** What systems of the body are involved when you prepare a sandwich and then eat it?

CHAPTER PROJECT

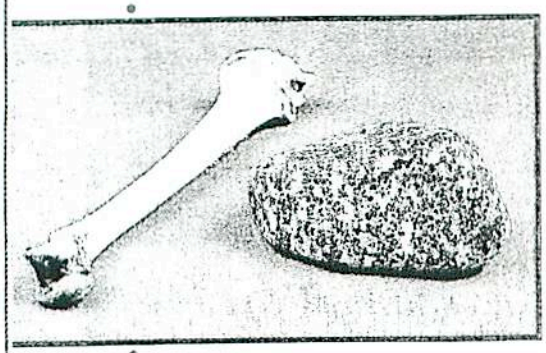
By now, you should have your teacher's approval for modeling the movement you chose. Ask a classmate or friend to perform the movement. Make drawings to study the motion. Find out what bones are involved, and determine their sizes and shapes. (*Hint:* Notice the direction of bone movement and the kinds of joints that are involved.)

SECTION 2

The Skeletal System

DISCOVER ..... **ACTIVITY**

Hard as a Rock?



1. Your teacher will give you a leg bone from a cooked turkey or chicken and a rock.
2. Use a hand lens to examine both the rock and the bone.
3. Gently tap both the rock and the bone on a hard surface.
4. Pick up each object to feel how heavy it is.
5. Wash your hands. Then make notes of your observations.

Observing Based on your observations, why do you think bones are sometimes compared to rocks? List some ways in which bones and rocks are similar and different.

GUIDE FOR READING

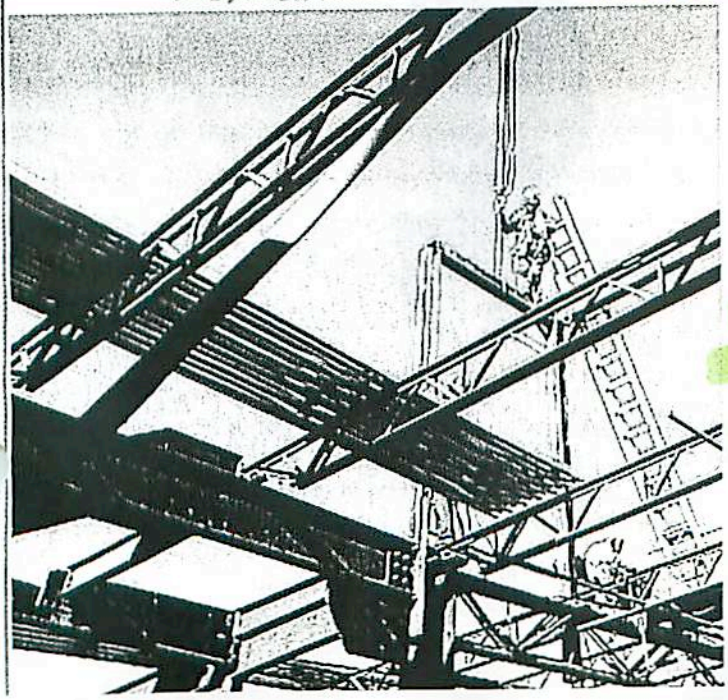
- What are the functions of the skeleton?
- What role do movable joints play in the body?
- How can you keep your bones strong and healthy?

Reading Tip Before you read, rewrite the headings in the section as *how*, *why*, or *what* questions. As you read, write answers to the questions.

ossification →

A construction site is a busy place. After workers have prepared the building's foundation, they begin to assemble thousands of steel pieces into a frame for the building. People watch as the steel pieces are joined to create a rigid frame that climbs toward the sky. By the time the building is finished, however, the building's framework will no longer be visible.

Like a building, you also have an inner framework, but it is made up of bones instead of steel. Your framework, or skeleton, is shown in Figure 9. The number of bones in your skeleton depends on your age. A newborn baby has about 275 bones. An adult, however, has about 206 bones. As a baby grows, some of the bones fuse together. For example, as a baby, you had many more individual bones in your skull than you do now. As you grew, some of your bones grew together to form the larger bones of your skull.



Just as a building could not stand without its frame, you would collapse without your skeleton. **Your skeleton has five major functions. It provides shape and support, enables you to move, protects your internal organs, produces blood cells, and stores certain materials until your body needs them.**

Figure 8 Like the steel beams that support a building, your skeleton supports your body.

Your skeleton determines the shape of your body, much as a steel frame determines the shape of a building. The backbone, or vertebral column, is the center of the skeleton. Locate the backbone in Figure 9. Notice that all the bones of the body are in some way connected to this column. If you move your fingers down the center of your back, you can feel the 26 small bones, or **vertebrae** (VUR tuh bray)(singular **vertebra**), that make up your backbone. Bend forward at the waist and feel the bones adjust as you move. You can think of each individual vertebra as a bead on a string. Just as a beaded necklace is flexible and able to bend, so too is your vertebral column. If your backbone were just one bone, you would not be able to bend or twist.

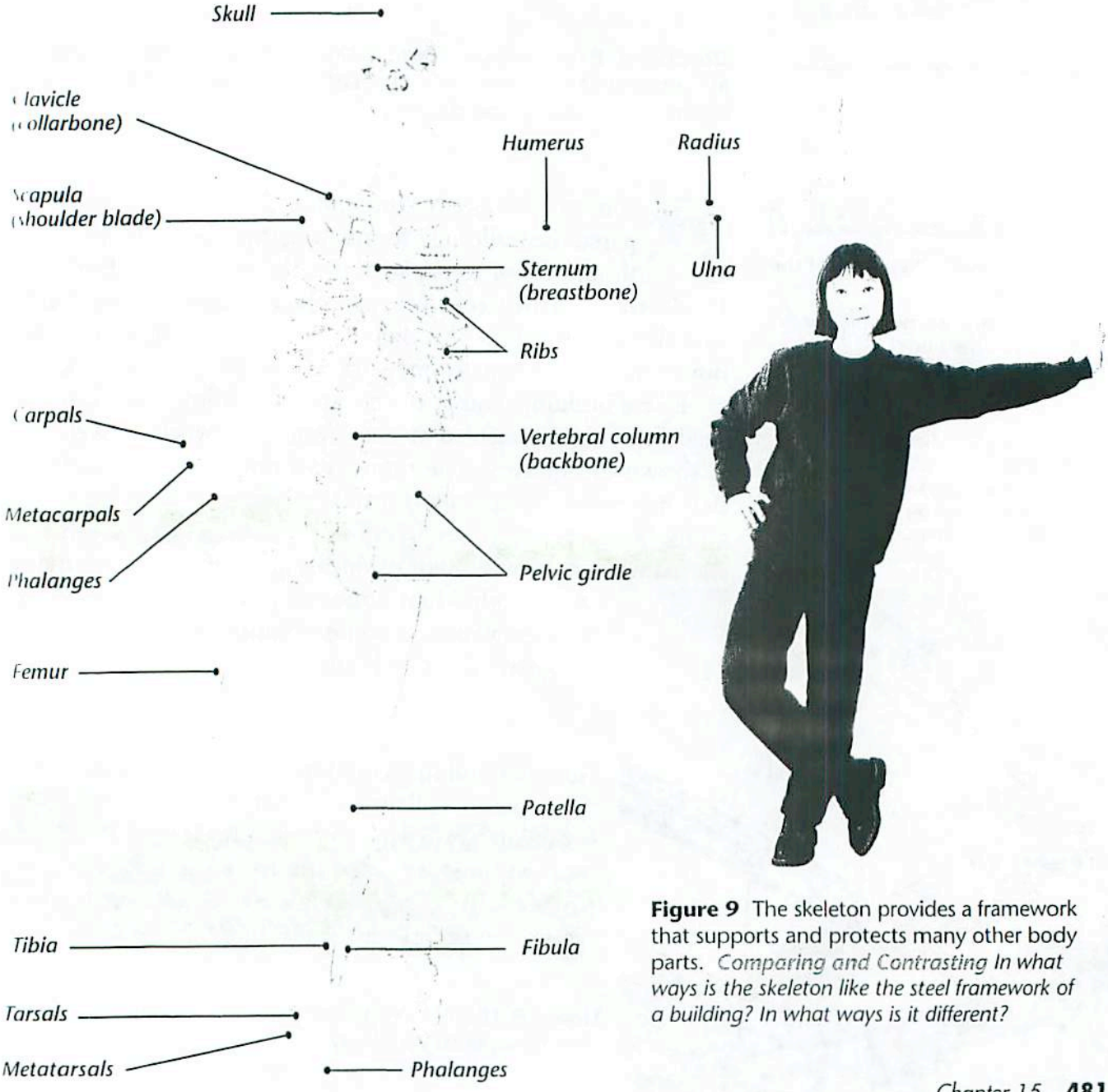


Figure 9 The skeleton provides a framework that supports and protects many other body parts. *Comparing and Contrasting In what ways is the skeleton like the steel framework of a building? In what ways is it different?*

In this activity, you will explore the role that calcium plays in bones.

ACTIVITY

1. Put on protective gloves. Soak one clean chicken bone in a jar filled with water. Soak a second clean chicken bone in a jar filled with vinegar. (Vinegar causes calcium to dissolve out of bone.)
2. After one week, put on protective gloves and remove the bones from the jars.
3. Compare how the two bones look and feel. Note any differences between the two bones.

Drawing Conclusions Based on your results, explain why it is important to consume a diet that is high in calcium.

Your skeleton also allows you to move. Most of the body bones are associated with muscles. The muscles pull on the bones to make the body move. Bones also protect many of the organs in your body. For example, your skull protects your brain, and your breastbone and ribs form a protective cage around your heart and lungs.

Some of the bones in your body produce substances that your body needs. You can think of the long bones of your arms and legs as factories that make blood cells. Bones also store minerals such as calcium and phosphorus. Calcium and phosphorus make bones strong and hard. When the body needs these minerals, the bones release small amounts of them into the blood for use elsewhere.

Checkpoint ***Why is the vertebral column considered the center of the skeleton?***

When you think of a skeleton, you may think of the paper cutouts that are used as decorations at Halloween. Many people connect skeletons with death. The ancient Greeks did, too. The word *skeleton* actually comes from a Greek word meaning "a dried body." The bones of your skeleton, however, are not dead at all. They are very much alive.

Bone Strength Your bones are both strong and lightweight. In fact, bones are so strong that they can absorb more force without breaking than can concrete or granite rock. Yet, bones are much lighter than these materials. In fact, only about 20 percent of an average adult's body weight is bone.

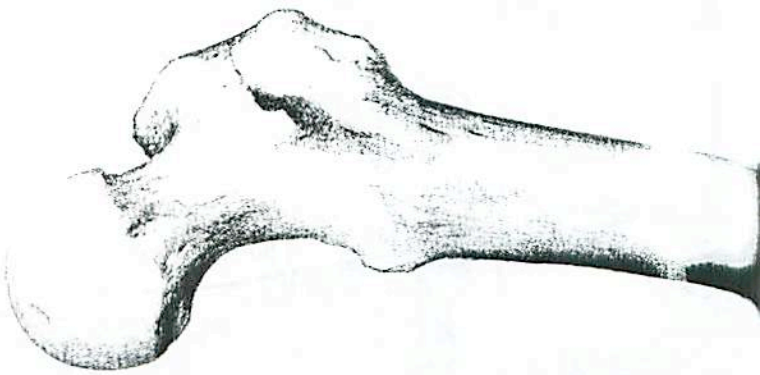


Figure 10 The most obvious feature of a long bone, such as the femur, is its long shaft, which contains compact bone. Running through compact bone is a system of canals that bring materials to the living bone cells. One canal is seen in the photograph. *Interpreting Diagrams What different tissues make up the femur?*

Have you ever heard the phrase "as hard as a rock"? Most rock is hard because it is made up of minerals that are packed tightly together. In a similar way, bones are hard because they are made up of two minerals—phosphorus and calcium.

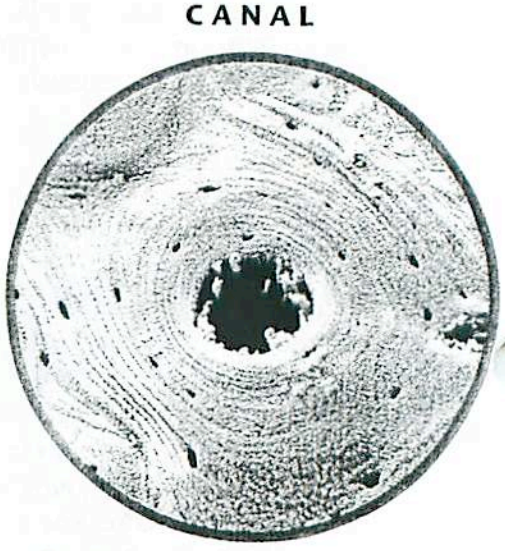
Bone Growth Bones also contain cells and tissues, such as blood and nerves. And, because your bone cells are alive, they form new bone tissue as you grow. But even after you are grown, bone tissue continues to form within your bones. For example, every time you play soccer or basketball, your bones absorb the force of your weight. They respond by making new bone tissue.

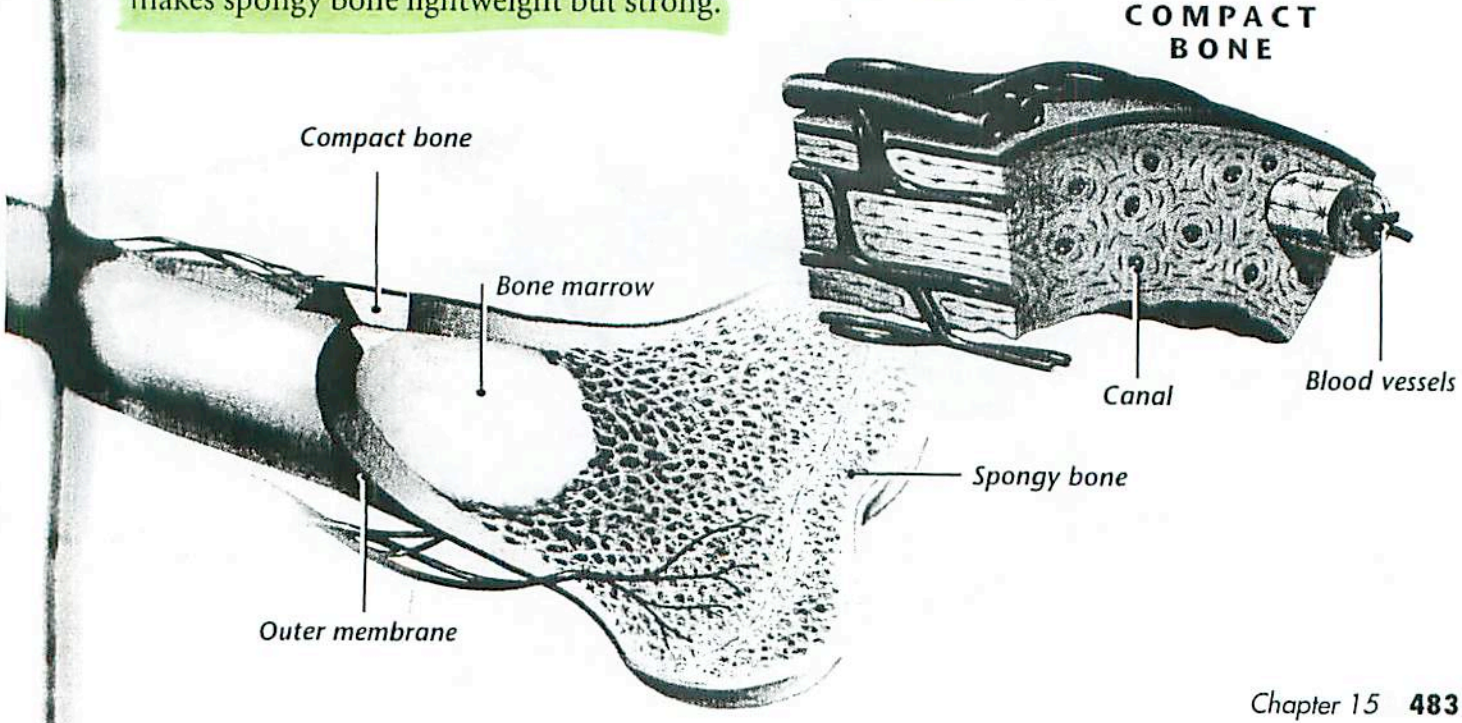
Sometimes, new bone tissue forms after an accident. If you break a bone, for example, new bone tissue forms to fill the gap between the broken ends of the bone. The healed region of new bone may be stronger than the original bone.

The Structure of Bones

Figure 10 shows the structure of the femur, or thighbone. The femur, which is the body's longest bone, connects the pelvic bones to the lower leg bones. Notice that a thin, tough membrane covers all of the bone except the ends. Blood vessels and nerves enter and leave the bone through the membrane. Beneath the membrane is a layer of compact bone, which is hard and dense, but not solid. As you can see in Figure 10, small canals run through the compact bone. These canals carry blood vessels and nerves from the bone's surface to the living cells within the bone.

Just inside the compact bone is a layer of spongy bone. Spongy bone is also found at the ends of the bone. Like a sponge, spongy bone has many small spaces within it. This structure makes spongy bone lightweight but strong.





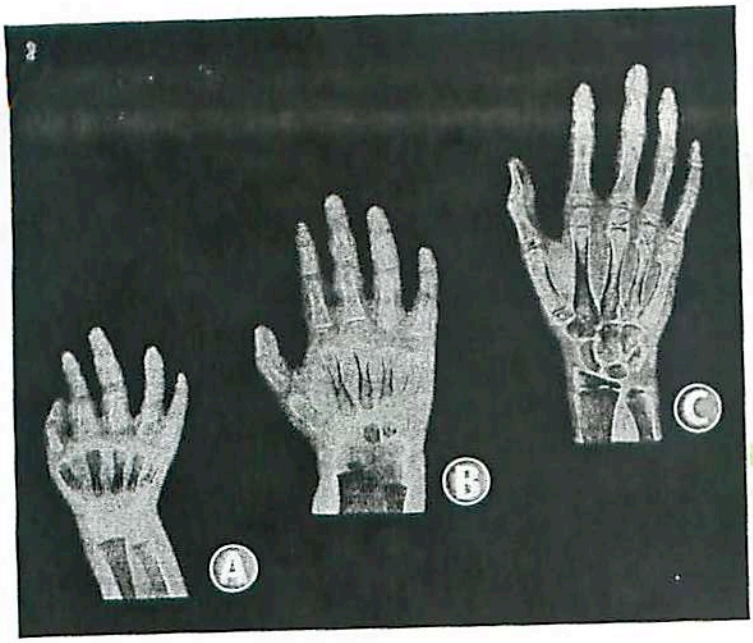


Figure 11 X-rays of the hands of a 1-year-old (A) and a 3-year-old (B) show that the cartilage in the wrist has not yet been replaced by bone. In the X-ray of the 13-year-old's hand (C), the replacement of cartilage by bone is almost complete.

The spaces in bone contain a soft connective tissue called **marrow.** There are two types of marrow—red and yellow. Red bone marrow produces the body's blood cells. As a child, most of your bones contained red bone marrow. As a teenager, only the ends of your femurs, skull, hip bones, and sternum (breastbone) contain red marrow. Your other bones contain yellow marrow. This marrow stores fat, which serves as an energy reserve.

How Bones Form

Try this activity: Move the tip of your nose from side to side between your fingers. Notice that the tip of your nose is not stiff. That is because it contains cartilage. **Cartilage** (KAHR tuh lij) is a connective tissue that is more flexible than bone. As an infant, much of your skeleton was cartilage. Over time, most of the cartilage has been replaced with hard bone tissue.

The replacement of cartilage by bone tissue usually is complete by the time you stop growing. But not all of your body's cartilage is replaced by bone. Even in adulthood, cartilage covers the ends of many bones. For example, in the knee, cartilage acts like a cushion that keeps your femur from rubbing against the bones of your lower leg.

Checkpoint What happens to cartilage as you grow?

Joints of the Skeleton

Imagine what life would be like if your femur ran the length of your leg. How would you get out of bed in the morning? How would you run for the school bus? Luckily, your body contains many small bones rather than fewer large ones. A place in the body where two bones come together is a **joint.** Joints allow bones to move in different ways. There are two kinds of joints in the body—immovable joints and movable joints.

Immovable Joints Some joints in the body connect bones in a way that allows little or no movement. These joints are called immovable joints. The bones of the skull are held together by immovable joints. The joints that attach the ribs to the sternum are also immovable.

Movable Joints Most of the joints in the body are movable joints. **Movable joints allow the body to make a wide range of movements.** Look at *Exploring Movable Joints* to see the variety of movements that these joints make possible.

Sharpen your Skills

Classifying

ACTIVITY

Perform each of the activities listed below:

- move your arm in a circle
- push open a door
- lift a book from a desk
- kneel down
- wave your hand
- twist your head from side to side.

Determine which type of joint or joints is involved in performing each activity. Give a reason to support your classifications.

EXPLORING *Movable Joints*

Without movable joints, your body would be as stiff as a board. The four types of movable joints shown here allow your body to move in a variety of ways.

Ball-and-socket joint Ball-and-socket joints allow the greatest range of motion. In your shoulder, the top of the arm bone fits into the deep, bowl-like socket of the scapula (shoulder blade). The joint allows you to swing your arm freely in a circle. Your hips also have ball-and-socket joints.

Pivot joint A pivot joint allows one bone to rotate around another. The pivot joint in the top of your neck gives you limited ability to turn your head from side to side.

Gliding joint A gliding joint allows one bone to slide over another. The gliding joint in your wrist enables you to bend and flex your wrist, as well as make limited side-to-side motions. Your ankles also have gliding joints.

Hinge joint Like the hinge of a door, a hinge joint allows extensive forward or backward motion. Your knee is a hinge joint that allows you to bend and straighten your leg. Your elbow is also a hinge joint.

The bones in movable joints are held together by strong connective tissues called **ligaments.** Cartilage that covers the ends of the bones keeps them from rubbing against each other. In addition, a fluid lubricates the ends of the bones, allowing them to move smoothly over each other.

INTEGRATING Because your skeleton performs so many necessary functions, it is important to keep it healthy. This is especially true while you are still growing. A **combination of a balanced diet and regular exercise can start you on the way to a lifetime of healthy bones.**

One way to ensure healthy bones is to eat a well-balanced diet. A well-balanced diet includes enough calcium and phosphorus to keep your bones strong while they are growing. Meats, whole grains, and leafy green vegetables are all excellent sources of both calcium and phosphorus. Dairy products, including milk, are excellent sources of calcium.

Arts CONNECTION

Leonardo da Vinci (1452–1519), was an Italian artist, inventor, and scientist. Although he is well known for his paintings, including the Mona Lisa, Leonardo also made accurate sketches of the human body. As a scientist, Leonardo used dissections and took precise measurements to create accurate drawings of bones, ligaments, tendons, and other body parts. His sketches are considered to be the first accurate drawings of the human body.

In Your Journal

Leonardo da Vinci relied on measurements and visual observations to make his drawings. Use a metric ruler to measure the lengths of the bones in your arm or leg. Then try to make an accurate drawing of your arm or leg.

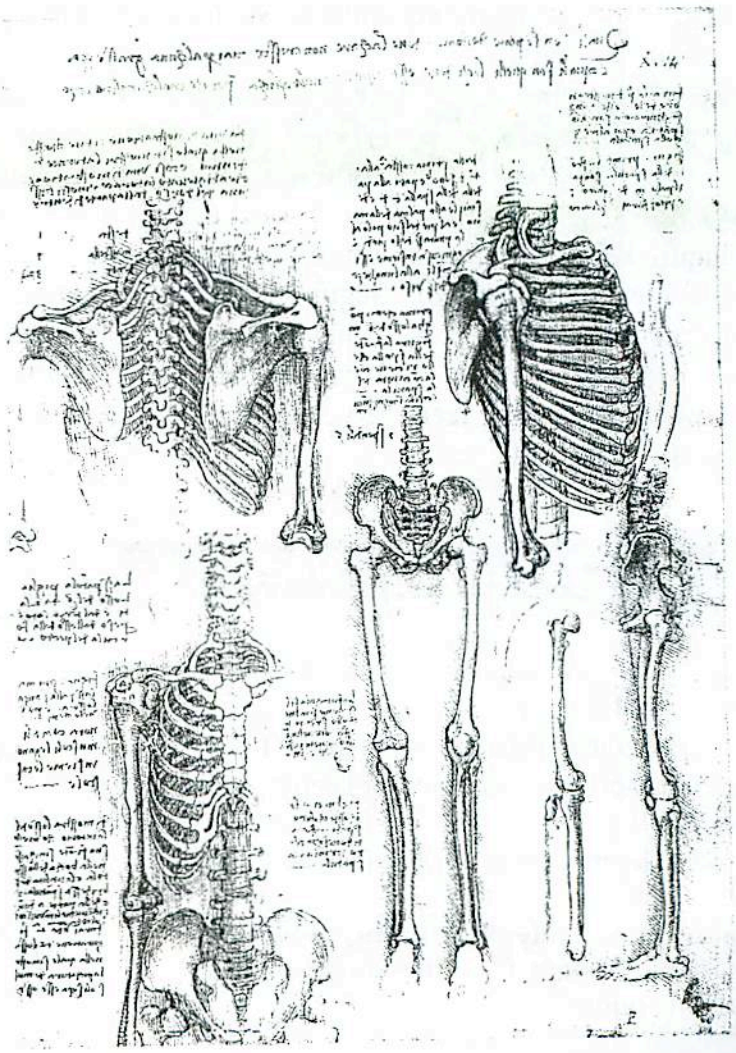


Figure 12 Leonardo da Vinci drew these sketches of the human chest, hip, and leg bones in 1510.

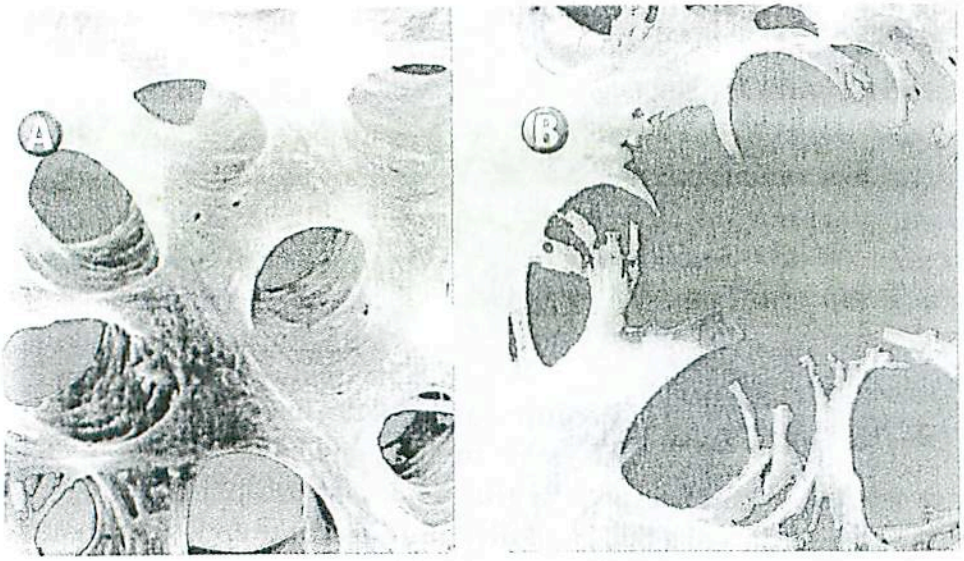


Figure 13 Without enough calcium in the diet, a person's bones weaken. **A.** This magnified view of healthy bone shows a continuous framework. **B.** Notice the large empty space in this bone from a person with osteoporosis. *Relating Cause and Effect* *What can you do to prevent osteoporosis?*

Another way to build and maintain strong bones is to get plenty of exercise. During activities such as walking, soccer, or basketball, your bones support the weight of your entire body. This helps your bones grow stronger and denser. Running, skating, and aerobics are other activities that help keep your bones healthy and strong. To prevent injuries while exercising, be sure to wear appropriate safety equipment, such as a helmet, knee pads, or shoulder pads.

As people become older, their bones begin to lose some of the minerals they contain. Mineral loss can lead to **osteoporosis** (ahs tee oh puh ROH sis), a condition in which the body's bones become weak and break easily. You can see the effect of osteoporosis in Figure 13B. Osteoporosis is more common in women than in men. Evidence indicates that regular exercise throughout life can help prevent osteoporosis. A diet with enough calcium can also help prevent osteoporosis. If you eat enough calcium-rich foods now, during your teenage years, you may help prevent osteoporosis later in life.

Section 2 Review

1. List five important functions that the skeleton performs in the body.
2. What is the role of movable joints in the body?
3. What behaviors are important for keeping your bones healthy?
4. Compare the motion of a hinge joint to that of a pivot joint.
5. **Thinking Critically Predicting** How would your life be different if your backbone consisted of just one bone?

Share at Home

Exercising Safely List the types of exercise you and your family members do. With your family, brainstorm a list of safety gear and precautions to use for each activity. (For example, for bicycling, you might list wearing a helmet, stretching before riding, and avoiding busy streets and nighttime riding.) How can you put these safety measures into practice?

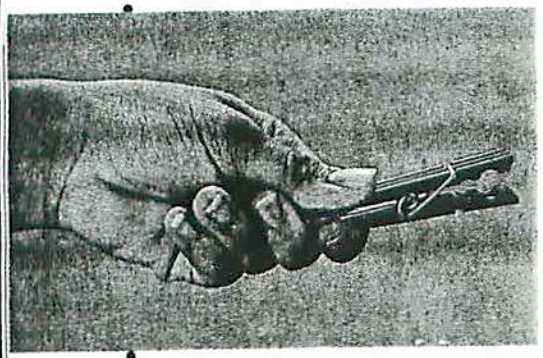
SECTION 3

The Muscular System

DISCOVER

ACTIVITY

How Do Muscles Work?



1. Grip a spring-type clothespin with the thumb and index finger of your writing hand. Squeeze the clothespin open and shut as quickly as possible for two minutes. Count how many times you can squeeze the clothespin before your muscles tire.
2. Rest for one minute. Then repeat Step 1.

Think It Over

Predicting What do you think would happen if you repeated Steps 1 and 2 with your other hand? Give a reason for your prediction. Then test your prediction.

GUIDE FOR READING

- What three types of muscles are found in the body?
- Why do skeletal muscles work in pairs?

Reading Tip Before you read, preview Figure 14. Predict the functions of skeletal, smooth, and cardiac muscle. After you read the section, look back at your predictions to see whether they were correct.

A rabbit becomes still when it senses danger. The rabbit sits so still that it doesn't seem to move a muscle. Could you sit without moving any muscles? If you tried to, you'd find that it is impossible to sit still for very long. Saliva builds up in your mouth. You swallow. You need to breathe. Your chest expands to let air in. All of these actions involve muscles.

There are about 600 muscles in your body. Muscles have many functions. For example, they keep your heart beating, pull your mouth into a smile, and move the bones of your skeleton.

Muscle Action

Some of your body's movements, such as smiling, are easy to control. Other movements, such as the beating of your heart, are impossible to control completely. That is because some muscles are not under your conscious control. Those muscles are called **involuntary muscles.** Involuntary muscles are responsible for activities such as breathing and digesting food.

The muscles that are under your control are called **voluntary muscles.** Smiling, turning a page in a book, and getting out of your chair when the bell rings are all actions controlled by voluntary muscles.

◀ A rabbit "frozen" in place

Your body has three types of muscle tissue—skeletal muscle, smooth muscle, and cardiac muscle. In Figure 14, you see a magnified view of each type of muscle in the body. Both skeletal and smooth muscles are found in many places in the body. Cardiac muscle is found only in the heart. Each muscle type performs specific functions in the body.

Skeletal Muscle Every time you type on a computer keyboard, shoot a basketball, or walk across a room, you are using skeletal muscles. As their name suggests, **skeletal muscles** are attached

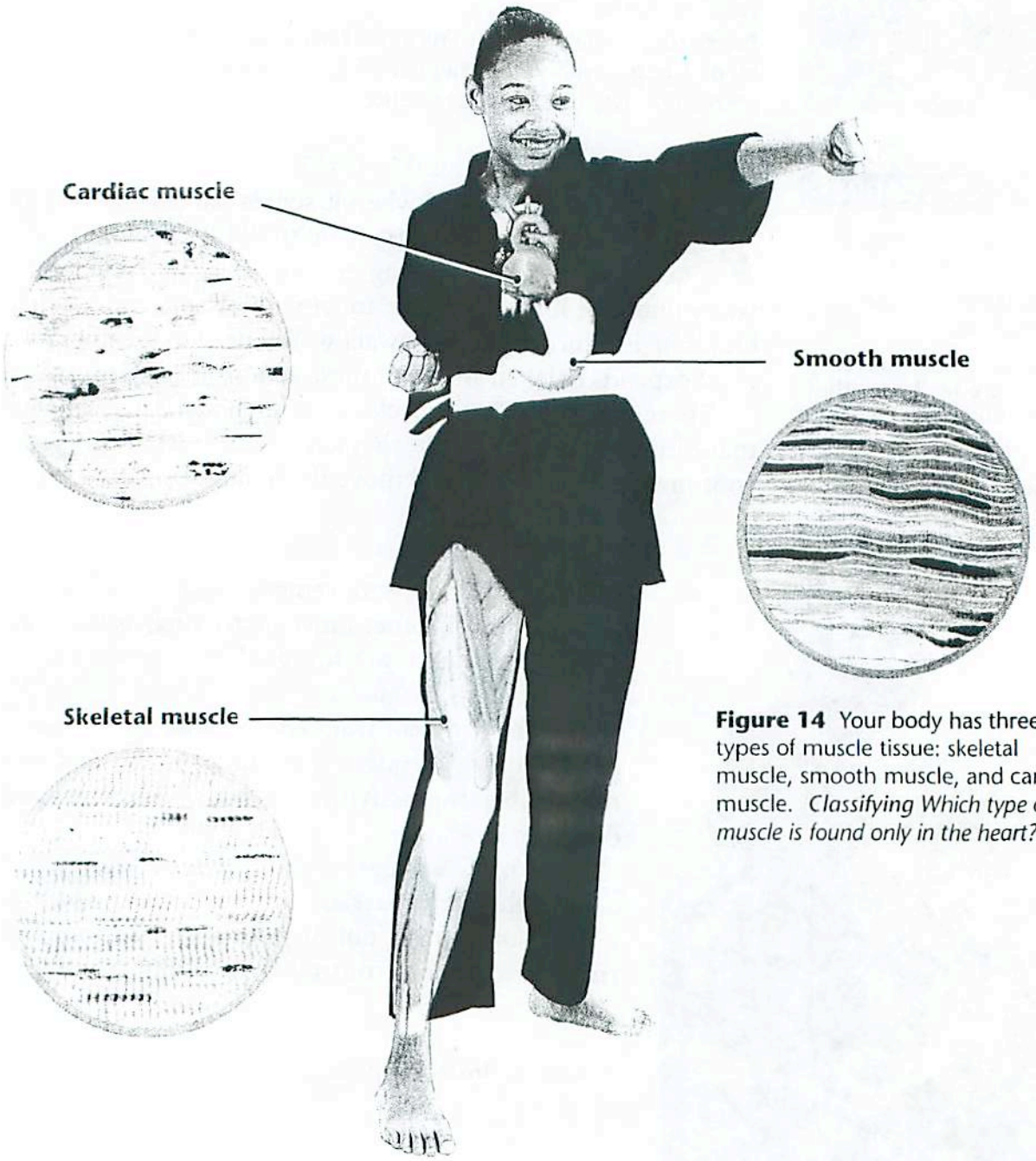
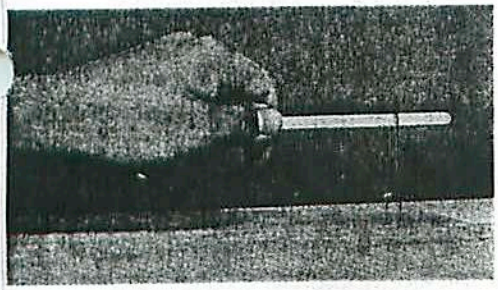


Figure 14 Your body has three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle. *Classifying Which type of muscle is found only in the heart?*

Get a Grip

Are skeletal muscles at work when you're not moving? Try this activity and see.

1. Hold a stirrer in front of you, parallel to a table top. Do not touch the table.
2. Have a partner place a hairpin on the stirrer.
3. Raise the stirrer until the "legs" of the hairpin just touch the table. The "head" of the hairpin should rest on the stirrer, as you see in the photo.



4. Hold the stirrer steady for 20 seconds. Observe what happens to the hairpin.
5. Grip the stirrer tighter and repeat Step 4. Observe what happens.

Inferring Based on your observations, are the skeletal muscles in your hand at work when you hold your hand still? Explain.

to the bones of your skeleton. These muscles provide the force that moves your bones. At each end of a skeletal muscle is a tendon. A **tendon** is a strong connective tissue that attaches muscle to bone. As you can see in Figure 14, skeletal muscle cells appear banded, or striated (STRY ay tid). For this reason, skeletal muscle is sometimes called striated muscle.

Because you have conscious control of skeletal muscles, they are classified as voluntary muscles. One characteristic of skeletal muscles is that they react very quickly. You can see an example of just how quickly skeletal muscle reacts by watching a swim meet. Immediately after the starting gun sounds, a swimmer's leg muscles quickly push the swimmer off the block into the pool. However, another characteristic of skeletal muscles is that they tire quickly. By the end of the race, the swimmer's muscles are tired and need a rest.

Smooth Muscle The inside of many internal organs of the body, such as the walls of the stomach and blood vessels, contain smooth muscles. **Smooth muscles** are involuntary muscles. They work automatically to control many types of movements inside your body, such as those involved in the process of digestion. For example, as the smooth muscles of your stomach contract, they produce a churning action. The churning mixes the food with chemicals produced by your stomach. This action and these chemicals help to digest the food.

Unlike skeletal muscles, smooth muscle cells are not striated. Smooth muscles behave differently than skeletal muscles, too. Smooth muscles react more slowly and tire more slowly.

Cardiac Muscle The tissue called **cardiac muscle** has characteristics in common with both smooth and skeletal muscles. Like smooth muscle, cardiac muscle is involuntary. Like skeletal muscle, cardiac muscle cells are striated. However, unlike skeletal muscle, cardiac muscle does not get tired. It can contract repeatedly. You call those repeated contractions heartbeats.

✓ *Checkpoint Which type of muscle reacts and tires quickly?*

Has anyone ever asked you to "make a muscle"? If so, you probably tightened your fist, bent your arm at the elbow, and made the muscles in your upper arm bulge. Like other skeletal muscles, the muscles in your arm do their work by contracting, or becoming shorter and thicker. Muscle cells contract when they receive messages from the nervous system. **Because muscle cells can only contract, not extend, skeletal muscles must work in pairs. While one muscle contracts, the other muscle in the pair returns to its original length.**

Figure 15 shows the muscle action involved in bending the arm at the elbow. First, the biceps muscle on the front of the upper arm contracts to bend the elbow, lifting the forearm and hand. As the biceps contracts, the triceps on the back of the upper arm returns to its original length. Then to straighten the elbow, the triceps muscle contracts. As the triceps contracts to extend the arm, the biceps returns to its original length. Another example of muscles that work in pairs are those in your thigh that bend and straighten the knee joint.

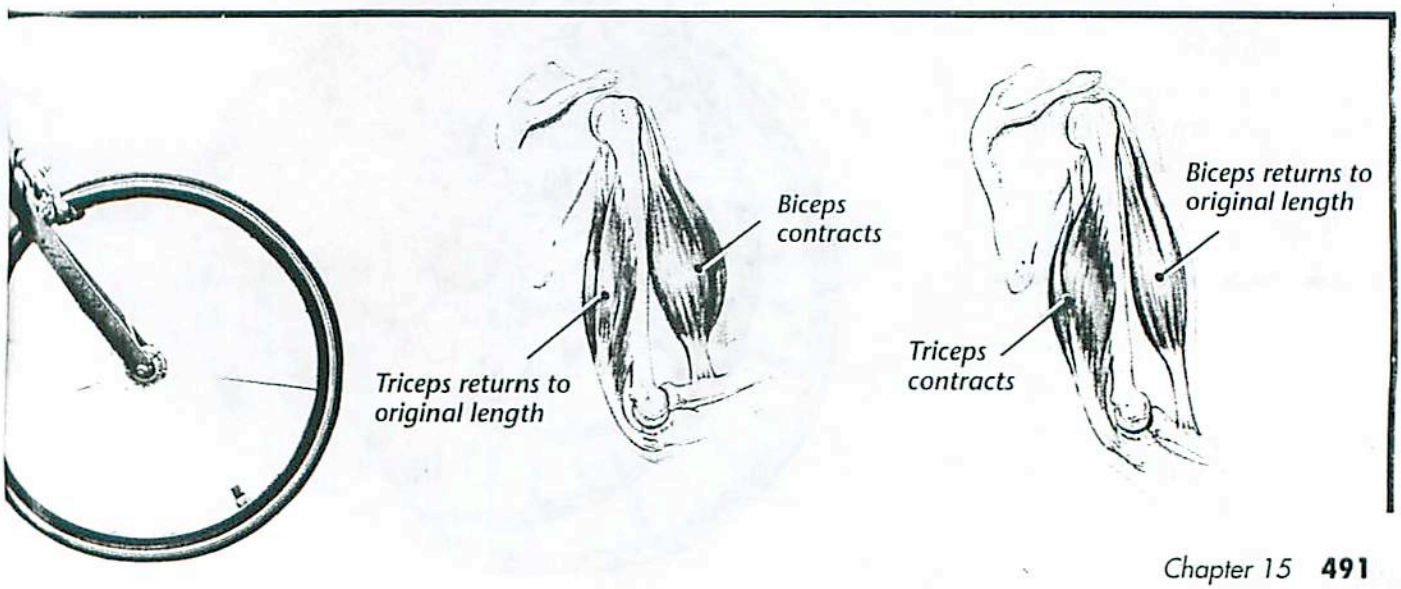


Figure 15 Because muscles can only contract, or shorten, they must work in pairs. To bend the arm at the elbow, the biceps contracts while the triceps returns to its original length.
Interpreting Diagrams What happens to each muscle to straighten the arm?

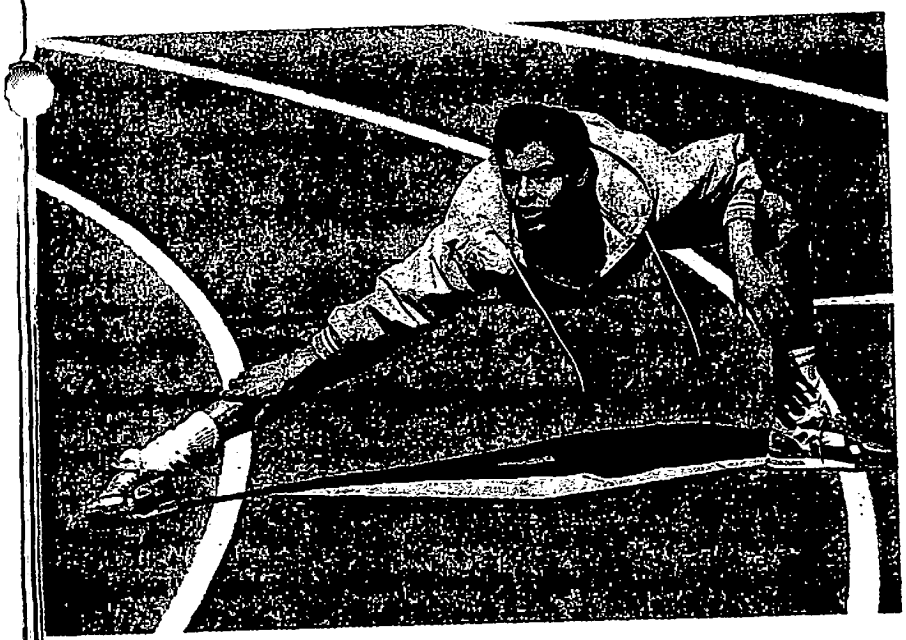


Figure 16 When you warm up before exercising, you increase the flexibility of your muscles.

Taking Care of Your Skeletal Muscles

Integrating Health Exercise is important for maintaining both muscular strength and flexibility. Exercise makes individual muscle cells grow wider. This, in turn, causes the whole muscle to become thicker. The thicker a muscle is, the stronger the muscle is. When you stretch and warm up thoroughly, your muscles become more flexible. This helps prepare your muscles for the work involved in exercising or playing.

Like your bones and joints, your skeletal muscles are subject to injuries. Some of the same precautions that help prevent bone and joint injuries can also help prevent muscle injuries. For example, warming up increases the flexibility of joints as well as muscles. In addition, using proper safety equipment can protect all of your tissues, including muscles and tendons.

Sometimes, despite taking proper precautions, muscles can become injured. A muscle strain, or a pulled muscle, can occur when muscles are overworked or overstretched. Tendons can also be overstretched or partially torn. After a long period of exercise, a skeletal muscle can cramp. When a muscle cramps, the entire muscle contracts strongly and stays contracted. If you injure a muscle or tendon, it is important to follow medical instructions and to rest the injured area until it heals.

Section 3 Review

1. Name the three types of muscle tissue. Where is each type found?
2. Describe how the muscles in your upper arm work together to bend and straighten your arm.
3. How do voluntary and involuntary muscles differ? Give an example of each type of muscle.
4. **Thinking Critically Predicting** The muscles that move your fingers are attached to the bones in your fingers by long tendons. Suppose one of the tendons in a person's index finger were cut all the way through. How would this injury affect the person's ability to move his or her index finger? Explain.

Chapter Project

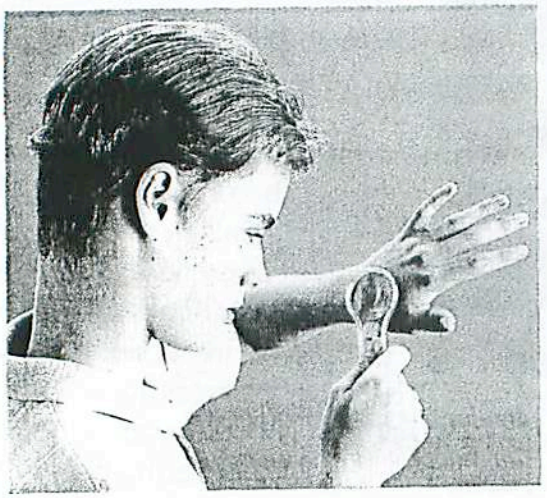
Check Your Progress

You should now be assembling your working model. Be sure that you include the muscles involved in the movement you are modeling. Also, remember that your model must show how muscle contractions produce the chosen movement. (*Hint:* After you have assembled your model, do a final check to be sure it functions the way it should.)

SECTION 4

The Skin

DISCOVER ACTIVITY



What Can You Observe About Skin?

1. Using a hand lens, examine the skin on your hand. Look for pores and hairs on both the palm and back of your hand.
2. Place a plastic glove on your hand. After five minutes, remove the glove. Then examine the skin on your hand with the hand lens.

Inferring Compare your hand before and after wearing the glove. What happened to the skin when you wore the glove? Why did this happen?

GUIDE FOR READING

- What are the functions of skin?
- What habits can help keep your skin healthy?

Reading Tip As you read, create a table that shows the two major layers of skin. Include columns to record the location, structures, and functions of each layer.

Here's a question for you: What's the largest organ in the human body? If your answer is the skin, you are right! If an adult's skin were stretched out flat, it would cover an area larger than 1.5 square meters—about the size of a mattress on a twin bed. You may think of the skin as nothing more than a covering that separates the inside of the body from the outside environment. You may be surprised to learn about the many important roles that the skin plays.

The skin performs several major functions in the body. **The skin covers the body and prevents the loss of water. It protects the body from injury and infection. The skin also helps to regulate body temperature, eliminate wastes, gather information about the environment, and produce vitamin D.**

Figure 17 The skin forms a barrier that protects the inside of the body from substances such as the chlorine in pool water.

The skin protects the body by forming a barrier that keeps disease-causing microorganisms and harmful substances outside the body. In addition, the skin helps keep important substances inside the body. Like plastic wrap that keeps food from drying out, the skin prevents the loss of important fluids such as water.

Figure 18 When you exercise, your body becomes warmer. Sweat glands in the skin produce perspiration, which leaves the body through pores like the one you see here. *Relating Cause and Effect How does perspiration help cool your body?*

Another function of the skin is to help the body maintain a steady temperature. Many blood vessels run through skin. When you become too warm, these blood vessels enlarge to increase the amount of blood that flows through them. This allows heat to move from your body into the outside environment. In addition, sweat glands in the skin respond to excess heat by producing perspiration. As perspiration evaporates from your skin, heat moves into the air. Because perspiration contains some dissolved waste materials, your skin also helps to eliminate wastes.

The skin also gathers information about the environment. To understand how the skin does this, place your fingertips on the skin of your arm and press down firmly. Then lightly pinch yourself. You have just tested some of the nerves in your skin. The nerves in skin provide information about such things as pressure, pain, and temperature. Pain messages are important because they warn you that something in your surroundings may have injured you.

Lastly, some skin cells produce vitamin D in the presence of sunlight. Vitamin D is important for healthy bones. This is because Vitamin D helps the cells in your digestive system to absorb the calcium in your food. Your skin cells need only a few minutes of sunlight to produce all the vitamin D you need in a day.

Checkpoint How does your skin help eliminate waste materials from your body?

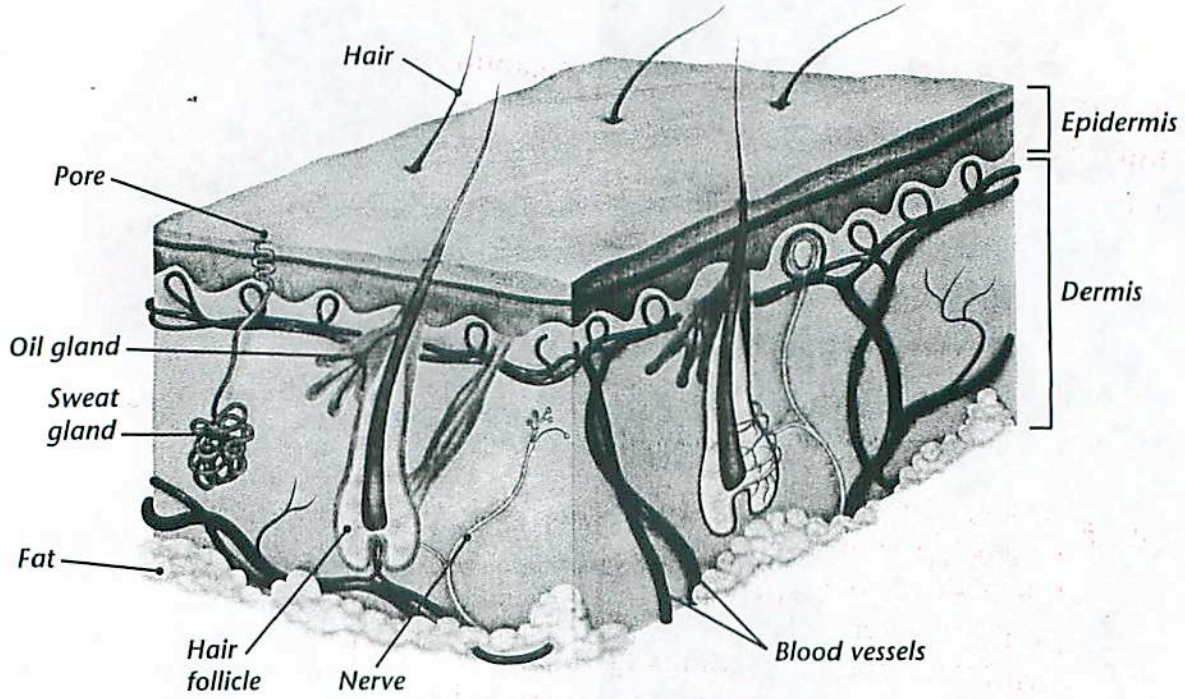


Figure 19 The skin is made of two main layers. The top layer is called the epidermis. The bottom layer is called the dermis. *Interpreting Diagrams In which layer of the skin do you find blood vessels?*

The Epidermis

The skin is organized into two main layers, the epidermis and the dermis. You can see these layers in Figure 19. The **epidermis** is the outermost layer of the skin. In most places, the epidermis is thinner than the dermis. The epidermis does not have nerves or blood vessels. This is why you usually don't feel pain from very shallow scratches and why shallow scratches do not bleed.

Dead or Alive? The cells in the epidermis have a definite life cycle. Each epidermal cell begins life deep in the epidermis, where cells divide to form new cells. The new cells gradually mature and move upward in the epidermis as new cells form beneath them. After about two weeks, the cells die and become part of the surface layer of the epidermis. Under a microscope, this surface layer of dead cells resembles flat bags laid on top of each other. Cells remain in this layer for about two weeks. Then they are shed and replaced by the dead cells below.

Protecting the Body In some ways, the cells of the epidermis are more valuable to the body dead than alive. Most of the protection provided by the skin is due to the layer of dead cells on the surface. The thick layer of dead cells on your fingertips, for example, protects and cushions your fingertips. The shedding of dead cells also helps to protect the body. As the cells fall away, they carry with them bacteria and other substances that settle on the skin. Every time you rub your hands together, you lose hundreds, even thousands, of dead skin cells.

Some cells in the inner layer of the epidermis help to protect the body, too. On your fingers, for example, some cells produce hard fingernails, which protect the fingertips from injury and help you scratch and pick up objects.

Other cells deep in the epidermis produce **melanin**, a pigment, or colored substance, that gives skin its color. The more melanin in your skin, the darker it is. Exposure to sunlight stimulates the skin to make more melanin. Melanin production helps to protect the skin from burning.

Checkpoint *How do dead skin cells help to protect the body?*

The Dermis

The **dermis** is the lower layer of the skin. Find the dermis in Figure 19. Notice that it is located below the epidermis and above a layer of fat. This fat layer pads the internal organs and helps keep heat in the body.

The dermis contains nerves and blood vessels. The dermis also contains other structures as well—sweat glands, hairs, and oil glands. Sweat glands produce perspiration, which reaches the surface through openings called **pores.** Strands of hair grow within the dermis in structures called **follicles** (FAHL ih kulz). The hair that you see above the skin's surface is made up of dead cells. Oil produced in glands around the hair follicles waterproofs the hair. In addition, oil that reaches the surface helps to keep the skin moist.

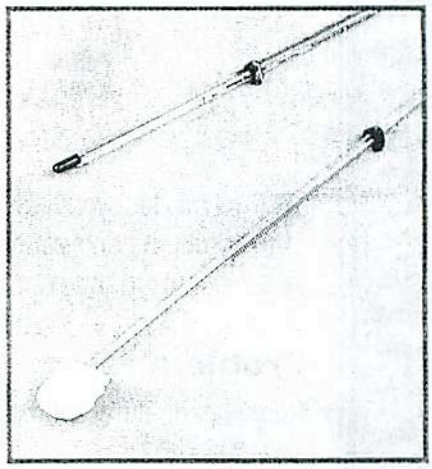
Figure 20 Hairs grow from follicles in the dermis of the skin. Hair is made of dead cells.

TRY THIS

ACTIVITY

This activity illustrates one of the skin's important functions.

1. Put on your safety goggles. Wrap a wet cotton ball around the bulb of one thermometer. Place a second thermometer next to the first one.



2. After two minutes, record the temperature reading on each thermometer.
3. Using a piece of cardboard, fan both thermometers for several minutes. The cardboard should be at least 10 cm from the thermometers. Then record the temperatures.

Measuring Which of the two thermometers had a lower temperature after Step 3? How does this activity relate to the role of skin in regulating body temperature?

Because your skin has so many important functions, it is important to take care of it. **Four simple habits can help you keep your skin healthy. Eat properly. Drink enough water. Limit your exposure to the sun. Keep your skin clean and dry.**

Eating Properly Your skin is always active. The cells in the epidermis are replaced, hair strands and nails grow, and oil is produced. These activities require energy—and a well-balanced diet provides the energy needed for these processes. You will learn more about healthy diets in Chapter 16.

Real-World Lab

You and Your Environment

Sun Safety

In this lab, you'll investigate how sunscreen products and various fabrics protect your skin from the sun.

Problem

How well do different materials protect the skin from the sun?

Skills Focus

predicting, observing, drawing conclusions

Materials

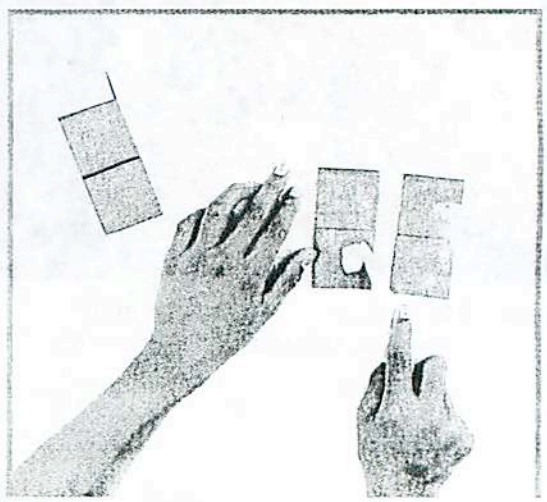
scissors
3 different fabrics
photosensitive paper
white construction paper
resealable plastic bag
2 sunscreens with SPF ratings of 4 and 30
pencil
plastic knife
metric ruler
stapler
staple remover

Procedure

1. Read over the procedure. Then write a prediction about how well each of the sunscreens and fabrics will protect against the sun.
2. Use scissors to cut five strips of photosensitive paper that measure 5 cm by 15 cm.
3. Divide each strip into thirds by drawing lines across the strips as shown in the photo.
4. Cover one third of each strip with a square of white construction paper. Staple each square down.

Part 1 Investigating Sunscreens

5. Use a pencil to write the lower SPF (sun protection factor) rating on the back of the first strip. Write the other SPF rating on the back of a second strip.
6. Place the two strips side by side in a plastic bag. Seal the bag, then staple through the white squares to hold the strips in place.



Drinking Water To keep your skin healthy, it is also important to drink plenty of water. When you participate in strenuous activities, such as playing soccer, you can perspire up to 10 liters of liquid a day. You need to replace the water lost in perspiration by drinking water or other beverages and by eating foods, such as fruits, that contain water.

Limiting Sun Exposure You can also take actions to protect your skin from cancer and early aging. Cancer is a disease in which some body cells divide uncontrollably. Repeated exposure to sunlight can damage skin cells and cause them to become

7. With a plastic knife, spread a thin layer of each sunscreen on the bag over the last square of each strip. Make certain each layer has the same depth. Be sure not to spread sunscreen over the middle squares.
8. Place the bag in direct sunlight with the sunscreen side up. Leave it there until the middle squares turn white.
9. Remove the strips from the bag, and take off the construction paper. Rinse the strips for one minute in cold water. Then dry them flat.
10. Observe all the squares. Record your observations.

Part 2 Investigating Fabrics

11. Obtain three fabrics of different thicknesses. Staple a square of each fabric over the last square of a photosensitive strip. Write a description of the fabric on the back of the strip.
12. Expose the strips to the sun, fabric-side up, until the middle square turns white. Then follow Steps 9 and 10.

Analyze and Conclude

1. Did the sunscreens protect against sun exposure? How do you know?
2. Which sunscreen provided more protection? Was your prediction correct?
3. Did the fabrics protect against sun exposure? How do you know?
4. Which fabric provided the most protection? The least protection? How did your results compare with your predictions?
5. **Apply** What advice would you give people about protecting their skin from the sun?

Design an Experiment

Design an experiment to find out whether ordinary window glass protects skin against sun exposure. Obtain your teacher's approval before carrying out this experiment.

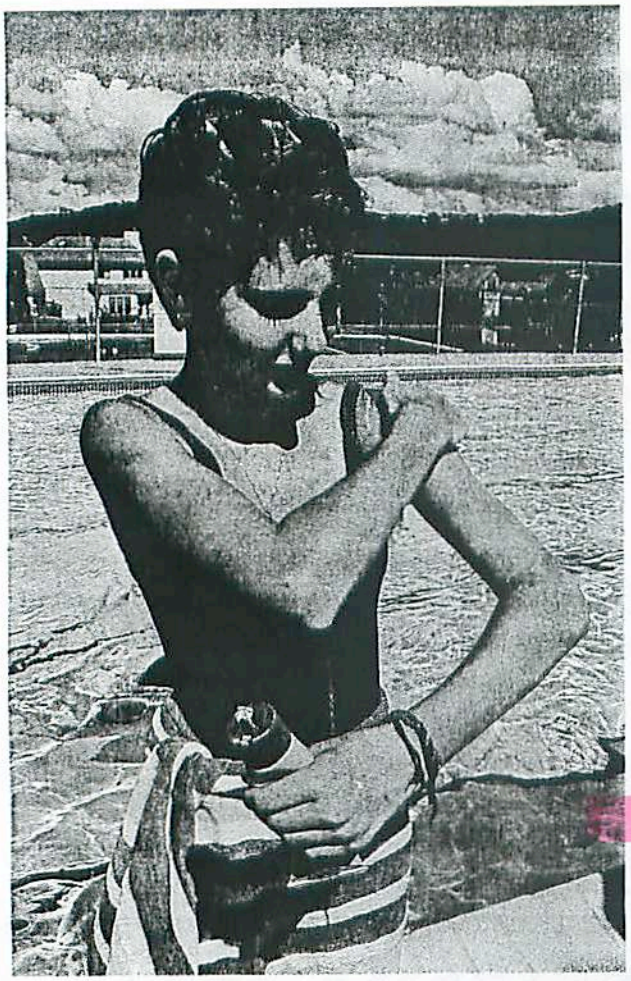


Figure 21 This person is taking precautions to protect her skin from the sun. *Applying Concepts What other behaviors can provide protection from the sun?*

cancerous. In addition, exposure to the sun can cause the skin to become leathery and wrinkled.

There are many things you can do to protect your skin from damage by the sun. When you are outdoors, wear a hat and sunglasses and use a sunscreen on exposed skin. The clothing you wear can also protect you. Choose clothing made of tightly woven fabrics for the greatest protection. In addition, avoid exposure to the sun between the hours of 10 A.M. and 2 P.M. That is the time when sunlight is the strongest.

Keeping Skin Clean When you wash your skin with mild soap, you get rid of dirt and harmful bacteria. Good washing habits are particularly important during the teenage years when oil glands are more active. When oil glands become clogged with oil, bacterial infections can occur.

One bacterial infection of the skin that can be difficult to control is known as **acne.** If you develop acne, your doctor may prescribe an antibiotic to help control the infection. When you wash, you help to control oiliness and keep your skin from becoming infected with more bacteria.

Other organisms, called fungi, can also live on and infect the skin. Fungi grow best in warm, moist surroundings. Athlete's foot is a very common fungal infection that occurs on the feet, especially between the toes. You can prevent athlete's foot by keeping your feet, especially the spaces between your toes, clean and dry.

Section 4 Review

1. Describe the functions of the skin.
2. List three things you can do to keep your skin healthy.
3. Describe the structure of the two layers of skin.
4. **Thinking Critically Making Judgments** Do you think it is possible to wash your skin too much and damage it as a result? Why or why not?

Science at Home

Protection From the Sun With a family member, look for products in your home that provide protection from the sun. You may also want to visit a store that sells these products. Make a list of the products and place them in categories such as sunblocks, clothing, eye protectors, and other products. Explain to your family member why it is important to use such products.

CHAPTER 15 STUDY GUIDE

Body Organization and Homeostasis

INTEGRATING

Key Ideas

The levels of organization in the body consist of cells, tissues, organs, and organ systems.
Homeostasis is the process by which an organism's internal environment is kept stable in spite of changes in the external environment.

Key Terms

cell	muscle tissue	organ
cell membrane	nerve tissue	organ system
nucleus	connective tissue	homeostasis
cytoplasm	epithelial tissue	stress
tissue		

The Skeletal System

Key Ideas

The skeleton provides shape and support, enables movement, protects internal organs, produces blood cells, and stores materials.
Movable joints allow the body to make a wide range of motions.
A combination of a balanced diet and regular exercise helps keep bones healthy.

Key Terms

vertebra	cartilage	ligament
marrow	joint	osteoporosis

The Muscular System

Key Ideas

Skeletal muscles are voluntary muscles that are attached to the bones of the skeleton.
Smooth muscles, which are involuntary muscles, line the walls of many internal organs and blood vessels. Cardiac muscles are involuntary muscles found only in the heart.

Key Terms

involuntary muscle	tendon
voluntary muscle	smooth muscle
skeletal muscle	cardiac muscle

The Skin

Key Ideas

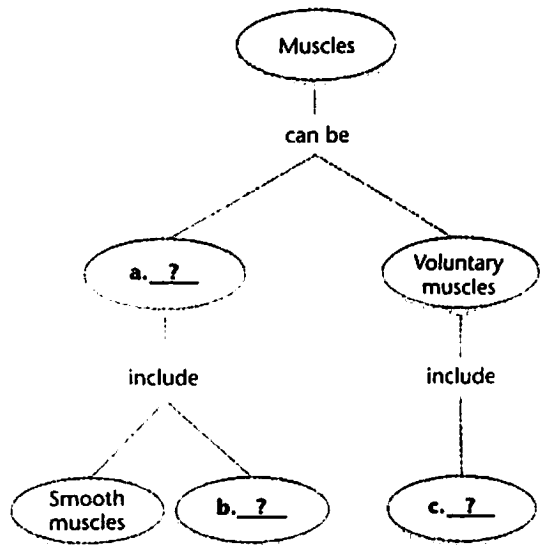
Skin covers and protects the body from injury and infection. It also helps to regulate body temperature, get rid of wastes, gather information about the environment, and produce vitamin D.
The epidermis is the top layer of the skin. The dermis is the lower layer of the skin.
For healthy skin, eat a well-balanced diet and drink enough water. Also limit your exposure to the sun and keep your skin clean.

Key Terms

epidermis	follicle
melanin	cancer
dermis	acne
pore	

Organizing Information

Concept Map Copy the concept map about muscles onto a separate sheet of paper. Then complete it and add a title. (For more information on concepts maps, see the Skills Handbook.)



Reviewing Content


For more review of key concepts, see the Interactive Student Tutorial CD-ROM.

Multiple Choice

Choose the letter of the best answer.

1. A group of similar cells that perform a similar function is called a(n)
   a. cell.
   b. organ.
   c. tissue.
   d. organ system.
2. The term most closely associated with homeostasis is
   a. growth.
   b. stability.
   c. temperature.
   d. energy.
3. Blood cells are produced in
   a. compact bone.
   b. marrow.
   c. cartilage.
   d. ligaments.
4. Muscles that help the skeleton move are
   a. cardiac muscles.
   b. smooth muscles.
   c. skeletal muscles.
   d. involuntary muscles.
5. Which structures help to maintain body temperature?
   a. oil glands
   b. follicles
   c. sweat glands
   d. ligaments

True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

6. Epithelial tissue makes parts of your body move.
7. The circulatory system carries needed materials to the body cells.
8. Spongy bone is filled with cartilage.
9. Skeletal muscle is sometimes called striated muscle.
10. The epidermis contains nerve endings and blood vessels.

Checking Concepts

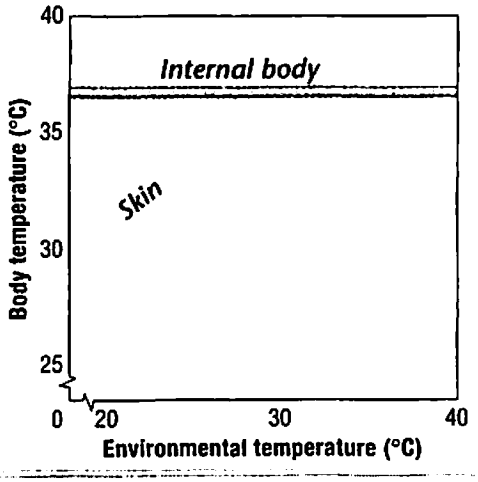
11. Explain the relationship among cells, tissues, organs, and organ systems.
12. How does hunger help your body maintain homeostasis?
13. Think of a situation that might cause long-term stress. Identify some ways in which a person might deal with that stress.
14. Describe the structure of a bone.
15. List the four kinds of movable joints. Describe how each kind of joint functions.
16. How does the appearance of smooth muscle differ from that of skeletal muscle when viewed with a microscope?
17. Explain how skeletal muscles work in pairs to move a body part.
18. Why is it important to limit your exposure to the sun?
19. **Writing to Learn** Write an article for your school newspaper about preventing skeletal and muscular injuries. The article should focus on ways in which athletes can strengthen their muscles and bones and decrease the risk of injuries during sports.

Thinking Critically

20. **Inferring** Why do you think scientists classify blood as a connective tissue?
21. **Making Generalizations** How is homeostasis important to survival?
22. **Applying Concepts** At birth, the joints in an infant's skull are flexible and not yet fixed. As the child develops, the bones become more rigid and grow together. Why is it important that the bones of an infant's skull not grow together too rapidly?
23. **Predicting** If smooth muscle had to be consciously controlled, what problems could you foresee in day-to-day living?
24. **Relating Cause and Effect** A person who is exposed to excessive heat may suffer from a condition known as heat stroke. The first sign of heat stroke is that the person stops sweating. Why is this condition a life-threatening emergency?

lying Skills

The graph below shows the effects of the temperature of the environment on a girl's skin temperature and on the temperature inside her body. Use the graph to answer Questions 25–27.



25. **Interpreting Data** As the temperature of the environment rises, what happens to the girl's internal temperature? How does this demonstrate homeostasis?

26. **Inferring** What happens to the temperature of the girl's skin? Why is this pattern different from the pattern shown by the girl's internal temperature?

27. **Developing Hypotheses** Suppose the girl went outdoors on a chilly fall morning. Write a hypothesis that predicts what would happen to her internal body temperature and skin temperature.

Performance CHAPTER PROJECT Assessment

Present Your Project Demonstrate your model for the class. Explain how your model shows your chosen motion. Describe how the contraction of muscle is involved.

Reflect and Record Why did you select the motion that you modeled? What new information did you discover about the human body? If you could do the project again, what would you change? Write your thoughts in your journal.

Test Preparation

Use these questions to prepare for standardized tests.

Read the passage. Then answer Questions 28–30.

Magnetic resonance imaging, or MRI, is a method used to take clear images of both the bones and soft tissues of the body. An MRI scanner is a large cylinder that contains electromagnets. The person is placed on a platform that slides into the center of the cylinder. The person is then exposed to short bursts of magnetic energy. This magnetic energy causes atoms within the body to vibrate, or resonate. A computer then analyzes the vibration patterns and produces an image of the area.

MRI can produce images of body tissues at any angle. The images clearly show muscles and other soft tissues that an X-ray image cannot show. Another advantage of MRI is that it does not damage cells. Because MRI machines are very expensive to buy and use, this technique is not used to examine broken bones.

28. Which of the following is the best title for this passage?
   a. Using X-Rays to Diagnose Bone Injuries
   b. Using MRI to Diagnose Injuries
   c. The Dangers of MRI
   d. Two Methods for Diagnosing Injuries

29. Why is MRI often used to diagnose muscle and other soft tissue injuries?
   a. MRI creates clear images of soft tissues.
   b. MRI can produce images from many angles.
   c. MRI does not damage body cells.
   d. all of the above

30. According to the passage, why are X-rays used instead of MRI to examine broken bones?
   a. X-ray images are less expensive to produce.
   b. MRI involves placing a person inside a cylinder.
   c. Vibration of atoms is uncomfortable.
   d. MRI causes damage to cells.