

Structure and Movement

chapter preview

sections

- 1 The Skeletal System
- 2 The Muscular System
- 3 The Skin

Lab *Measuring Skin Surface*

Lab *Similar Skeletons*



Virtual Lab *What are the major bones in the human body?*

How are you like a building?


Internal and external structures support both buildings and the human body. Bones support us instead of steel or wood. The covering of a building protects the inside from the outside environment. Your skin protects your body's internal environment.

Science Journal Imagine that your body did not have a support system. Describe how you might perform your daily activities.

Start-Up Activities



Effect of Muscles on Movement

The expression “Many hands make light work” is also true when it comes to muscles in your body. In fact, hundreds of muscles and bones work together to bring about smooth, easy movement. Muscle interactions enable you to pick up a penny or lift a 10-kg weight. 



1. Sit on a chair at an empty table and place the palm of one hand under the edge of the table.
2. Push your hand up against the table. Do not push too hard.
3. Use your other hand to feel the muscles located on both sides of your upper arm, as shown in the photo.
4. Next, place your palm on the top of the table and push down. Again, feel the muscles in your upper arm.
5. **Think Critically** Describe in your Science Journal how the different muscles in your upper arm were working during each movement.

FOLDABLES™ Study Organizer

Structure and Movement

Without skin, muscle and bone each of us would be a formless mass. Make the following Foldable to help you understand the function of skin, muscle and bone in structure and movement.

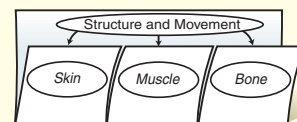
- STEP 1** **Fold** a sheet of paper in half length-wise. Make the back edge about 5 cm longer than the front edge.



- STEP 2** **Turn** the paper so the fold is on the bottom. Then, **fold** it into thirds.



- STEP 3** **Unfold and cut** only the top layer along both folds to make three tabs. **Label** the Foldable as shown.



Read and Write As you read this chapter, write the functions that skin, muscle, and bone each have in structure and movement.



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

The Skeletal System

as you read

What You'll Learn

- **Identify** five functions of the skeletal system.
- **Compare and contrast** movable and immovable joints.

Why It's Important

You'll begin to understand how your bones and joints allow you to move.

Review Vocabulary

skeleton: a framework of living bones that supports your body

New Vocabulary

- skeletal system
- periosteum
- cartilage
- joint
- ligament

Figure 1 The 206 bones of the human body are connected, forming a framework called the skeleton.

Living Bones

Often in a horror movie, a mad scientist works frantically in his lab while a complete human skeleton hangs silently in the corner. When looking at a skeleton, you might think that bones are dead structures made of rocklike material. Although these bones are no longer living, the bones in your body are very much alive. Each is a living organ made of several different tissues. Like all the other living tissues in your body, bone tissue is made of cells that take in nutrients and use energy. Bone cells have the same needs as other body cells.

Functions of Your Skeletal System All the bones in your body make up your **skeletal system**, as shown in **Figure 1**. It is the framework of your body and has five major functions.



1. The skeleton gives shape and support to your body.
2. Bones protect your internal organs. For example, ribs surround the heart and lungs, and the skull encloses the brain.
3. Major muscles are attached to bone and help them move.
4. Blood cells are formed in the center of many bones in soft tissue called red marrow.
5. Major quantities of calcium and phosphorus compounds are stored in the skeleton for later use. Calcium and phosphorus make bones hard.

Bone Structure

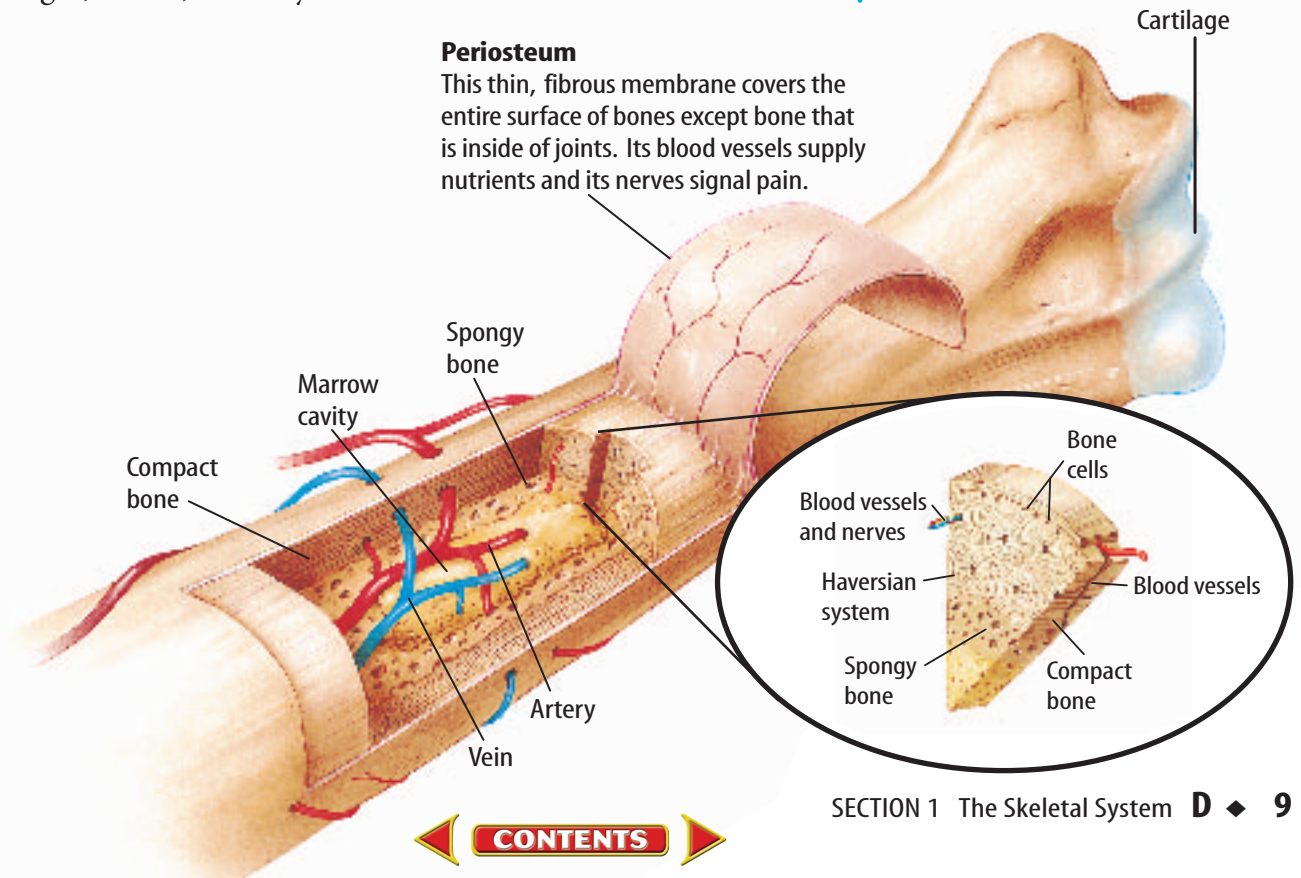
Several characteristics of bones are noticeable. The most obvious are the differences in their sizes and shapes. The shapes of bones are inherited. However, a bone's shape can change when the attached muscles are used.

Looking at bone through a magnifying glass will show you that it isn't smooth. Bones have bumps, edges, round ends, rough spots, and many pits and holes. Muscles and ligaments attach to some of the bumps and pits. In your body blood vessels and nerves enter and leave through the holes. Internal characteristics, how a bone looks from the inside, and external characteristics, how the same bone looks from the outside, are shown in **Figure 2**.

A living bone's surface is covered with a tough, tight-fitting membrane called the **periosteum** (per ee AH stee um). Small blood vessels in the periosteum carry nutrients into the bone. Cells involved in the growth and repair of bone also are found in the periosteum. Under the periosteum are two different types of bone tissue—compact bone and spongy bone.

Compact Bone Directly under the periosteum is a hard, strong layer called compact bone. Compact bone gives bones strength. It has a framework containing deposits of calcium phosphate. These deposits make the bone hard. Bone cells and blood vessels also are found in this layer. This framework is living tissue and even though it's hard, it keeps bone from being too rigid, brittle, or easily broken.

Figure 2 Bone is made of layers of living tissue. Compact bone is arranged in circular structures called Haversian systems—tiny, connected channels through which blood vessels and nerve fibers pass.



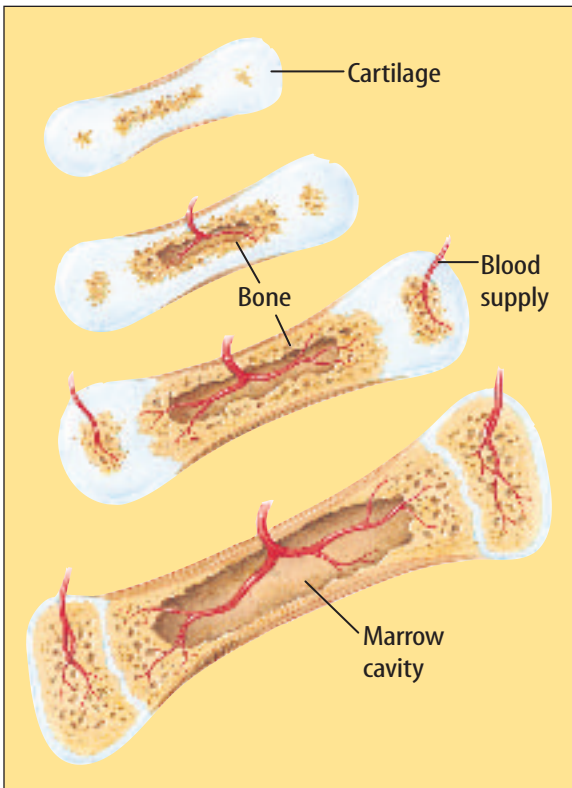
Topic: Bone Fractures

Visit bookd.msscience.com for Web links to information about new techniques for treating bone fractures.

Activity Describe one of these new techniques in your Science Journal.

Figure 3 Cartilage is replaced slowly by bone as solid tissue grows outward. Over time, the bone reshapes to include blood vessels, nerves, and marrow.

Describe the type of bone cell that builds up bone.



Spongy Bone Spongy bone is located toward the ends of long bones such as those in your thigh and upper arm. Spongy bone has many small, open spaces that make bones lightweight. If all your bones were completely solid, you'd have greater mass. In the centers of long bones are large openings called cavities. These cavities and the spaces in spongy bone are filled with a substance called marrow. Some marrow is yellow and is composed of fat cells. Red marrow produces red blood cells at an incredible rate of 2 million to 3 million cells per second.

Cartilage The ends of bones are covered with a smooth, slippery, thick layer of tissue called **cartilage**. Cartilage does not contain blood vessels or minerals. Nutrients are delivered to cartilage by nearby blood vessels. Cartilage is flexible and important in joints because it acts as a shock absorber. It also makes movement easier by reducing friction that would be caused by bones rubbing together. Cartilage can be damaged because of disease, injury, or years of use. People with damaged cartilage experience pain when they move.

Reading Check What is cartilage?

Bone Formation

Although your bones have some hard features, they have not always been this way. Months before your birth, your skeleton was made of cartilage. Gradually the cartilage broke down and was replaced by bone, as illustrated in **Figure 3**. Bone-forming cells called osteoblasts (AHS tee oh blasts) deposit the minerals calcium and phosphorus in bones, making the bone tissue hard. At birth, your skeleton was made up of more than 300 bones. As you developed, some bones fused, or grew together, so that now you have only 206 bones.

Healthy bone tissue is always being formed and re-formed. Osteoblasts build up bone. Another type of bone cell, called an osteoclast, breaks down bone tissue in other areas of the bone. This is a normal process in a healthy person. When osteoclasts break bone down, they release calcium and phosphorus into the bloodstream. This process maintains the elements calcium and phosphorus in your blood at about the levels they need to be. These elements are necessary for the working of your body, including the movement of your muscles.

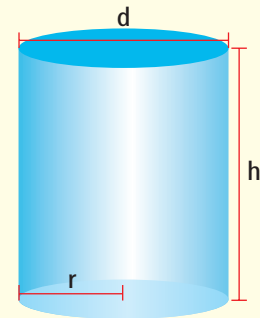
Joints

What will you do during your lunch break today? You may sit at a table, pick up a sandwich, bite off a piece of a carrot and chew it, and walk to class. All of these motions are possible because your skeleton has joints.

Anyplace where two or more bones come together is a **joint**. The bones making up healthy joints are kept far enough apart by a thin layer of cartilage so that they do not rub against each other as they move. The bones are held in place at these joints by a tough band of tissue called a **ligament**. Many joints, such as your knee, are held together by more than one ligament. Muscles move bones by moving joints.

Applying Math Calculate Volume

VOLUME OF BONES The Haversian systems found in the cross section of your bones are arranged in long cylinders. This cylindrical shape allows your bones to withstand great pressure. Estimate the volume of a bone that is 36 cm long and is 7 cm in diameter.



Solution

- 1** *This is what you know:* The bone has a shape of a cylinder whose height, h , measures 36 cm and whose diameter is 7.0 cm.
- 2** *This is what you need to find out:* What is the volume of the cylinder?
 - Volume = $\pi \times (\text{radius})^2 \times \text{height}$, or $V = \pi \times r^2 \times h$
 - A radius is one-half the diameter ($\frac{1}{2} \times 7 \text{ cm}$), so $r = 3.5 \text{ cm}$, $h = 36 \text{ cm}$, and $\pi = 3.14$.
 - Substitute in known values and solve.
 $3.14 \times (3.5 \text{ cm})^2 \times 36 \text{ cm} = 1,384.74 \text{ cm}^3$
 - The volume of the bone is approximately $1,384.74 \text{ cm}^3$.
- 3** *This is the procedure you need to use:*
- 4** *Check your answer:* Divide your answer by 3.14 and then divide that number by $(3.5)^2$. This number should be the height of the bone.

Practice Problems

1. Estimate the volume of a bone that has a height of 12 cm and a diameter of 2.4 cm.
2. If a bone has a volume of 314 cm^3 and a diameter of 4 cm, what is its height?

ScienceOnline

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

Figure 4 When a basketball player shoots a ball, several types of joints are in action.

Describe other activities that use several types of joints.

Immovable Joints Refer to **Figure 4** as you learn about different types of joints. Joints are broadly classified as immovable or movable. An immovable joint allows little or no movement. The joints of the bones in your skull and pelvis are classified as immovable joints.

Movable Joints All movements, including somersaulting and working the controls of a video game, require movable joints. A movable joint allows the body to make a wide range of motions. There are several types of movable joints—pivot, ball and socket, hinge, and gliding. In a pivot joint, one bone rotates in a ring of another bone that does not move. Turning your head is an example of a pivot movement.

A ball-and-socket joint consists of a bone with a rounded end that fits into a cuplike cavity on another bone. A ball-and-socket joint provides a wider range of motion than a pivot joint does. That's why your legs and arms can swing in almost any direction.

A third type of joint is a hinge joint. This joint has a back-and-forth movement like hinges on a door. Elbows, knees, and fingers have hinge joints. Hinge joints have a smaller range of motion than the ball-and-socket joint. They are not dislocated as easily, or pulled apart, as a ball-and-socket joint can be.

A fourth type of joint is a gliding joint in which one part of a bone slides over another bone. Gliding joints also move in a back-and-forth motion and are found in your wrists and ankles and between vertebrae. Gliding joints are used the most in your body. You can't write a word, use a joystick, or take a step without using a gliding joint.



Moving Smoothly When you rub two pieces of chalk together, their surfaces begin to wear away, and they get reshaped. Without the protection of the cartilage at the end of your bones, they also would wear away at the joints. Cartilage helps make joint movement easier. It reduces friction and allows bones to slide more easily over each other. Shown in **Figure 5**, pads of cartilage, called disks, are located between the vertebrae in your back. They act as a cushion and prevent injury to your spinal cord. A fluid that comes from nearby blood vessels also lubricates the joint.

 **Reading Check** Why is cartilage important?

Common Joint Problems Arthritis is the most common joint problem. The term *arthritis* describes more than 100 different diseases that can damage the joints. About one out of every seven people in the United States suffers from arthritis. All forms of arthritis begin with the same symptoms: pain, stiffness, and swelling of the joints.

Two types of arthritis are osteoarthritis and rheumatoid arthritis. Osteoarthritis results when cartilage breaks down because of years of use. Rheumatoid arthritis is an ongoing condition in which the body's immune system tries to destroy its own tissues.

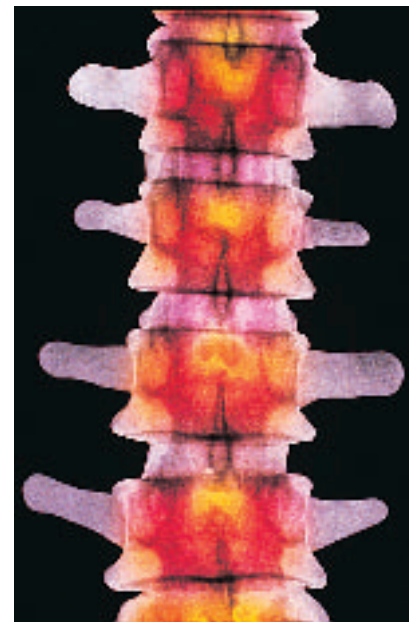


Figure 5 A colored X ray of the human backbone shows disks of cartilage between the vertebrae.

section 1 review

Summary

Living Bones

- The skeletal system is the framework of your body and has five major functions.

Bone Structure

- A tough membrane called the periosteum covers a bone and supplies nutrients to it.
- Compact bone is hard bone located directly under the periosteum.
- Spongy bone is lightweight and located toward the ends of long bones.
- Cartilage covers the ends of bones and acts as a shock absorber.

Bone Formation

- Osteoblasts are bone-forming cells and osteoclasts are cells that break down bone.
- A joint is anyplace where two or more bones come together.
- Ligaments are tough bands of tissue that hold bones together at joints.

Self Check

1. **List** the five major functions of the skeletal system.
2. **Name** and give an example of both a movable joint and an immovable joint.
3. **Explain** the functions of cartilage in your skeletal system.
4. **Describe** ligaments.
5. **Think Critically** A thick band of bone forms around a broken bone as it heals. In time, the thickened band disappears. Explain how this extra bone can disappear over time.

Applying Skills

6. **Make and Use Tables** Use a table to classify the bones of the human body as follows: *long, short, flat, or irregular*.
7. **Use graphics software** to make a circle graph that shows how an adult's bones are distributed: *29 skull bones, 26 vertebrae, 25 ribs, four shoulder bones, 60 arm and hand bones, two hip bones, and 60 leg and feet bones*.

The Muscular System

as you read

What You'll Learn

- **Identify** the major function of the muscular system.
- **Compare and contrast** the three types of muscles.
- **Explain** how muscle action results in the movement of body parts.

Why It's Important

The muscular system is responsible for how you move and the production of heat in your body. Muscles also give your body its shape.

Review Vocabulary

bone: dense, calcified tissue of the skeleton, that is moved by muscles

New Vocabulary

- muscle
- voluntary muscle
- involuntary muscle
- skeletal muscle
- tendon
- cardiac muscle
- smooth muscle

Movement of the Human Body

The golfer looks down the fairway and then at the golf ball. With intense concentration and muscle coordination, the golfer swings the club along a graceful arc and connects with the ball. The ball sails through the air, landing inches away from the flag. The crowd applauds. A few minutes later, the golfer makes the final putt and wins the tournament. The champion has learned how to use controlled muscle movement to bring success.

Muscles help make all of your daily movements possible. **Figure 6** shows which muscles connect some of the bones in your body. A **muscle** is an

organ that can relax, contract, and provide the force to move your body parts. In the process, energy is used and work is done. Imagine how much energy the more than 600 muscles in your body use each day. No matter how still you might try to be, some muscles in your body are always moving. You're breathing, your heart is beating, and your digestive system is working.



Figure 6 Your muscles come in many shapes and sizes. Even simple movements require the coordinated use of several muscles. The muscles shown here are only those located directly under the skin. Beneath these muscles are middle and deep layers of muscles.



Muscle Control Your hand, arm, and leg muscles are voluntary. So are the muscles of your face, shown in **Figure 7**. You can choose to move them or not move them. Muscles that you are able to control are called **voluntary muscles**. In contrast, **involuntary muscles** are muscles you can't control consciously. They go on working all day long, all your life. Blood gets pumped through blood vessels, and food is moved through your digestive system by the action of involuntary muscles.

 **Reading Check**

What is a body activity that is controlled by involuntary muscles?

Your Body's Simple Machines—Levers



Your skeletal system and muscular system work together when you move, in the same way that the parts of a bicycle work together when it moves. A machine, such as a bicycle, is any device that makes work easier. A simple machine does work with only one movement, like a hammer. The hammer is a type of simple machine called a lever, which is a rod or plank that pivots or turns about a point. This point is called a fulcrum. The action of muscles, bones, and joints working together is like a lever. In your body, bones are rods, joints are fulcrums, and contraction and relaxation of muscles provide the force to move body parts. Levers are classified into three types—first-class, second-class, and third-class. Examples of the three types of levers that are found in the human body are shown in **Figure 8**.

Figure 7 Facial expressions generally are controlled by voluntary muscles. It takes only 13 muscles to smile, but 43 muscles to frown.

 **Science online**

Topic: Joint Replacement

Visit bookd.msscience.com for Web links to recent news or magazine articles about replacing diseased joints.

Activity Make a list in your Science Journal of the most commonly replaced joints.

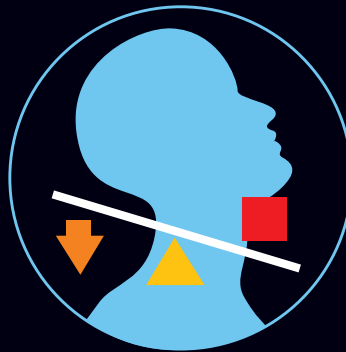
Figure 8



All three types of levers—first-class, second-class, and third-class—are found in the human body. In the photo below, a tennis player prepares to serve a ball. As shown in the accompanying diagrams, the tennis player's stance demonstrates the operation of all three classes of levers in the human body.

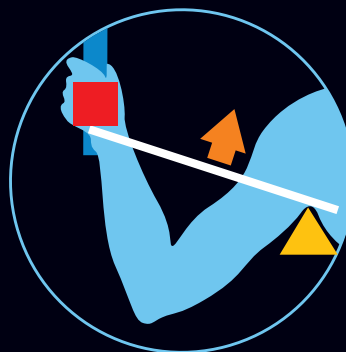


-  Fulcrum
-  Effort force
-  Load



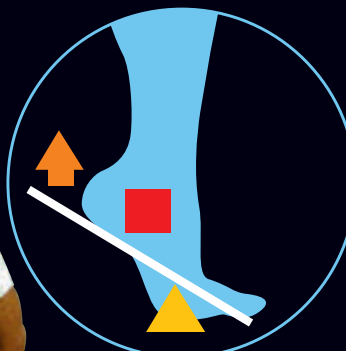
FIRST-CLASS LEVER

The fulcrum lies between the effort force and the load. This happens when the tennis player uses his neck muscles to tilt his head back.



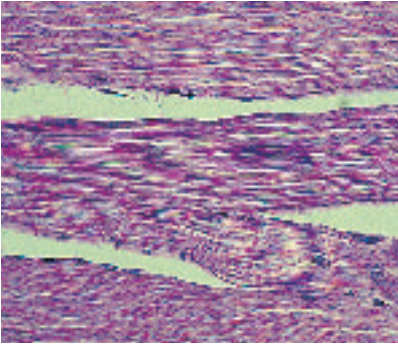
THIRD-CLASS LEVER

The effort force is between the fulcrum and the load. This happens when the tennis player flexes the muscles in his arm and shoulder.



SECOND-CLASS LEVER

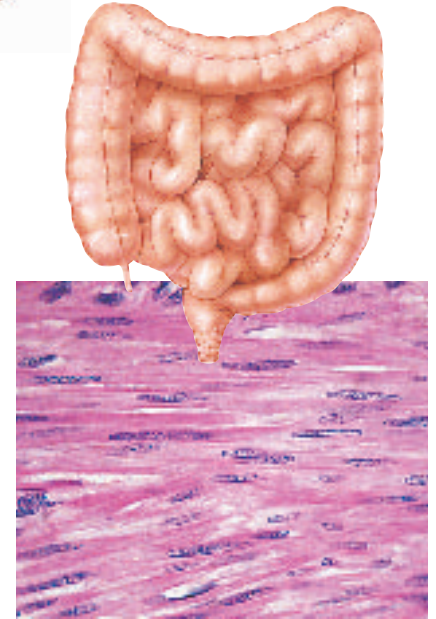
The load lies between the fulcrum and the effort force. This happens when the tennis player's calf muscles lift the weight of his body up on his toes.



A Skeletal muscles move bones. The muscle tissue is striated, and attached to bone.



B Cardiac muscle is found only in the heart. The muscle tissue has striations.



C Smooth muscle is found in many of your internal organs, such as the digestive tract. This muscle tissue is nonstriated.

Classification of Muscle Tissue

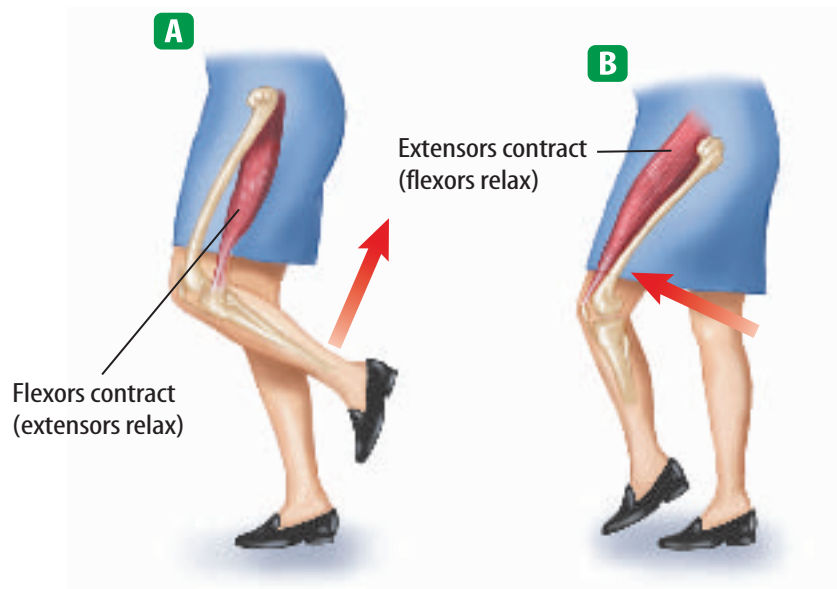
All the muscle tissue in your body is not the same. The three types of muscles are skeletal, smooth, and cardiac. The muscles that move bones are **skeletal muscles**. They are more common than other muscle types and are attached to bones by thick bands of tissue called **tendons**. When viewed under a microscope, skeletal muscle cells are striated (STRIPED), and appear striped. You can see the striations in **Figure 9A**. Skeletal muscles are voluntary muscles. You choose when to walk or when not to walk. Skeletal muscles tend to contract quickly and tire more easily than involuntary muscles do.

The remaining two types of muscles are shown in **Figures 9B** and **9C**. **Cardiac muscle** is found only in the heart. Like skeletal muscle, cardiac muscle is striated. This type of muscle contracts about 70 times per minute every day of your life. **Smooth muscles** are found in your intestines, bladder, blood vessels, and other internal organs. They are nonstriated, involuntary muscles that slowly contract and relax. Internal organs are made of one or more layers of smooth muscles.

Figure 9 The three types of muscle tissue are skeletal muscle, cardiac muscle, and smooth muscle.

Figure 10 **A** When the flexor (hamstring) muscles of your thigh contract, the lower leg is brought toward the thigh. **B** When the extensor (quadriceps) muscles contract, the lower leg is straightened.

Describe the class of lever shown to the right.



Working Muscles

How do muscles allow you to move your body? You move because pairs of skeletal muscles work together. When one muscle of a pair contracts, the other muscle relaxes, or returns to its original length, as shown in **Figure 10**. Muscles always pull. They never push. When the muscles on the back of your upper leg contract, they shorten and pull your lower leg back and up. When you straighten your leg, the back muscles lengthen and relax, and the muscles on the front of your upper leg contract. Compare how the muscles of your legs work with how the muscles of your arms work.

Changes in Muscles Over a period of time, muscles can become larger or smaller, depending on whether or not they are used. Skeletal muscles that do a lot of work, such as those in your writing hand, become strong and large. For example, many soccer and basketball players have noticeably larger, defined leg muscles. Muscles that are given regular exercise respond quickly to stimuli. Some of this change in muscle size is because of an increase in the number of muscle cells. However, most of this change in muscle size is because individual muscle cells become larger.

In contrast, if you participate only in nonactive pastimes such as watching television or playing computer games, your muscles will become soft and flabby and will lack strength. Muscles that aren't exercised become smaller in size. When someone is paralyzed, his or her muscles become smaller due to lack of exercise.

Reading Check How do muscles increase their size?

Mini LAB

Comparing Muscle Activity

Procedure

1. Hold a light **book** in your outstretched hand over a dining or kitchen **table**.
2. Lift the book from this position to a height of 30 cm from the table 20 times.

Analysis

1. Compare your arm muscle activity to the continuous muscle activity of the heart.
2. Infer whether heart muscles become tired.



How Muscles Move Your muscles need energy to contract and relax. Your blood carries energy-rich molecules to your muscle cells where the chemical energy stored in these molecules is released. As the muscle contracts, this released energy changes to mechanical energy (movement) and thermal energy (heat), as shown in **Figure 11**. When the supply of energy-rich molecules in a muscle is used up, the muscle becomes tired and needs to rest. During this resting period, your blood supplies more energy-rich molecules to your muscle cells. The heat produced by muscle contractions helps keep your body temperature constant.



Figure 11 Chemical energy is needed for muscle activity. During activity, chemical energy supplied by food is changed into mechanical energy (movement) and thermal energy (heat).

section 2 review

Summary

Movement of the Human Body

- Muscles are organs that relax, contract, and provide force to move your body parts.

Classification of Muscle Tissue

- Skeletal muscles are striated muscles that move bones.
- Cardiac muscles are striated muscles which are found only in the heart.
- Smooth muscles are found in your internal organs and are nonstriated muscles.

Working Muscles

- Muscles always pull and when one muscle of a pair contracts, the other muscle relaxes.
- Chemical energy is needed for muscle activity.

Self Check

1. **Describe** the function of muscles.
2. **Compare and contrast** the three types of muscle tissue.
3. **Name** the type of muscle tissue found in your heart.
4. **Describe** how a muscle attaches to a bone.
5. **Think Critically** What happens to your upper-arm muscles when you bend your arm at the elbow?

Applying Skills

6. **Concept Map** Using a concept map, sequence the activities that take place when you bend your leg at the knee.
7. **Communicate** Write a paragraph in your Science Journal about the three forms of energy involved in a muscle contraction.

The Skin

as you read

What You'll Learn

- **Distinguish** between the epidermis and dermis of the skin.
- **Identify** the skin's functions.
- **Explain** how skin protects the body from disease and how it heals itself.

Why It's Important

Skin plays a vital role in protecting your body.

Review Vocabulary

vitamin: an inorganic nutrient needed by the body in small quantities for growth, disease prevention, and/or regulation of body functions

New Vocabulary

- epidermis
- dermis
- melanin

Your Largest Organ

What is the largest organ in your body? When you think of an organ, you might imagine your heart, stomach, lungs, or brain. However, your skin is the largest organ of your body. Much of the information you receive about your environment comes through your skin. You can think of your skin as your largest sense organ.

Skin Structures

Skin is made up of three layers of tissue—the epidermis, the dermis, and a fatty layer—as shown in **Figure 12**. Each layer of skin is made of different cell types. The **epidermis** is the outer, thinnest layer of your skin. The epidermis's outermost cells are dead and water repellent. Thousands of epidermal cells rub off every time you take a shower, shake hands, blow your nose, or scratch your elbow. New cells are produced constantly at the base of the epidermis. These new cells move up and eventually replace those that are rubbed off.

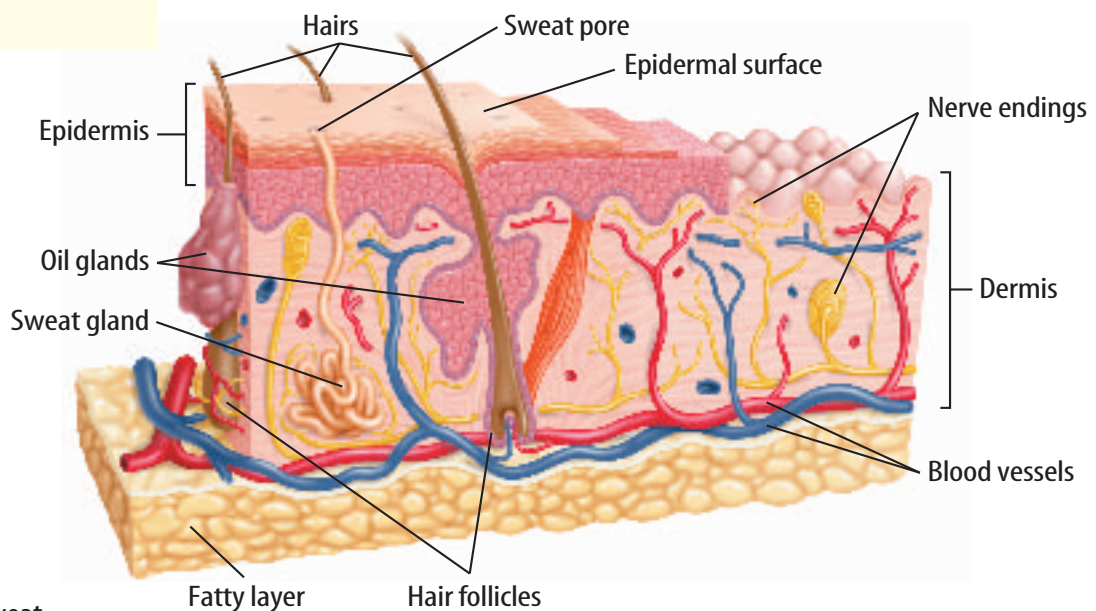


Figure 12 Hair, sweat glands, and oil glands are part of your body's largest organ, the skin.

(l) Clyde H. Smith/Peter Arnold, Inc., (tc) Erik Sampers/Photo Researchers, (cc) Dean Conger/CORBIS, (r) Michael A. Keller/The Stock Market/CORBIS, (b) Ed Bock/The Stock Market/CORBIS, (bc) Joe McDonald/Visuals Unlimited, (bc) Art Stein/Photo Researchers, (br) Peter Turnley/CORBIS

Melanin Cells in the epidermis produce the chemical melanin (MEL uh nun). **Melanin** is a pigment that protects your skin and gives it color. The different amounts of melanin produced by cells result in differences in skin color, as shown in **Figure 13**. When your skin is exposed to ultraviolet rays, melanin production increases and your skin becomes darker. Lighter skin tones have less protection from the Sun. Such skin burns more easily and may be more susceptible to skin cancer.

Other Skin Layers The **dermis** is the layer of cells directly below the epidermis. This layer is thicker than the epidermis and contains many blood vessels, nerves, muscles, oil and sweat glands, and other structures. Below the dermis is a fatty region that insulates the body. This is where much of the fat is deposited when a person gains weight.

Skin Functions

Your skin is not only the largest organ of your body, it also carries out several major functions, including protection, sensory response, formation of vitamin D, regulation of body temperature, and ridding the body of wastes. The most important function of the skin is protection. The skin forms a protective covering over the body that prevents physical and chemical injury. Some bacteria and other disease-causing organisms cannot pass through the skin as long as it is unbroken. Glands in the skin secrete fluids that can damage or destroy some bacteria. The skin also slows down water loss from body tissues.

Specialized nerve cells in the skin detect and relay information to the brain, making the skin a sensory organ, too. Because of these cells, you are able to sense the softness of a cat, the sharpness of a pin, or the heat of a frying pan.

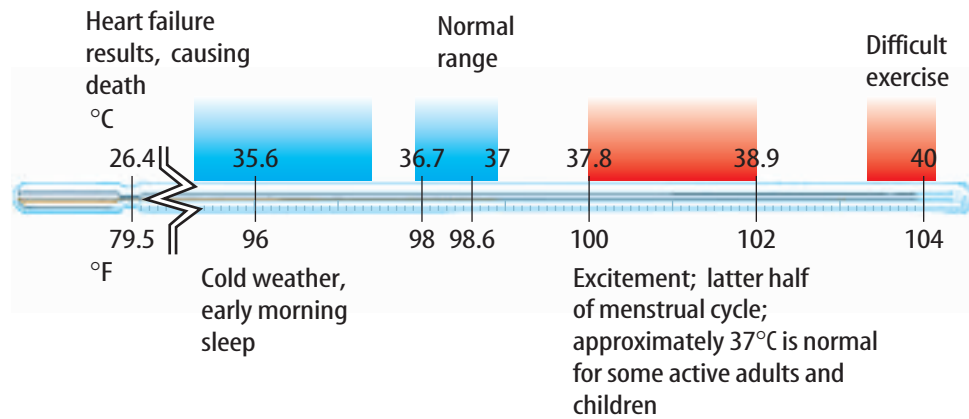


Mountain Climber

Research the effects of ultraviolet radiation on skin. Mountain climbers risk becoming severely sunburned even in freezing temperatures due to increased ultraviolet (UV) radiation. Research other careers that increase your risk of sunburn. Record your answers in your Science Journal.

Figure 13 Melanin gives skin and eyes their color. The more melanin that is present, the darker the color is. This pigment provides protection from damage caused by harmful UV rays.

Figure 14 Normal human body temperature is about 37°C. Temperature varies throughout the day. The highest body temperature is reached at about 11 A.M. and the lowest at around 4 A.M. At 43°C (109.5°F) internal bleeding results, causing death.



Vitamin D Formation Another important function of skin is the formation of vitamin D. Small amounts of this vitamin are produced in the presence of ultraviolet light from a fatlike molecule in your epidermis. Vitamin D is essential for good health because it helps your body absorb calcium into your blood from food in your digestive tract.

Heat and Waste Exchange Humans can withstand a limited range of body temperatures, as shown in **Figure 14**. Your skin plays an important role in regulating your body temperature. Blood vessels in the skin can help release or hold heat. If the blood vessels expand, or dilate, blood flow increases and heat is released. In contrast, less heat is released when the blood vessels constrict. Think of yourself after running—are you flushed red or pale and shivering?

The adult human dermis has about 3 million sweat glands. These glands help regulate the body's temperature and excrete wastes. When the blood vessels dilate, pores open in the skin that lead to the sweat glands. Perspiration, or sweat, moves out onto the skin. Heat transfers from the body to the sweat on the skin. Eventually, this sweat evaporates, removing the heat and cooling the skin. This system eliminates excess heat produced by muscle contractions.

Reading Check *What are two functions of sweat glands?*

As your cells use nutrients for energy, they produce wastes. Such wastes, if not removed from your body, can act as poisons. In addition to helping regulate your body's temperature, sweat glands release water, salt, and other waste products. If too much water and salt are released by sweating during periods of extreme heat or physical exertion, you might feel light-headed or may even faint.

Mini LAB

Recognizing Why You Sweat

Procedure

1. Examine the epidermis and the pores of your skin using a **magnifying lens**.
2. Place a **clear-plastic sandwich bag** on your hand. Use tape to seal the bag around your wrist. **WARNING:** Do not wrap the tape too tightly.
3. Quietly study your **text** for 10 min, then look at your hand. Remove the bag.
4. Describe what happened to your hand while it was inside the bag.

Analysis

1. Identify what formed inside the bag. Where did this substance come from?
2. Why does this substance form even when you are not active?

Skin Injuries and Repair

Your skin often is bruised, scratched, burned, ripped, and exposed to harsh conditions like cold and dry air. In response, the skin produces new cells in its epidermis and repairs tears in the dermis. When the skin is injured, disease-causing organisms can enter the body rapidly. An infection often results.

Bruises Bruises are common, everyday events. Playing sports or working around your house often results in minor injuries. What is a bruise and how does your body repair it?

When you have a bruise, your skin is not broken but the tiny blood vessels underneath the skin have burst. Red blood cells from these broken blood vessels leak into the surrounding tissue. These blood cells then break down, releasing a chemical called hemoglobin. The hemoglobin gradually breaks down into its components, called pigments. The color of these pigments causes the bruised area to turn shades of blue, red, and purple, as shown in **Figure 15**. Swelling also may occur. As the injury heals, the bruise eventually turns yellow as the pigment in the red blood cells is broken down even more and reenters the bloodstream. After all of the pigment is absorbed into the bloodstream, the bruise disappears and the skin looks normal again.



What is the source of the yellow color of a bruise that is healing?

Cuts Any tear in the skin is called a cut. Blood flows out of the cut until a clot forms over it. A scab then forms, preventing bacteria from entering the body. Cells in the surrounding blood vessels fight infection while the skin cells beneath the scab grow to fill the gap in the skin. In time, the scab falls off, leaving the new skin behind. If the cut is large enough, a scar may develop because of the large amounts of thick tissue fibers that form.

The body generally can repair bruises and small cuts. What happens when severe burns, some diseases, and surgeries result in injury to large areas of skin? Sometimes, not enough skin cells are left that can divide to replace this lost layer. If not treated, this can lead to rapid water loss from skin and muscle tissues, leading to infection and possible death. Skin grafts can prevent such problems. What are skin grafts?



Acidic Skin Oil and sweat glands in your skin cause the skin to be acidic. With a pH between 3 and 5, the growth of potential disease-causing microorganisms on your skin is reduced. What does pH mean? What common substances around your home have a pH value similar to that of your skin? Research to find these answers and then record them in your Science Journal.

Figure 15 Bruising occurs when capillaries and other tiny blood vessels beneath the skin burst.





Figure 16 A cancerous growth was removed from the nose of a 69-year-old woman. A piece of skin removed from her scalp was grafted onto her nose to replace the lost skin (top). The skin graft is healing after only one month (bottom).

Skin Grafts Pieces of skin that are cut from one part of a person's body and then moved to the injured or burned area where there is no skin are called skin grafts. This skin graft is kept alive by nearby blood vessels and soon becomes part of the surrounding skin. Successful skin grafts, shown in **Figure 16**, must be taken from the victim's own body or possibly an identical twin. Skin transplants from other sources are rejected in about three weeks.

What can be done for severe burn victims who have little healthy skin left? Since the 1880s, doctors have used the skin from dead humans, called cadavers, to treat such burns temporarily. However, the body usually rejects this skin, so it must be replaced continually until the burn heals.

A recent advancement in skin repair uses temporary grafts from cadavers to prevent immediate infections, while scientists grow large sheets of epidermis from small pieces of the burn victim's healthy skin. After 19 to 21 days, the cadaver skin patch is removed and the new epidermis is applied. With new technologies, severe cases of skin loss or damage that cannot be repaired may no longer be fatal.

section 3 review

Summary

Skin Structures

- The epidermis is the thinnest, outermost layer of skin.
- The dermis is the thick layer below the epidermis. It contains blood vessels, nerves, muscles, oil, and sweat glands.
- Melanin is a pigment that protects your skin and gives it color.

Skin Functions

- Your skin provides protection, and eliminates body wastes.

Skin Injuries and Repair

- A bruise is caused by tiny broken blood vessels underneath the skin.
- When you cut your skin, blood flows out of the cut until a clot forms, causing a scab to protect against bacteria.
- Skin grafts can be made from a cadaver or a victim's healthy skin to repair the epidermis.

Self Check

1. **Compare and contrast** the epidermis and dermis.
2. **List** five of the major functions of the body's largest organ, skin.
3. **Explain** how skin helps prevent disease in the body.
4. **Describe** one way in which doctors are able to repair severe skin damage from burns, injuries, or surgeries.
5. **Think Critically** Why is a person who has been severely burned in danger of dying from loss of water?

Applying Math

6. **Solve One-Step Equations** The skin of eyelids is about 0.5 mm thick. On the soles of your feet, skin is up to 0.4 cm thick. How many times thicker is the skin on the soles of your feet compared to your eyelids?
7. **Calculate** The outermost layers of your skin are replaced every 27 days. How many times per year are your outermost layers of skin replaced?

Measuring Skin Surface

Skin covers the entire surface of your body and is your body's largest organ. Skin cells make up a layer of skin about 2 mm thick. These cells are continually lost and re-formed. Skin cells are shed daily at a rate of an average of 50,000 cells per minute. In one year, humans lose about 2 kg of skin and hair. How big is this organ? Find the surface area of human skin.

Real-World Question

How much skin covers your body?

Goal

■ **Estimate** the surface area of skin that covers the body of a middle-school student.

Materials

10 large sheets	tape
of newspaper	meterstick or ruler
scissors	

Safety Precautions



Procedure

1. Form groups of three or four, either all female or all male. Select one person from your group to measure the surface area of his or her skin.
2. **Estimate** how much skin covers the average student in your classroom. In your Science Journal, record your estimation.
3. Wrap newspaper snugly around each part of your classmate's body. Overlap sheets of paper and use tape to secure them. Cover entire hands and feet. Small body parts, such as fingers and toes, do not need to be wrapped individually.
WARNING: Do not cover face. May cause suffocation.

4. After your classmate is completely covered with paper, carefully cut the newspaper off his or her body. **WARNING:** Do not cut any clothing or skin.
5. Lay all of the overlapping sheets of newspaper on the floor. Using scissors and more tape, cut and piece the paper suit together to form a rectangle.
6. Using a meterstick, measure the length and width of the resulting rectangle. Multiply these two measurements for an estimate of the surface area of your classmate's skin.



Conclude and Apply

1. Was your estimation correct? Explain.
2. How accurate are your measurements of your classmate's skin surface area? How could your measurements be improved?
3. **Calculate** the skin's volume using 2 mm as the average skin thickness and your calculated surface area from this lab.

Communicating Your Data

Make a table of all data. Find the average area for male groups and then for female groups. Discuss the differences. **For more help, refer to the Math Skill Handbook.**

Similar Skeletons

Goals

- **Identify** a skeletal structure in the human body.
- **Write** a list of mammals with which you are familiar.
- **Compare** the identified human skeletal structure to a skeletal structure in each of the mammals.
- **Determine** if the mammal skeletal structure that you selected is similar to the human skeletal structure you identified.
- **Describe** how the mammal skeletal structure is similar to or different from the skeletal structure in a human.

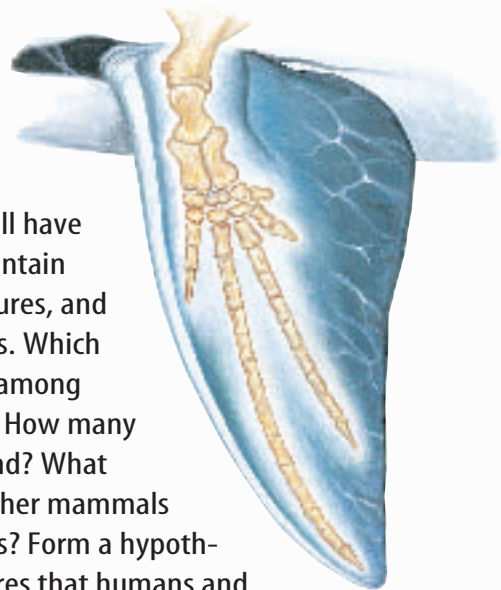
Data Source

Science  online

Visit bookd.msscience.com/internet_lab for Web links to more information about skeletal structures, and for data collected by other students.

Real-World Question

Humans and other mammals share many similar characteristics, including similar skeletal structures. Think about all the different types of mammals you have seen or read about. Tigers, dogs, and household cats are meat-eating mammals. Whales and dolphins live in water. Primates, which include gorillas, chimpanzees, and humans, can walk on two legs. Mammals live in different environments, eat different types of food, and even look different, but they all have hair, possess the ability to maintain fairly constant body temperatures, and have similar skeletal structures. Which skeletal structures are similar among humans and other mammals? How many bones do you have in your hand? What types of bones are they? Do other mammals have similar skeletal structures? Form a hypothesis about the skeletal structures that humans and other mammals have in common.



Make a Plan

1. Choose a specific part of the human skeletal structure to study, such as your hand, foot, skull, leg, or arm.

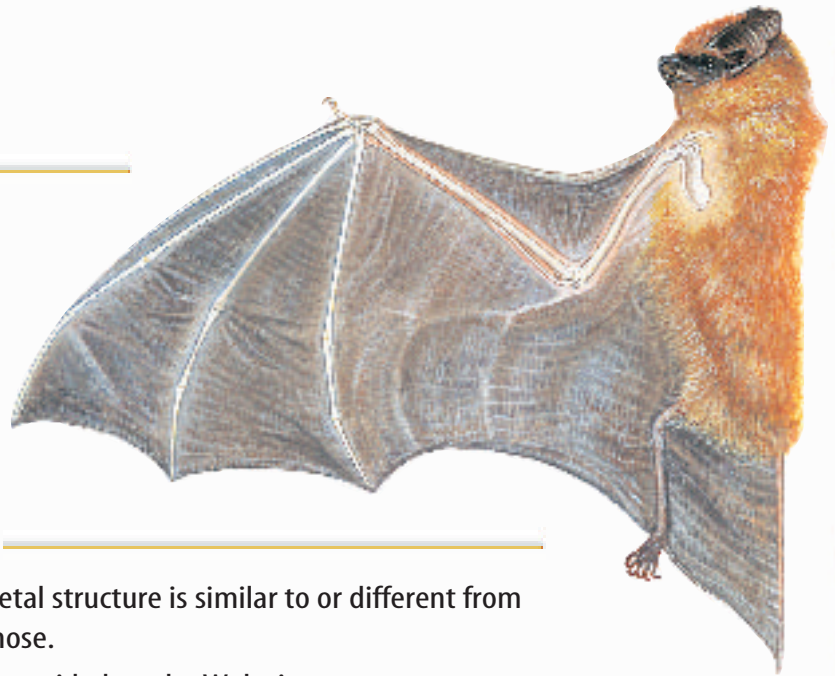


Using Scientific Methods

2. **List** four to six different mammals.
3. Do these mammals possess skeletal structures similar to the human skeleton? Remember, the mammals' skeletons can be similar to that of the human, but the structures can have different functions.
4. **Compare and contrast** the mammal and human skeletal structures. Are the types of bone similar? Is the number of bones the same? Where are these structures located?

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Visit the link below to post your data.



Analyze Your Data

1. **Describe** how each mammal's skeletal structure is similar to or different from the human skeletal structure you chose.
2. **Record** your data in the data table provided on the Web site.

Conclude and Apply

1. Visit the link below and compare your data to that of other students. Do other students agree with your conclusions?
2. Do the structures studied have similar functions in the human and the mammals you researched?

Communicating Your Data

Find this lab using the link below. Post your data in the table provided. Compare your data with that posted by other students.

 ScienceOnline

bookd.msscience.com/internet_lab

First Aid Dolls

A fashion doll is doing her part for medical science! It turns out that the plastic joints that make it possible for one type of doll's legs to bend make good joints in prosthetic (artificial) fingers for humans.

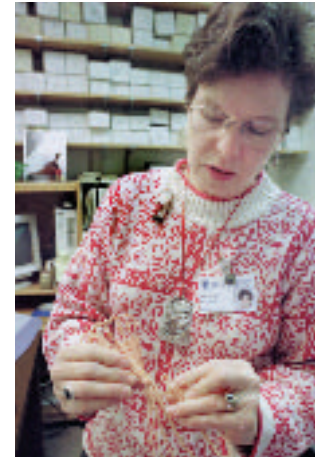
Jane Bahor (photo at right) works at Duke University Medical Center in Durham, North Carolina. She makes lifelike body parts for people who have lost legs, arms, or fingers. A few years ago, she met a patient named Jennifer Jordan, an engineering student who'd lost a finger. The artificial finger that Bahor made looked real, but it couldn't bend. She and Jordan began to discuss the problem.

"If only the finger could bend like a doll's legs bend," said Bahor. "It would be so much more useful to you!"

Jordan's eyes lit up. "That's it!" Jordan said. The engineer went home and borrowed one of her sister's dolls. Returning with it to Bahor's office, she and Bahor did "surgery." They operated on the fashion doll's legs and removed the knee joints from their vinyl casings.



"It turns out that the doll's knee joints flexed the same way that human finger joints do," says Bahor. "We could see that using these joints would allow patients more use and flexibility with their 'new' fingers."



Holding On

The new, fake, flexible fingers can bend in the same way that a doll's legs bend. A person can use his or her other hand to bend and straighten the joint. When the joint bends, it makes a sound similar to a cracking knuckle.

Being able to bend prosthetic fingers allows wearers to hold a pen, pick up a cup, or grab a steering wheel. These are tasks that were impossible before the plastic knee joints were implanted in the artificial fingers. "We've even figured out how to insert three joints in each finger, so that now its wearer can almost make a fist," adds Bahor. Just like the doll's legs, the prosthetic fingers stay bent until the wearer straightens them.

Bahor removes a knee joint from a doll. The joint will soon be in a human's prosthetic finger!

Invent Choose a "problem" you can solve. Use what Bahor calls "commonly found materials" to solve the problem. Then make a model or a drawing of the problem-solving device.

Science  **online**

For more information, visit
bookd.msscience.com/oops

Reviewing Main Ideas

Section 1 The Skeletal System

1. Bones are living structures that protect, support, make blood, store minerals, and provide for muscle attachment.
2. The skull and pelvic joints in adults do not move and are classified as immovable.
3. Movable joints move freely, and include pivot, hinge, ball-and-socket, and gliding joints.

Section 2 The Muscular System

1. Skeletal muscle is voluntary and moves bones. Smooth muscle is involuntary and controls movement of internal organs. Cardiac muscle is involuntary and located only in the heart.
2. Muscles contract—they pull, not push, to move body parts.

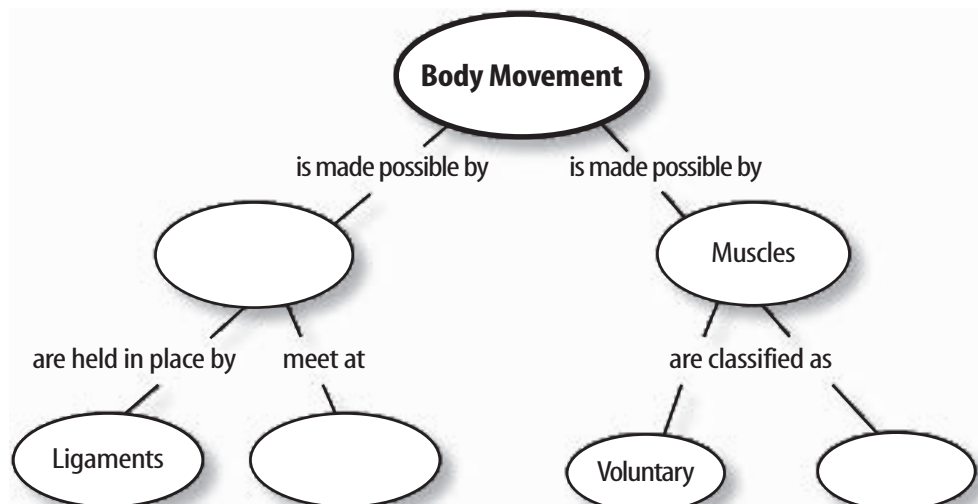
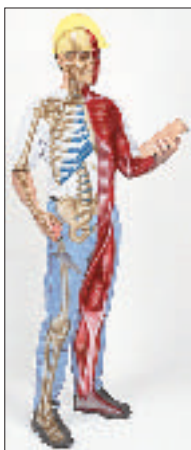
3. Skeletal muscles work in pairs—when one contracts, the other relaxes.

Section 3 The Skin

1. The epidermis has dead cells on its surface. Melanin is produced in the epidermis. Cells at the base of the epidermis produce new skin cells. The dermis is the inner layer where nerves, sweat and oil glands, and blood vessels are located.
2. The functions of skin include protection, reduction of water loss, production of vitamin D, and maintenance of body temperature.
3. Glands in the epidermis produce substances that destroy bacteria.
4. Severe damage to skin, including injuries and burns, can lead to infection and death if it is not treated.

Visualizing Main Ideas

Copy and complete the following concept map on body movement.



Using Vocabulary

cardiac muscle p.17	muscle p.14
cartilage p.10	periosteum p.9
dermis p.21	skeletal muscle p.17
epidermis p.20	skeletal system p.8
involuntary muscle p.15	smooth muscle p.17
joint p.11	tendon p.17
ligament p.11	voluntary muscle p.15
melanin p.21	

Match the definitions with the correct vocabulary word.

- tough outer covering of bone
- internal framework of the body
- outer layer of skin
- thick band of tissue that attaches muscle to a bone
- muscle found only in the heart
- a tough band of tissue that holds two bones together
- organ that can relax and contract to aid in the movement of the body
- a muscle that you control

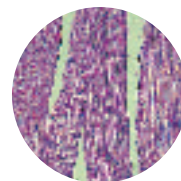
Checking Concepts

Choose the word or phrase that best answers the question.

- Which of the following is the most solid form of bone?
 - compact
 - periosteum
 - spongy
 - marrow
- Where are blood cells made?
 - compact bone
 - periosteum
 - cartilage
 - marrow
- Where are minerals stored?
 - bone
 - skin
 - muscle
 - blood

- What are the ends of bones covered with?
 - cartilage
 - tendons
 - ligaments
 - muscle
- Where are immovable joints found in the human body?
 - at the elbow
 - at the neck
 - in the wrist
 - in the skull
- What kind of joints are the knees, toes, and fingers?
 - pivot
 - hinge
 - gliding
 - ball and socket
- Which vitamin is made in the skin?
 - A
 - B
 - D
 - K
- Where are dead skin cells found?
 - dermis
 - marrow
 - epidermis
 - periosteum
- Which of the following is found in bone?
 - iron
 - calcium
 - vitamin D
 - vitamin K
- Which of the following structures helps retain fluids in the body?
 - bone
 - muscle
 - skin
 - a joint

Use the illustration below to answer question 19.



- Where would this type of muscle tissue be found in your body?
 - heart
 - esophagus
 - stomach
 - leg

Part 1 Multiple Choice

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

- Which type of muscle tends to contract quickly and tire more easily?
 - A. cardiac muscle C. skeletal muscle
 - B. bladder D. smooth muscle

Use the table below to answer questions 2 and 3.

Number of Bicycle Deaths per Year		
Year	Male	Female
1996	654	107
1997	712	99
1998	658	99
1999	656	94
2000	605	76

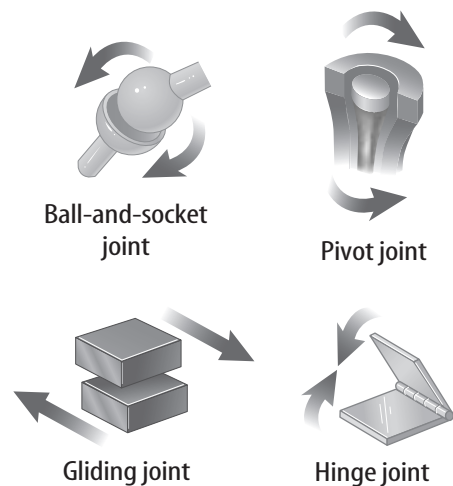
Data from Insurance Institute for Highway Safety

- If 99% of the people who die in bicycle accidents were not wearing helmets, to the nearest whole number, how many people who died in 1998 were wearing bicycle helmets?
 - A. 7 C. 8
 - B. 6 D. 9
- Which year had the greatest total number of bicycle deaths?
 - A. 1996 C. 1998
 - B. 1997 D. 1999
- Which of the following is NOT released by sweat glands?
 - A. water C. waste products
 - B. salt D. oil

Test-Taking Tip

Ease Nervousness Stay calm during the test. If you feel yourself getting nervous, close your eyes and take five slow, deep breaths.

Use the illustration below to answer questions 5 and 6.



- Which type of joint do your elbows have?
 - A. hinge C. ball-and-socket
 - B. gliding D. pivot
- Which type of joint allows your legs and arms to swing in almost any direction?
 - A. hinge C. ball-and-socket
 - B. gliding D. pivot
- What is the name of the pigment that gives your skin color?
 - A. hemoglobin C. melanin
 - B. keratin D. calcium
- What does the periosteum do?
 - A. connects bones together
 - B. covers the surface of bones
 - C. produces energy
 - D. makes vitamin D
- Which type of muscle is found in the intestines?
 - A. skeletal muscle
 - B. smooth muscle
 - C. cardiac muscle
 - D. tendon

Part 2 Short Response/Grid In

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

10. At birth, your skeleton had approximately 300 bones. As you developed, some bones fused together. Now you have 206 bones. How many fewer bones do you have now?
11. One in seven people in the United States suffers from arthritis. Calculate the percentage of people that suffer from arthritis.
12. Explain the difference between voluntary and involuntary muscles.

Use the illustration below to answer questions 13 and 14.



13. What type of lever is shown in the photo?
14. Where is the fulcrum?
15. How do muscles help maintain body temperature?
16. Explain what happens when your skin is exposed to ultraviolet rays.

Part 3 Open Ended

Record your answers on a sheet of paper.

17. Compare and contrast compact and spongy bone.
18. Explain how bone cells help maintain homeostasis.
19. Describe the changes that occur in muscles that do a lot of work. Compare these muscles to the muscles of a person who only does inactive pastimes.

Use the illustration below to answer questions 20 and 21.



20. Identify the injury in the photograph. Describe the sequence of events from the time of injury until the injury disappears.
21. Contrast the injury in the photograph with a cut. Explain why a cut needs to be cleaned but the injury in the photograph does not.
22. What might happen to your body temperature if blood vessels in the skin did not contain smooth muscle?