

**The BIG Idea**

The structures and functions of the skin and the muscular, skeletal, and nervous systems help maintain your body's homeostasis.

SECTION 1**The Skin**

Main Idea The skin protects you, senses stimuli, forms vitamin D, helps regulate body temperature, and excretes wastes.

SECTION 2**The Muscular System**

Main Idea Muscles provide motion for internal organs, perform many tasks, and enable you to move from place to place.

SECTION 3**The Skeletal System**

Main Idea Bones support your body, protect internal organs, and store minerals.

SECTION 4**The Nervous System**

Main Idea The nervous system senses and responds to internal and external stimuli.

Support, Movement, and Responses

How are you like a building?

Buildings are supported and protected by internal and external structures. Your body is supported by your skeleton and protected by your skin. In this chapter, you also will learn how your body senses and responds to the world around you.

Science Journal Imagine for a moment that your body does not have a support system. How will you perform your daily activities? Explain your reasoning.

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 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

Support, Movement, and Responses Make the following Foldable to help you understand the functions of skin, muscles, bones, and nerves.

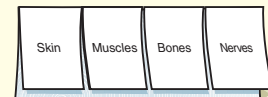
- STEP 1** **Fold** a sheet of paper in half lengthwise. Make the back edge about 1.25 cm longer than the front edge.



- STEP 2** **Fold** the paper in half widthwise, twice.



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



Read and Write As you read this chapter, list the functions that skin, muscles, bones, and nerves have in support, movement, and responses.



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

Get Ready to Read

Make Inferences

1 Learn It! When you make inferences, you draw conclusions that are not directly stated in the text. This means you “read between the lines.” You interpret clues and draw upon prior knowledge. Authors rely on a reader’s ability to infer because all the details are not always given.

2 Practice It! Read the excerpt below and pay attention to highlighted words as you make inferences. Use this Think-Through chart to help you make inferences.

Wastes are produced
when **nutrients** are broken down in cells. Such wastes, if not removed, can **act as poisons**.
—from page 436

Text	Question	Inferences
Wastes are produced	What wastes?	liquid, gaseous, and solid wastes
nutrients	Which nutrients?	proteins, carbohydrates, and lipids
act as poisons	How might these poisons affect you?	affect the functions of cells, tissues, organs, and organ systems

3 Apply It! As you read this chapter, practice your skill at making inferences by making connections and asking questions.

Reading Tip

Sometimes you make inferences by using other reading skills, such as questioning and predicting.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

- 1 **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
 - Write an **A** if you **agree** with the statement.
 - Write a **D** if you **disagree** with the statement.
- 2 **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
 - If any of your answers changed, explain why.
 - Change any false statements into true statements.
 - Use your revised statements as a study guide.

Before You Read A or D	Statement	After You Read A or D
	1 The skin is the largest organ of the human body.	
	2 The different skin colors result from different pigments in skin.	
	3 Your arm muscles are the same as your heart muscles.	
	4 Movement occurs because muscles relax and contract.	
	5 Bones are hard, nonliving structures.	
	6 Red blood cells form in the centers of some bones.	
	7 A neuron only moves messages from the brain to the body.	
	8 Damage to the left side of your brain affects the function of the left side of your body.	
	9 You can identify most foods using only your sense of taste.	
	10 Internal organs have sensory receptors.	

Science 
Print out a worksheet
of this page at
green.msscience.com



The Skin

as you read

What You'll Learn

- **Distinguish** between the epidermis and dermis of the skin.
- **Identify** the functions of the skin.
- **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 against injury and disease.



Review Vocabulary

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

New Vocabulary

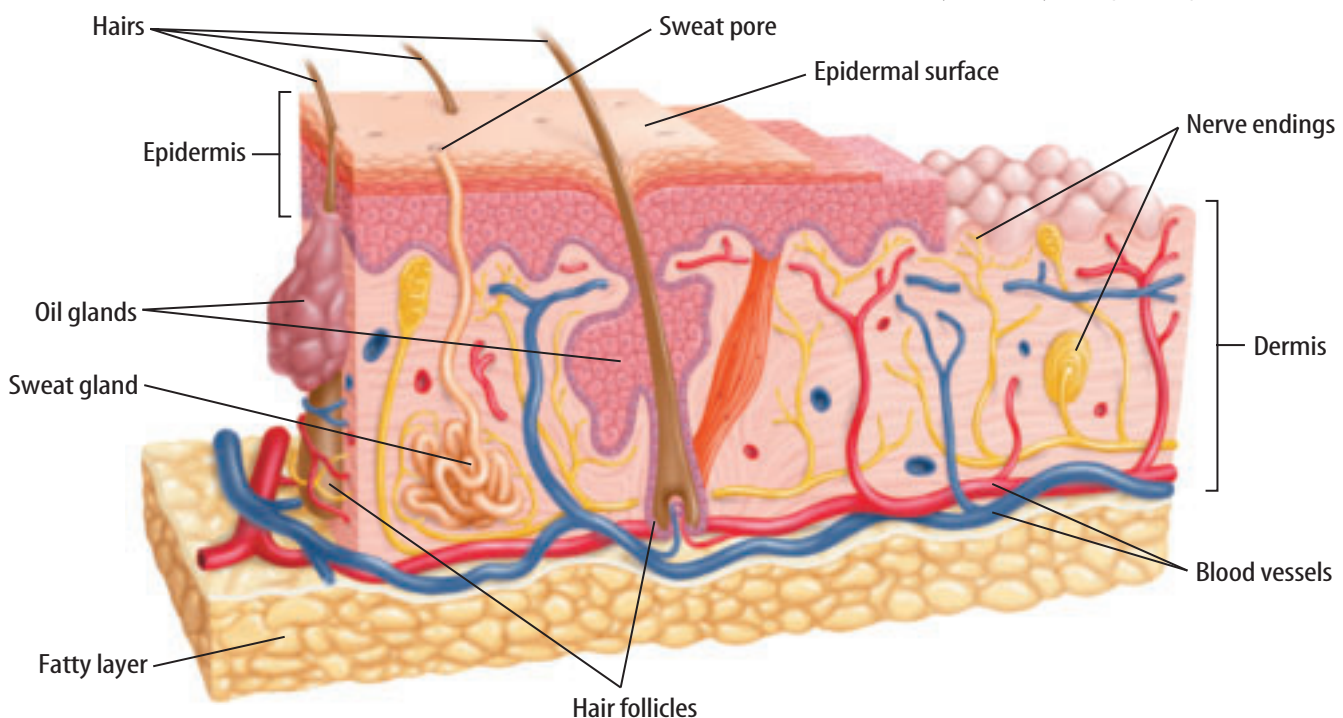
- epidermis
- melanin
- dermis

Skin Structures

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 is made up of three layers of tissue—the epidermis, the dermis, and a fatty layer—as shown in **Figure 1**. Each layer is made of different cell types. The **epidermis** is the outer, thinnest layer. The epidermis's outermost cells are dead and water repellent. Thousands of epidermal cells rub off every time you take a shower, shake hands, 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. The **dermis** is the layer of cells directly below the epidermis. This layer is thicker than the epidermis and contains 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.

Figure 1 Hair, sweat glands, and oil glands are part of your body's largest organ.





Melanin Cells in the epidermis produce the chemical **melanin** (ME luh nun), 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 2**. When your skin is exposed to ultraviolet rays, melanin production increases and your skin becomes darker. Lighter skin tones have less protection. Such skin burns more easily and can be more susceptible to skin cancer.

Skin Functions

Your skin 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 skin as long as it is unbroken. Glands in the skin secrete fluids that can damage or destroy some bacteria. The skin also slows water loss from body tissues.

Specialized nerve cells in the skin detect and relay information to the brain. Because of these cells, you are able to sense the softness of a cat, the sharpness of a pin, or that a frying pan is hot.

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.



High Altitude and Skin

There have been many books written about mountain climbing. Search the library for such a book and find references to the effects of sunlight and weather on the skin at high altitudes. In your Science Journal, list the book title and author and summarize the passage that describes the effects of sunlight and weather on the skin.

Figure 2 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 light energy.



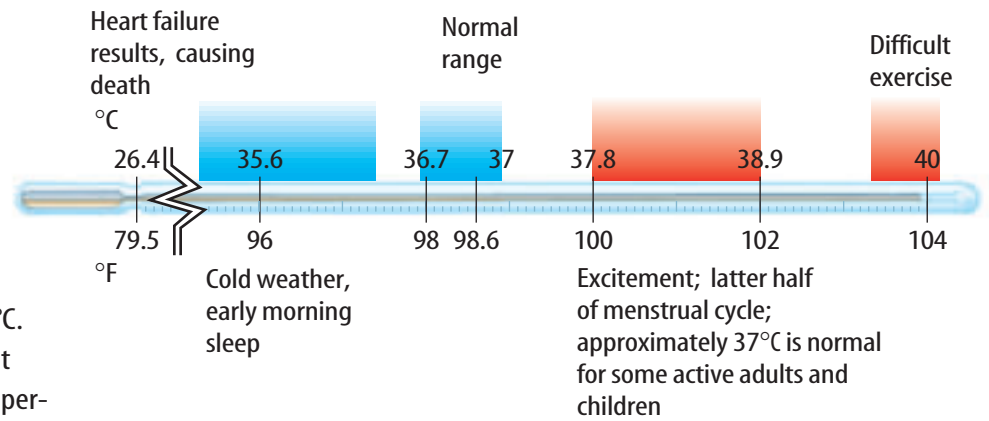


Figure 3 Normal human body temperature is about 37°C. Temperature varies throughout the day. The highest body temperature is reached at about 11 A.M. and the lowest at around 4 A.M. At 43°C (109.5°F), fatal bleeding results, causing death.

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 textbook 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?

Thermal Energy and Waste Exchange Humans can withstand a limited range of body temperatures, as shown in **Figure 3**. Your skin plays an important role in regulating your body temperature. Blood vessels in the skin can help release or hold thermal energy. If the blood vessels expand, or dilate, blood flow increases and thermal energy is released. In contrast, less thermal energy is released when the blood vessels constrict. Think of yourself after running—are you flushed red or pale and shivering?

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

Reading Check What are two functions of sweat glands?

Wastes are produced when nutrients are broken down in cells. Such wastes, if not removed, can act as poisons. In addition to helping regulate your body's temperature, sweat glands release waste products, such as water and salt. If too much water and salt are released during hot weather or physical exertion, you might feel light-headed or even faint.

Skin Injuries and Repair

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



Bruises When tiny blood vessels burst under unbroken skin, a bruise results. Red blood cells from these broken blood vessels leak into the surrounding tissue. These blood cells then break down, releasing a chemical called hemoglobin that gradually breaks down into its components, called pigments. The colors of these pigments cause the bruised area to turn shades of blue, red, and purple, as shown in **Figure 4**. Swelling also can 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 appears normal again.



Reading Check

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

The body usually can repair bruises and small cuts. What happens when severe burns, some diseases, and surgeries result in injury to large areas of skin? Sometimes there are not enough skin cells left to produce new skin. If not treated, this can lead to rapid water loss from skin and muscle tissues, leading to infection and possibly death. Skin grafts can prevent this. Pieces of skin are cut from one part of a person's body and moved to the injured or burned area where there is no skin. This new graft is kept alive by nearby blood vessels and soon becomes part of the surrounding skin.



Figure 4 Bruising occurs when tiny blood vessels beneath the skin burst.

Infer whether this bruise is new or is already healing.

section 1 review

Summary

Skin Structures

- Skin is the largest organ in your body.
- There are three layers of tissue in skin and each layer is made of different cell types.
- Melanin protects your skin and gives it color.

Skin Functions

- The most important function of skin is protection.
- Specialized nerve cells in the skin detect and relay information to the brain.

Skin Injuries and Repair

- When skin is injured, disease-causing organisms can enter the body rapidly.
- When skin is damaged, the epidermis produces new cells and the dermis repairs tears.

Self Check

1. **Compare and contrast** the epidermis and dermis.
2. **Identify** the major functions of the skin.
3. **Describe** the role that your skin plays in regulating body temperature.
4. **Explain** how skin helps prevent disease in the body.
5. **Describe** one way doctors are able to repair severe skin damage from burns, injuries, or surgeries.
6. **Think Critically** Why is a person who has been severely burned in danger of dying from loss of water?

Applying Math

7. **Solve One-Step Equations** The skin of eyelids is 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?

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. How big is this organ?

Real-World Question

How much skin covers your body?

Goals

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

Materials

10 large sheets of newspaper
scissors
tape
meterstick or ruler

Safety Precautions



Procedure

1. Form groups of three or four, either all female or all male. Select one person from your group to measure his or her skin surface area.
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. Overlapping the sheets of paper, use tape to secure the paper. Small body parts, such as fingers and toes, do not need to be wrapped individually. Cover entire hands and feet. Do not cover the face.

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 volume of your classmate's skin, using 2 mm as the average thickness and your calculated surface area from this activity.

Communicating Your Data

Using a table, record the estimated skin surface area from all the groups in your class. Find the average surface areas for both males and females. Discuss any differences in these two averages.

The Muscular System

Movement of the Human Body

Muscles help make all of your daily movements possible. In the process of relaxing, contracting, and providing the force for movements, 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.

Muscle Control Your hand, arm, and leg muscles are voluntary. So are the muscles of your face, as shown in **Figure 5**. You can choose to move them or not to move them. Muscles that you are able to control are called **voluntary muscles**. Muscles that you can't control consciously are **involuntary muscles**. They work all day long, all your life. Blood is pumped through blood vessels, and food is moved through your digestive system by the action of involuntary muscles.



Reading Check

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

Figure 5 Facial expressions generally are controlled by voluntary muscles. It takes only 13 muscles to smile, but 43 muscles to frown.



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.

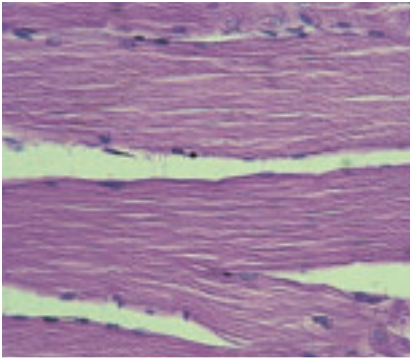


Review Vocabulary

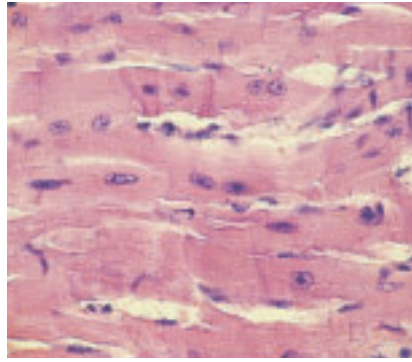
muscle: an organ that can relax, contract, and provide the force to move bones and body parts

New Vocabulary

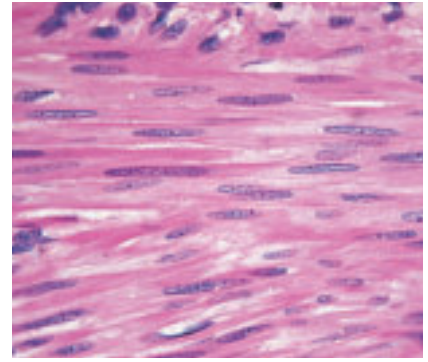
- voluntary muscle
- involuntary muscle
- tendon



Skeletal muscles move bones. The muscle tissue appears striped, or striated, and is attached to bone.



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



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

Figure 6 The three types of muscle tissue are skeletal muscle, cardiac muscle, and smooth muscle.

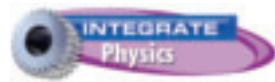
Infer *what type of muscle tissue makes up the walls of veins, which carry blood.*

Classification of Muscle Tissue

Humans have three types of muscle tissue: skeletal, smooth, and cardiac. Skeletal muscles are voluntary muscles that move bones. They are more common than other muscle types, and are attached to bones by thick bands of tissue called **tendons**. Skeletal muscle cells are striated (STRIPed), and when viewed under a microscope, appear striped. You can see the striations in **Figure 6**.

The remaining two types of muscles also are shown in **Figure 6**. 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 nonstriated involuntary muscles and are found in your intestines, bladder, blood vessels, and other internal organs.

Your Body's Simple Machines—Levers



Your skeletal system and muscular system work together when you move, like a machine. 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 7**.

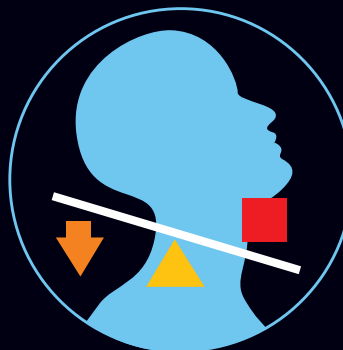


Figure 7

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.

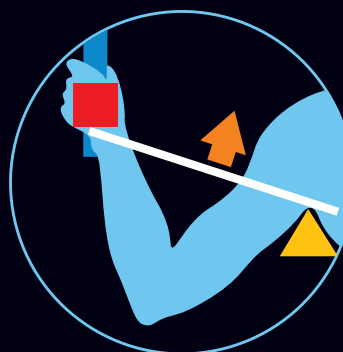


- ▲ Fulcrum
- ↓ Input force
- Output force



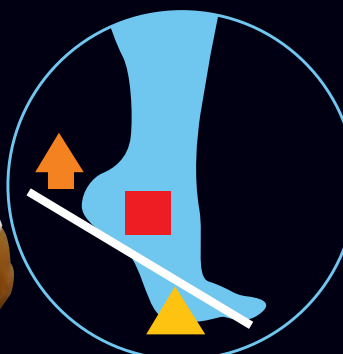
FIRST-CLASS LEVER

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



THIRD-CLASS LEVER

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



SECOND-CLASS LEVER

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



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 of muscles contracts, the other muscle relaxes or returns to its original length, as shown in **Figure 8**. 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 relax and return to their original lengths, and the muscles on the front of your upper leg contract. Compare how your leg muscles work with how the muscles of your arms work.

Changes in Muscles Over time, muscles can become larger or smaller, depending on whether or not they are used. Also, muscles that are given regular exercise respond quickly to stimuli. Skeletal muscles that do a lot of work, such as those in your writing hand, can become stronger and larger. 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. For example, many soccer and basketball players have noticeably larger, defined leg muscles. In contrast, someone who only participates in nonactive pastimes such as watching television or playing computer games, instead of participating in more active pastimes, will have smaller and weaker muscles. Muscles that aren't exercised become smaller in size. Paralyzed muscles also become smaller because they cannot be moved or have limited movement.

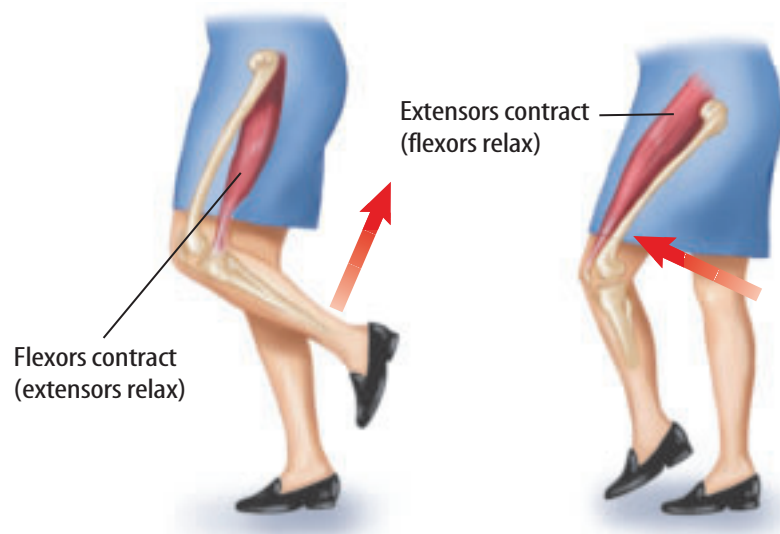


Reading Check

How do muscles increase their size?

Figure 8 When the flexor (hamstring) muscles of your thigh contract, the lower leg is brought toward the thigh. When the extensor (quadriceps) muscles contract, the lower leg is straightened.

Describe the class of lever shown to the right.



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 (warmth), as shown in **Figure 9**. The thermal energy released by muscle contractions helps keep your body temperature constant. 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.



Figure 9 Chemical energy is needed for muscle activity. During activity, chemical energy supplied by food is changed into mechanical energy and thermal energy.



How do muscles obtain energy to contract and relax?

section 2 review

Summary

Movement of the Human Body

- Muscles contract to move bones and body parts.
- You can control voluntary muscles, but you cannot consciously control involuntary muscles.

Classification of Muscle Tissue

- Skeletal muscles are voluntary, smooth muscles control movement of internal organs, and cardiac muscle is striated and involuntary.

Your Body's Simple Machines—Levers

- Your muscles, bones, and joints work together like levers to move your body.

Working Muscles

- Muscles always pull, and when one muscle of a pair contracts, the other 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. **Identify** and describe the appearance of the type of muscle tissue found in your heart.
4. **Explain** how your muscles, bones, and joints work together to move your body.
5. **Describe** how a muscle attaches to a bone.
6. **Think Critically** What happens to your upper arm muscles when you bend your arm at the elbow to eat your favorite sandwich?

Applying Skills

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



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 each of your body parts moves and what happens that allows you to move them.



Review Vocabulary

skeleton: a framework of living bones that supports your body

New Vocabulary

- periosteum
- cartilage
- joint
- ligament

Functions of Your Skeletal System

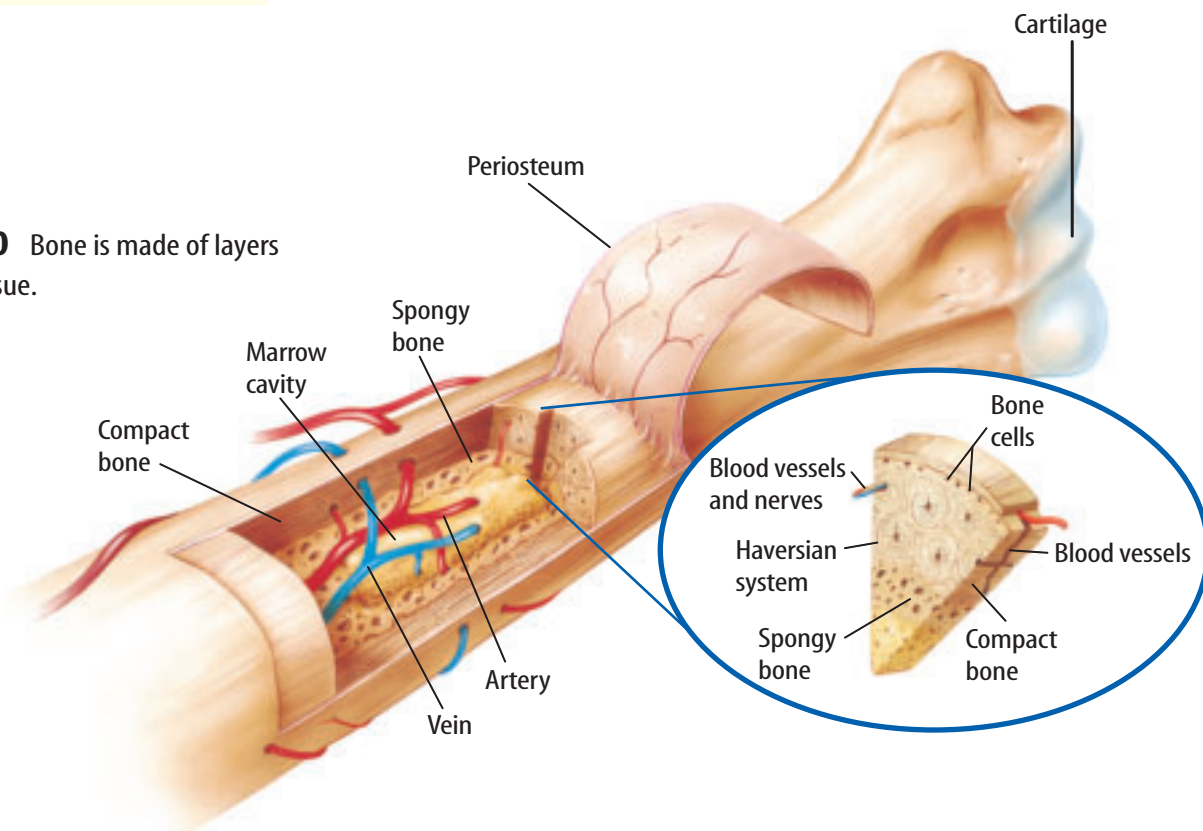
The skeletal system includes all the bones in your body and has five major functions.

1. The skeleton gives shape and support to your body.
2. Bones protect your internal organs.
3. Major muscles are attached to bones and help them move.
4. Blood cells form in the red marrow of many bones.
5. Major quantities of calcium and phosphorous compounds are stored in the skeleton for later use. Calcium and phosphorus make bones hard.

Bone Structure

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 in bones. How a bone looks from the inside and the outside is shown in **Figure 10**.

Figure 10 Bone is made of layers of living tissue.





Bone Tissue Living bone is an organ made of several different tissues. A living bone's surface is covered with a tough, tight-fitting membrane called the **periosteum** (pur ee AHS tee um). Small blood vessels in the periosteum carry nutrients into the bone and its nerves signal pain. Under the periosteum are compact bone and spongy bone.

Compact bone gives bones strength. It has a framework containing deposits of calcium phosphate that make the bone hard. 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.

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 a 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. It 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.

 **Reading Check** What is cartilage?

Bone Formation

Your bones have not always been as hard as they are now. Months before your birth, your skeleton was made of cartilage. Gradually, the cartilage broke down and was replaced by bone, as illustrated in **Figure 11**. Bone-forming cells called osteoblasts (AHS tee oh blasts) deposit 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 reformed. 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. These elements are necessary for the working of your body, including the movement of your muscles.

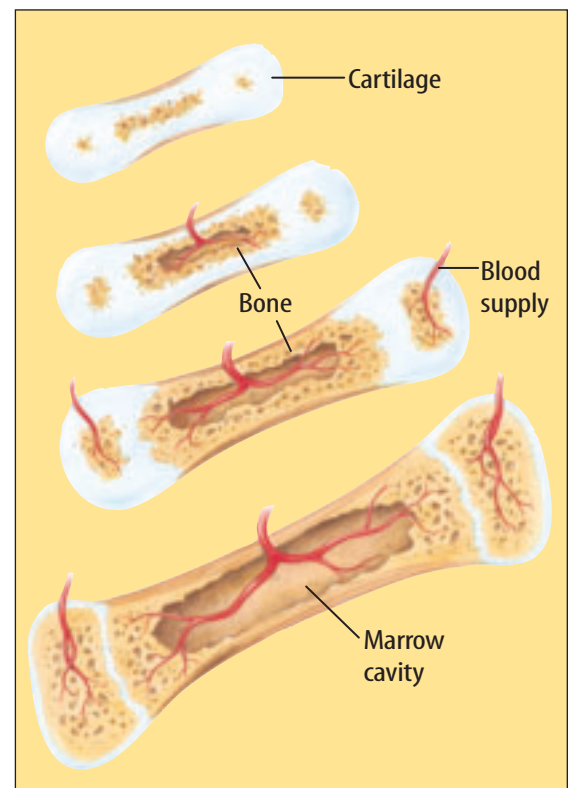


Topic: Bone Fractures

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

Activity Using captions, illustrate one technique in your Science Journal.

Figure 11 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.





Joints

What will you do at school today? You may sit at a table, chew and swallow your lunch, or walk to class. All of these motions are possible because your skeleton has joints.

Any place where two or more bones come together is a **joint**. Bones are held in place at joints by a tough bands of tissue called **ligaments**. Many joints, such as your knee, are held together by more than one ligament. Muscles move bones by moving joints. The bones in healthy joints are separated by a thin layer of cartilage so that they do not rub against each other as they move.

Applying Math Estimate

VOLUME OF BONES Although bones are not perfectly shaped, many of them are cylindrical. This cylindrical shape allows your bones to withstand great pressure. Estimate the volume of a bone that is 36 cm long and 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 want to find out:*

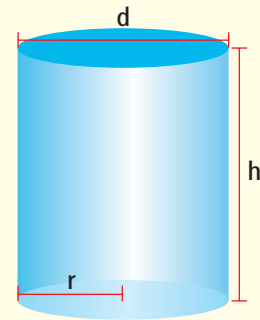
Volume of the cylinder

3 *This is the procedure you need to use:*

- Use this equation:
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 $\pi = 3.14$.
- $V = 3.14 \times (3.5 \text{ cm})^2 \times 36 \text{ cm}$
 $V = 1,384.74 \text{ cm}^3$
- The volume of the bone is approximately $1,384.74 \text{ cm}^3$.

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 the volume of a bone is 62.8 cm^3 and its height is 20 cm, what is its diameter?



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



Immovable 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.

 **Reading Check** *How are bones held in place at joints?*

Movable Joints All movements, including somersaulting and working the controls of a video game, require movable joints, such as those in **Figure 12**. 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, which 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, or pulled apart, as easily 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 joy stick, or take a step without using one of your gliding joints.

Figure 12 When a basketball player shoots a ball, several types of joints are in action.

Name other activities that use several types of joints.





Figure 13 A colored X ray of the human backbone shows disks of cartilage between the vertebrae.

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. As shown in **Figure 13**, pads of cartilage, called disks, are located between the vertebrae in your back. They act as cushions and prevent injury to your spinal cord. A fluid that comes from nearby blood vessels also lubricates the joint.

Common Joint Problems Arthritis is the most common joint problem. The term *arthritis* describes more than 100 different diseases that can damage 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.

section 3 review

Summary

Functions of Your Skeletal System

- The skeletal system includes all the bones in your body and is your body's framework.

Bone Structure

- Bones are living organs that need nutrients.
- Compact bone is hard and strong, and spongy bone has many open spaces to make it lightweight.
- Cartilage covers the ends of bones.

Bone Formation

- Bone-forming cells deposit calcium and phosphorus to make the bone tissue hard.
- Healthy bone tissue is always being formed and reformed.

Joints

- Immovable joints allow little or no movement.
- Movable joints include pivot, ball and socket, hinge, and gliding joints.
- Cartilage helps make joint movement easier.

Self Check

1. **List** the five major functions of the human skeletal system.
2. **Describe** and give an example of an immovable joint.
3. **Explain** the functions of cartilage in your skeletal system.
4. **Describe** ligaments and their function in the skeletal system.
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, and irregular*.
7. **Use graphics software** to make a 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 Nervous System

How the Nervous System Works

After doing the dishes and finishing your homework, you settle down in your favorite chair and pick up that mystery novel you've been trying to finish. Only three pages to go. . . Who did it? Why did she do it? Crash! You scream. What made that unearthly noise? You turn around to find that your dog's wagging tail has just swept the lamp off the table. Suddenly, you're aware that your heart is racing and your hands are shaking. After a few minutes, your breathing returns to normal and your heart-beat is back to its regular rate. What's going on?

Responding to Stimuli The scene described above is an example of how your body responds to changes in its environment. Any internal or external change that brings about a response is called a stimulus (STIHM yuh lus). Each day, you're bombarded by thousands of stimuli, as shown in **Figure 14**. Noise, light, the smell of food, and the temperature of the air are all stimuli from outside your body. Chemical substances such as hormones are examples of stimuli from inside your body. Your body adjusts to changing stimuli with the help of your nervous system.



as you read

What You'll Learn

- **Describe** the basic structure of a neuron and how an impulse moves across a synapse.
- **Compare and contrast** the central and peripheral nervous systems.
- **List** the sensory receptors in each sense organ.
- **Explain** what type of stimulus each sense organ responds to and how.
- **Explain** how drugs affect the body.

Why It's Important

Your body reacts to your environment because of your nervous system.



Review Vocabulary

vertebrae: bones of the spine that are joined by flexible cartilage and protect the spinal cord

New Vocabulary

- neuron
- synapse
- central nervous system
- peripheral nervous system

Figure 14 Stimuli are found everywhere and all the time, even when you're enjoying being with your friends.

List the types of stimuli that are present at this party.

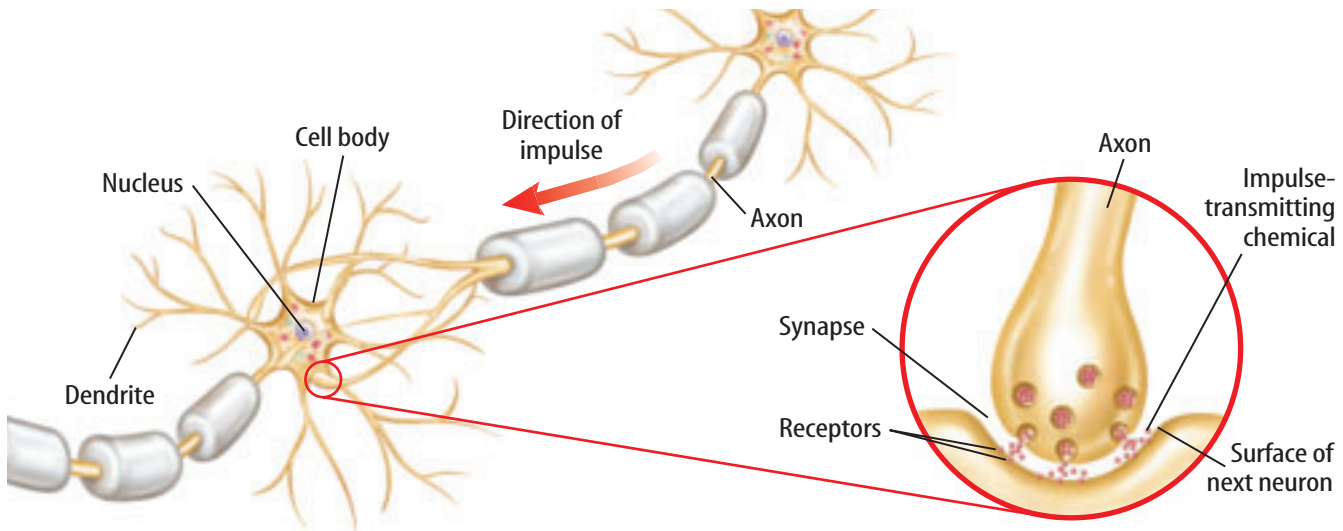


Figure 15 A neuron is made up of a cell body, dendrites, and an axon. An impulse moves in only one direction across a synapse—from an axon to the dendrites or cell body of another neuron.

Homeostasis It's amazing how your body handles all these stimuli. Control systems maintain homeostasis. They keep steady, life-maintaining conditions inside your body, despite changes around you. Examples of homeostasis are the regulation of your breathing, heartbeat, and digestion. Your nervous system is one of several control systems used by your body to maintain homeostasis.

Nerve Cells

The basic functioning units of the nervous system are nerve cells, or **neurons** (NOO rahnz). As shown in **Figure 15**, a neuron is made up of a cell body, branches called dendrites, and an axon (AK sahn). Any message carried by a neuron is called an impulse. Your neurons are adapted in such a way that impulses move in only one direction. Dendrites receive impulses from other neurons and send them to the cell body. An axon carries impulses away from the cell body. The end of the axon branches. This allows the impulses to move to many other muscles, neurons, or glands.

Three types of neurons—sensory neurons, motor neurons, and interneurons—transport impulses. Sensory neurons receive information and send impulses to the brain or spinal cord, where interneurons relay these impulses to motor neurons. Motor neurons then conduct impulses from the brain or spinal cord to muscles or glands throughout your body.

Synapses Neurons don't touch each other. As an impulse moves from one neuron to another it crosses a small space called a **synapse** (SIH naps). When an impulse reaches the end of an axon, the axon releases a chemical, as shown in **Figure 15**. This chemical flows across the synapse and stimulates the impulse in the dendrite of the next neuron.



The Divisions of the Nervous System

Figure 16 shows how organs of the nervous system are grouped into two major divisions—the central nervous system (CNS) and the peripheral (puh RIH fuh rul) nervous system (PNS). The **central nervous system** includes the brain and spinal cord. The brain is the control center for all activities in the body. It is made of billions of neurons. The spinal cord is made up of bundles of neurons. An adult's spinal cord is about the width of a thumb and about 43 cm long. Sensory neurons send impulses to the brain or spinal cord.

The Peripheral Nervous System All the nerves outside the CNS that connect the brain and spinal cord to other body parts are part of the **peripheral nervous system**. The PNS includes 12 pairs of nerves from your brain called cranial nerves, and 31 pairs of nerves from your spinal cord called spinal nerves. Spinal nerves are made up of bundles of sensory and motor neurons bound together by connective tissue. They carry impulses from all parts of the body to the brain and from the brain to all parts of your body. A single spinal nerve can have impulses going to and from the brain at the same time. Some nerves contain only sensory neurons, and some contain only motor neurons, but most nerves contain both types of neurons.

Somatic and Autonomic Systems

The peripheral nervous system has two major divisions. The somatic system controls voluntary actions. It is made up of the cranial and spinal nerves that go from the central nervous system to your skeletal muscles. The autonomic system controls involuntary actions—those not under conscious control—such as your heart rate, breathing, digestion, and glandular functions.

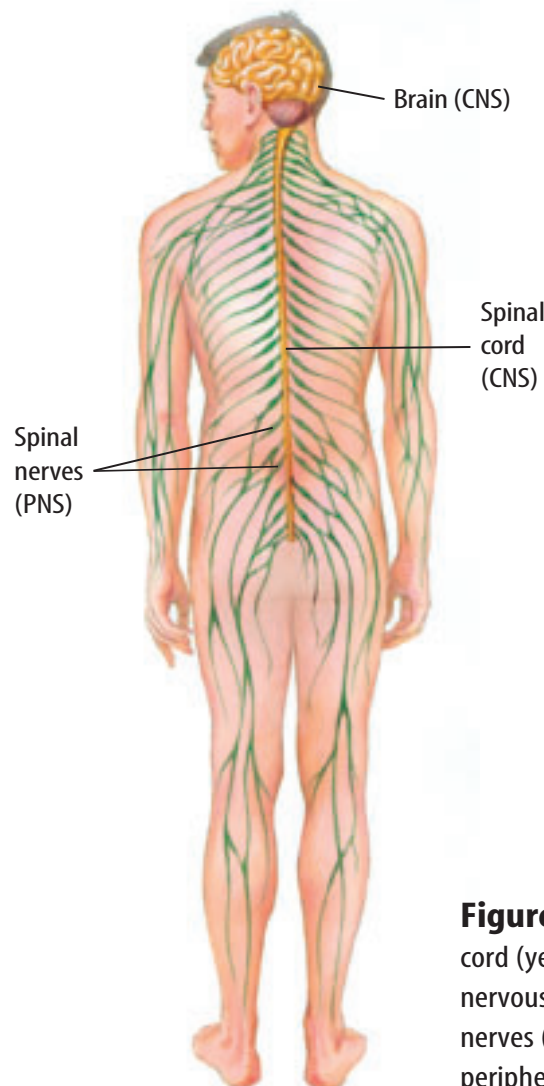


Figure 16 The brain and spinal cord (yellow) form the central nervous system (CNS). All other nerves (green) are part of the peripheral nervous system (PNS).



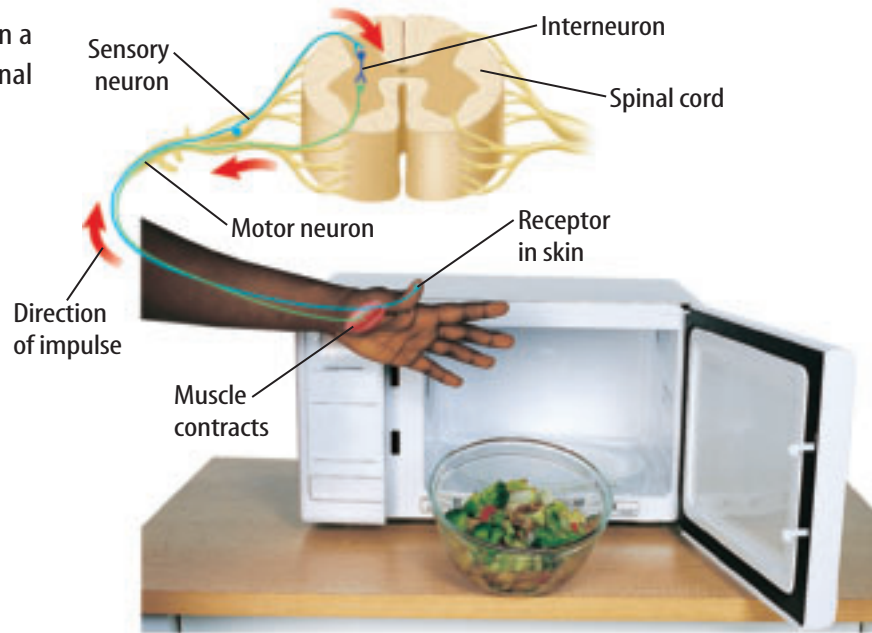
Topic: Nervous System

Visit green.msscience.com for Web links to information about the nervous system.

Activity Make a brochure outlining recent medical advances.



Figure 17 Your response in a reflex is controlled in your spinal cord, not your brain.



Safety and the Nervous System

Every mental process and physical action of the body involves structures of the central and peripheral nervous systems. Therefore, any injury to them can be serious. A severe blow to the head can bruise the brain and cause temporary or permanent loss of mental and physical abilities. For example, an injury to the back of the brain could result in the loss of vision.

The spinal cord is surrounded by vertebrae, but spinal cord injuries do occur. They can be just as dangerous as a brain injury. Injury to the spine can bring about damage to nerve pathways and result in paralysis (puh RAH luh suhs), which is the loss of muscle movement. Major causes of head and spinal injuries include automobile, motorcycle, and bicycle accidents, as well as sports injuries. Just like wearing seat belts in automobiles, it is important to wear the appropriate safety gear while playing sports and riding on bicycles, skateboards, and motorized vehicles.

Reflexes You experience a reflex if you accidentally touch something sharp, something extremely hot or cold, or when you cough or vomit. A reflex is an involuntary, automatic response to a stimulus. You can't control reflexes because they occur before you know what has happened. A reflex involves a simple nerve pathway called a reflex arc, as illustrated in **Figure 17**.

A reflex allows the body to respond without having to think about what action to take. Reflex responses are controlled in your spinal cord, not in your brain. Your brain acts after the reflex to help you figure out what to do to make the pain stop.



Neuron Chemical

Acetylcholine (uh see tul KOH leen) is a chemical produced by neurons that carries an impulse across a synapse to the next neuron. After the impulse is started, acetylcholine breaks down rapidly. In your Science Journal, make an inference about why the rapid breakdown of acetylcholine is important.



Reading Check

Why are reflexes important?



The Senses

Sense organs intercept stimuli, such as light rays, sound waves, temperature, chemicals, or pressure, and convert them into impulses transmitted by the nervous system. Your internal organs have several kinds of sensory receptors that respond to touch, pressure, pain, and temperature and transmit impulses to the brain or spinal cord. In turn, your body responds to this new information. Your body's senses work together to maintain homeostasis.

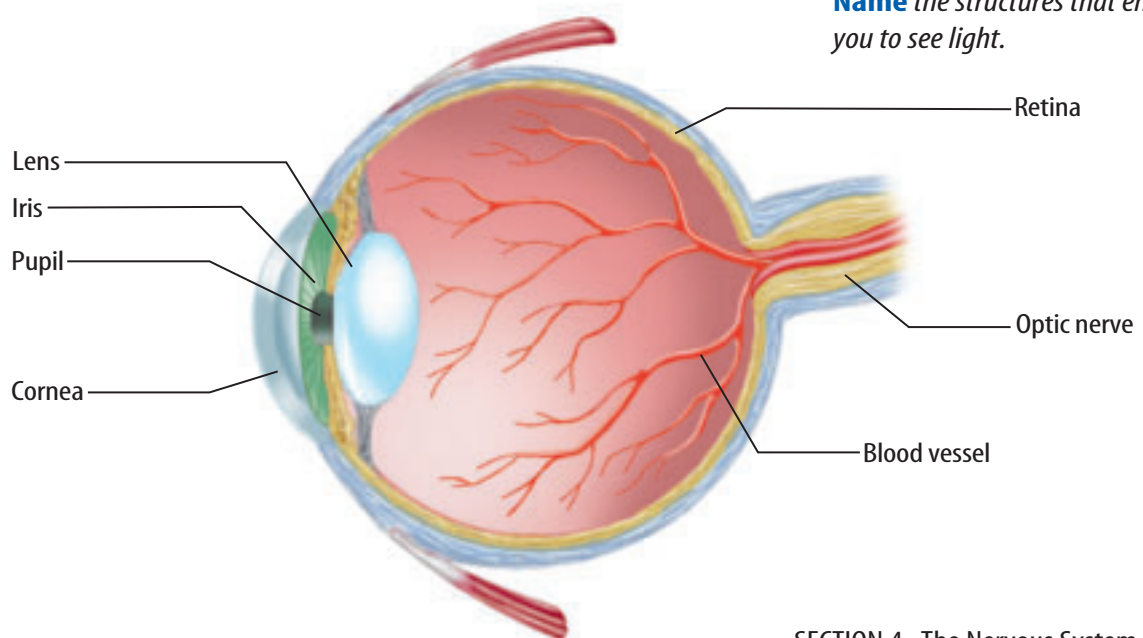
Sensory receptors also are located throughout your skin. Your lips are sensitive to temperature and can prevent you from drinking something that would burn you. Pressure-sensitive skin cells warn you of danger and enable you to move to avoid injury.

Vision Think about the different kinds of objects you might look at every day. The eye, shown in **Figure 18**, is a sense organ. Your eyes have unique adaptations that usually enable you to see shapes of objects, shadows, and color. It's amazing that at one glance you might see the words on this page, the color illustrations, and your classmate sitting next to you.

How do you see? Light travels in a straight line unless something causes it to refract or change direction. Your eyes have structures that refract light. Two of these structures are the cornea and the lens. As light enters the eye, it passes through the cornea—the transparent section at the front of the eye—and is refracted. Then light passes through a lens and is refracted again. The lens directs the light onto the retina (RET nuh), which is a tissue at the back of the eye that is sensitive to light energy. Two types of cells called rods and cones are found in the retina. Cones respond to bright light and color. Rods respond to dim light. They are used to help you detect shape and movement.

Figure 18 Light moves through the cornea and the lens—before striking the retina.

Name the structures that enable you to see light.





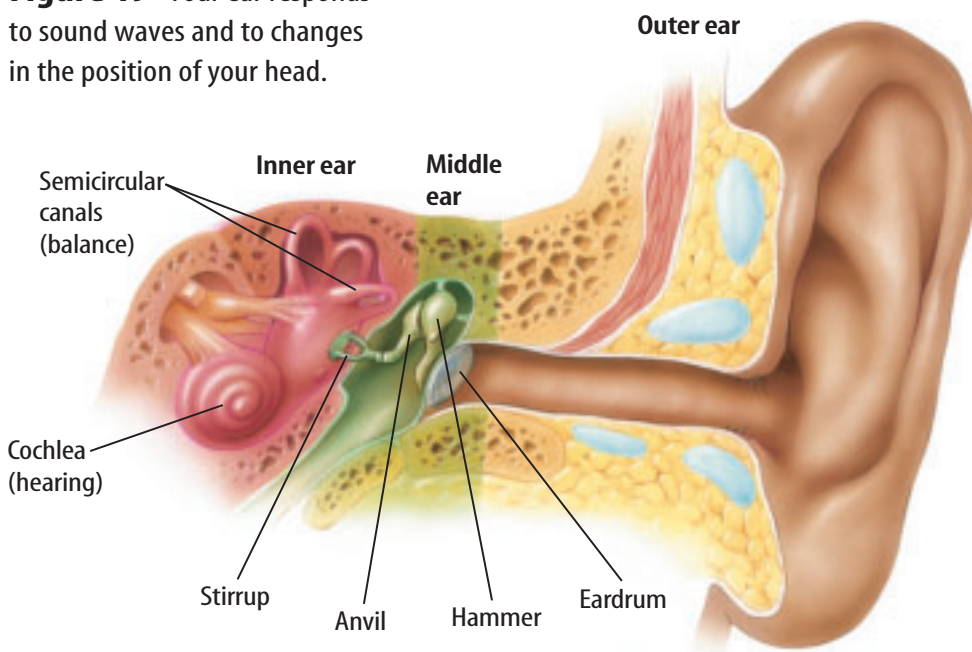
Images Light energy stimulates impulses in rods and cones that pass to the optic nerve. This nerve carries the impulses to the vision area of the brain. The image transmitted from the retina to the brain is upside down and reversed. The brain interprets the image correctly, and you see what you are looking at. The brain also interprets the images received by both eyes. It blends them into one image that gives you a sense of distance. This allows you to tell how close or how far away something is.

Hearing Whether it's the roar of a rocket launch, the cheers at a football game, or the distant song of a robin in a tree, sound waves are necessary for hearing. Sound is to hearing as light is to vision. When an object vibrates, sound waves are produced. Sound waves can travel through solids, liquids, and gases. When sound waves reach your ear, they usually stimulate nerve cells deep within your ear. Impulses from these cells are sent to the brain. When the sound impulse reaches the hearing area of the brain, it responds and you hear a sound.

Figure 19 shows that your ear is divided into three sections—the outer ear, middle ear, and inner ear. Your outer ear intercepts sound waves and they move down the ear canal to the middle ear. The sound waves cause the eardrum to vibrate much like the membrane on a musical drum vibrates when you tap it. These vibrations then move through three tiny bones called the hammer, anvil, and stirrup. The stirrup bone rests against a second membrane on an opening to the inner ear.



Figure 19 Your ear responds to sound waves and to changes in the position of your head.



The inner ear includes the cochlea (KOH klee uh) and the semicircular canals. The cochlea is a fluid-filled structure shaped like a snail's shell. When the stirrup vibrates, fluids in the cochlea begin to vibrate. These vibrations bend sensory hair cells in the cochlea, which cause electrical impulses to be sent to the brain by a nerve. Depending on how the nerve endings are stimulated, you hear a different type of sound.

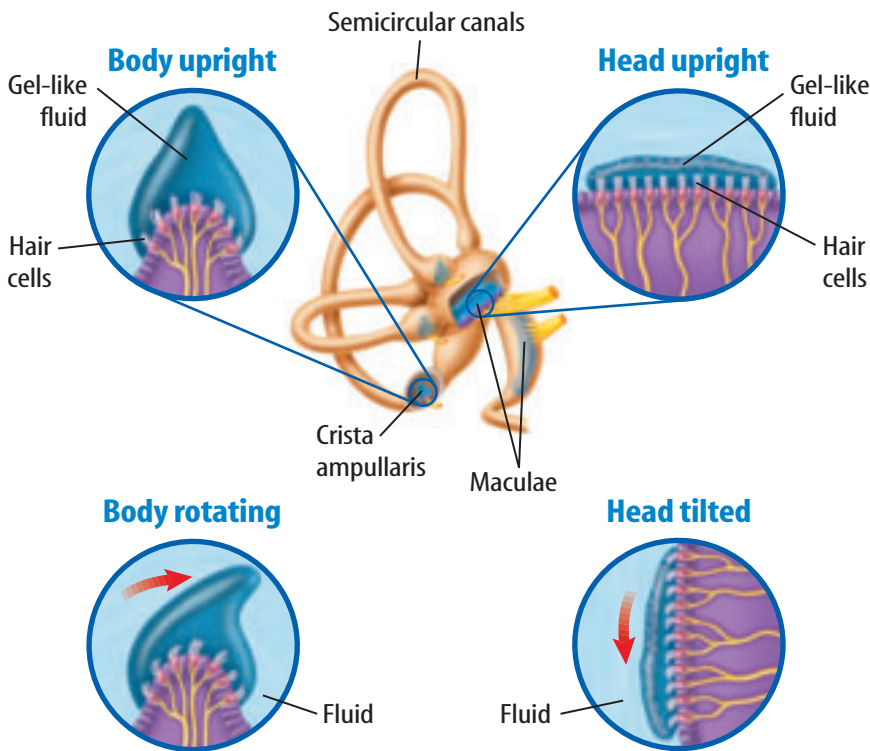


Figure 20 In your inner ear the cristae ampullaris react to rotating movements of your body, and the maculae check the position of your head with respect to the ground.

Explain why spinning around makes you dizzy.

Balance Structures in your inner ear also control your body's balance. Structures called the cristae ampullaris (KRIHS tee • am pyew LEER ihs) and the maculae (MA kyah lee), illustrated in **Figure 20**, sense body movement. The cristae ampullaris react to rotating body movements and the maculae responds to the tilt of your head. Both structures contain tiny hair cells. As your body moves, gel-like fluid surrounding the hair cells moves and stimulates the nerve cells at the base of the hair cells. This produces nerve impulses that are sent to the brain, which interprets the body movements. The brain, in turn, sends impulses to skeletal muscles, resulting in other body movements that maintain balance.

Smell How can you smell your favorite food? You can smell food because molecules from the food move into the air. If they enter your nasal passages, these molecules stimulate sensitive nerve cells, called olfactory (ohl FAK tree) cells. Olfactory cells are kept moist by mucus. When molecules in the air dissolve in this moisture, the cells become stimulated. If enough molecules are present, an impulse starts in these cells, then travels to the brain where the stimulus is interpreted. If the stimulus is recognized from a previous experience, you can identify the odor. If you don't recognize a particular odor, it is remembered and can be identified the next time you encounter it.



Reading Check

What produces nerve impulses that interpret body movement?

Mini LAB

Observing Balance Control

Procedure

1. Place **two narrow strips of paper** on the wall to form two parallel, vertical lines 35–40 cm apart. Have a person stand between them for 3 min, without leaning on the wall.
2. Observe how well balance is maintained.
3. Have the person close his or her eyes, then stand within the lines for 3 min.

Analysis

1. When was balance more difficult to maintain? Why?
2. What other factors might cause a person to lose his or her sense of balance?



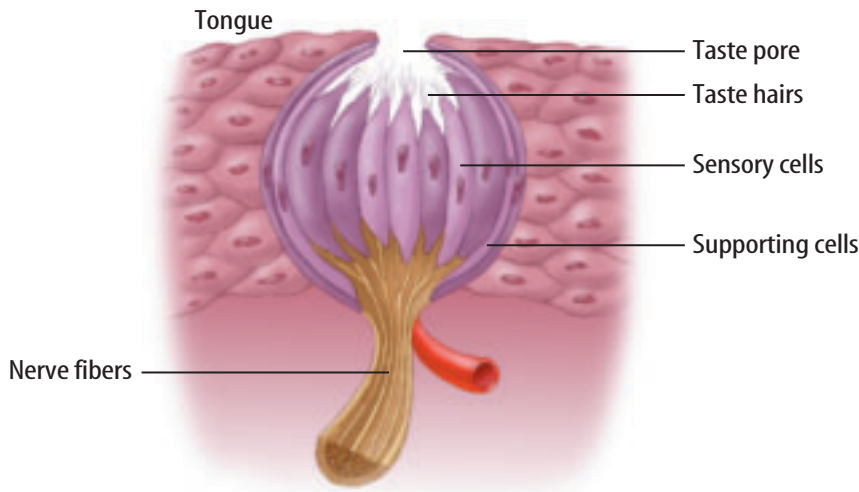


Figure 21 Taste buds are made up of a group of sensory cells with tiny taste hairs projecting from them. When food is taken into the mouth, it is dissolved in saliva. This mixture then stimulates receptor sites on the taste hairs, and an impulse is sent to the brain.

another. The five taste sensations are sweet, salty, sour, bitter, and the taste of MSG (monosodium glutamate).

A taste bud, shown in **Figure 21**, responds to chemical stimuli. In order to taste something, it has to be dissolved in water. Saliva begins this process. When a solution of saliva and food washes over taste buds, impulses are sent to your brain. The brain interprets the impulses, and you identify the tastes.



Reading Check

What needs to happen to food before you are able to taste it?

Smell and Taste The sense of smell is needed to identify some foods such as chocolate. When saliva in your mouth mixes with chocolate, odors travel up the nasal passage in the back of your throat. Olfactory cells in the nose are stimulated, and the taste and smell of chocolate are sensed. So when you have a stuffy nose and some foods seem tasteless, it might be because the food's molecules are blocked from contacting the olfactory cells in your nasal passages.

Drugs Affect the Nervous System

Many drugs, such as alcohol and caffeine, directly affect your nervous system. When swallowed, alcohol directly passes into cells of the stomach and small intestine then into the circulatory system. After it is in the circulatory system, it can travel throughout your body. Upon reaching neurons, alcohol moves through their cell membranes and disrupts their normal cell functions. As a result, this drug slows the activities of the central nervous system and is classified as a depressant. Muscle control, judgment, reasoning, memory, and concentration also are impaired. Heavy alcohol use destroys brain and liver cells.



Stimulants Any substance that speeds up the activity of the central nervous system is called a stimulant. Caffeine is a stimulant found in coffee, tea, cocoa, and many soft drinks, as shown in **Figure 22**. Too much caffeine can increase heart rate and aggravates restlessness, tremors, and insomnia in some people. It also can stimulate the kidneys to produce more urine.

Do you remember reading at the beginning of this section about being frightened after a lamp was broken? Think again about that scare. The organs of your nervous system control and coordinate responses to maintain homeostasis within your body. This task might be more difficult when your body is affected by drugs.



Figure 22 Caffeine, a substance found in colas, coffee, chocolate, and some teas, can cause excitability and sleeplessness.

section 4 review

Summary

How the Nervous System Works

- The nervous system responds to stimuli to maintain homeostasis.

Nerve Cells

- Neurons are the basic functioning units of the nervous system.
- To move from one neuron to another, an impulse crosses a synapse.

The Divisions of the Nervous System

- The autonomic system controls involuntary actions like heart rate and breathing.
- The somatic system controls voluntary actions.

Safety and the Nervous System

- Reflex responses are automatic and are controlled by the spinal cord.

The Senses

- Sense organs respond to stimuli and work together to maintain homeostasis.

Drugs Affect the Nervous System

- Drugs can slow or stimulate your nervous system.

Self Check

1. **Draw and label** the parts of a neuron and describe the function of each part.
2. **Name** the sensory receptors for the eyes, ears, and nose.
3. **Compare and contrast** the central and peripheral nervous systems.
4. **Explain** why you have trouble falling asleep after drinking several cups of hot cocoa.
5. **Identify** the role of saliva in tasting.
6. **Explain** why is it important to have sensory receptors for pain and pressure in your internal organs.
7. **Think Critically** Explain why many medications caution the consumer not to operate heavy machinery.

Applying Skills

8. **Communicate** Write a paragraph in your Science Journal that describes what each of the following objects would feel like: ice cube, snake, silk blouse, sandpaper, jelly, and smooth rock.
9. **Make and Use Tables** Organize the information on senses in a table that names the sense organs and which stimuli they respond to.

Skin Sensitivity

Goals

- **Observe** the sensitivity to touch on specific areas of the body.
- **Design** an experiment that tests the effects of a variable, such as how close the contact points are, to determine which body areas can distinguish which stimuli are closest to one another.

Possible Materials

3-in × 5-in index card
toothpicks

tape

*glue

metric ruler

*Alternate materials

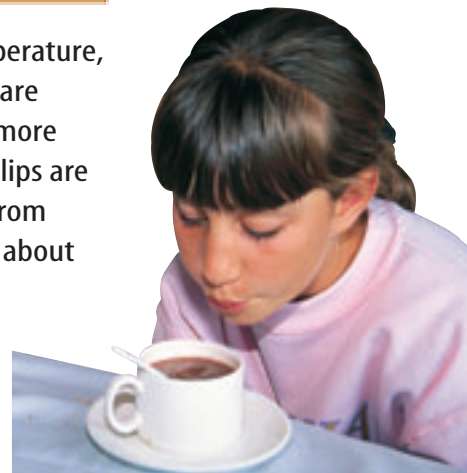
Safety Precautions



WARNING: Do not apply heavy pressure when touching the toothpicks to the skin of your classmates.

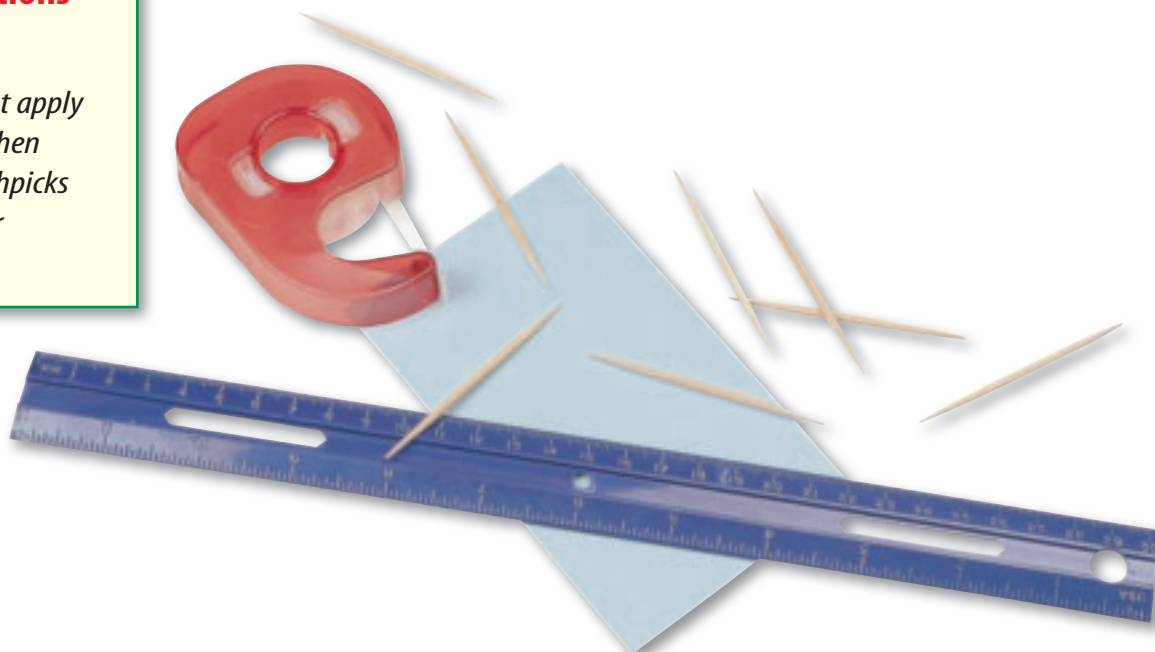
Real-World Question

Your body responds to touch, pressure, temperature, and other stimuli. Not all parts of your body are equally sensitive to stimuli. Some areas are more sensitive than others are. For example, your lips are sensitive to temperature. This protects you from burning your mouth and tongue. Now think about touch. How sensitive to touch is the skin on various parts of your body? Which areas can distinguish the smallest amount of distance between stimuli?



Form a Hypothesis

Based on your experiences, state a hypothesis about which of the following five areas of the body—fingertip, forearm, back of the neck, palm, and back of the hand—you believe to be most sensitive. Rank the areas from 5 (the most sensitive) to 1 (the least sensitive).



Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write the hypothesis statement.
2. As a group, list the steps you need to test your hypothesis. Describe exactly what you will do at each step. Consider the following as you list the steps. How will you know that sight is not a factor? How will you use the card shown on the right to determine sensitivity to touch? How will you determine that one or both points are sensed?
3. Design a data table in your Science Journal to record your observations.
4. Reread your entire experiment to make sure that all steps are in the correct order.
5. Identify constants, variables, and controls of the experiment.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment as planned.
3. While the experiment is going on, write down any observations that you make and complete the data table in your Science Journal.

Analyze Your Data

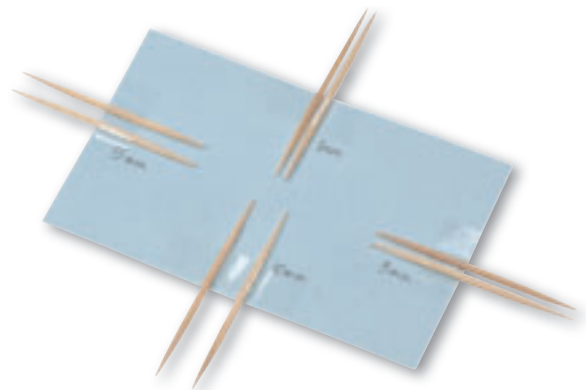
1. **Identify** which part of the body tested can distinguish between the closest stimuli.
2. **Compare** your results with those of other groups.
3. Rank body parts tested from most to least sensitive. Did your results from this investigation support your hypothesis? Explain.

Conclude and Apply

1. **Infer** Based on the results of your investigation, what can you infer about the distribution of touch receptors on the skin?
2. **Predict** what other parts of your body would be less sensitive? Explain your predictions.

Communicating Your Data

Write a report to share with your class about body parts of animals that are sensitive to touch.



First Aid

Dolls

A fashion doll helps improve the lives of people

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.

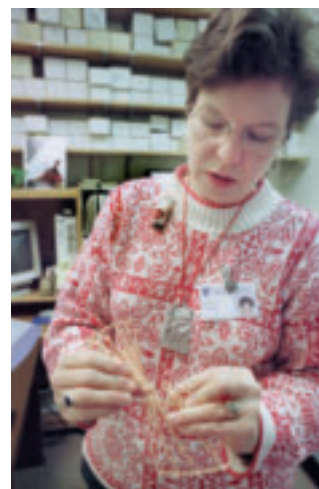
Jane Bahor works at Duke University Medical Center in Durham, North Carolina. She makes lifelike body parts for people who have lost legs, arms, or fingers. A few years ago, she met a patient named Jennifer Jordan, an engineering student who'd lost a finger. The artificial finger that Bahor made looked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

The engineer went home and borrowed one of her sister's dolls. Returning with it to Bahor's office, she and Bahor operated on the fashion doll's legs and removed the knee joints.

"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." Because these new prosthetic fingers can bend, the wearers can hold a pen, pick up a cup, or grab a steering wheel.

Bahor called the company that makes the fashion doll and shared the surprising discovery. The toymaker was so impressed that Bahor now has a ten-year supply of plastic knee joints—free of charge! But supplies come from other sources, too. "A Girl Scout troop in New Jersey just sent me a big box of donated dolls for the cause," reports Bahor. "It's really great to have kids' support in this effort."



Invent Choose a "problem" you can solve. Need a better place to store your notebooks in your locker, for instance? 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
green.msscience.com/oops

Reviewing Main Ideas

Section 1 The Skin

1. The epidermis produces melanin. Cells at the base of the epidermis produce new skin cells. The dermis contains nerves, sweat and oil glands, and blood vessels.
2. The skin protects the body, reduces water loss, produces vitamin D, and helps to maintain body temperature.
3. Severe skin damage can lead to infection and death if left untreated.

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 only can contract. When one skeletal muscle contracts, the other relaxes.

Section 3 The Skeletal System

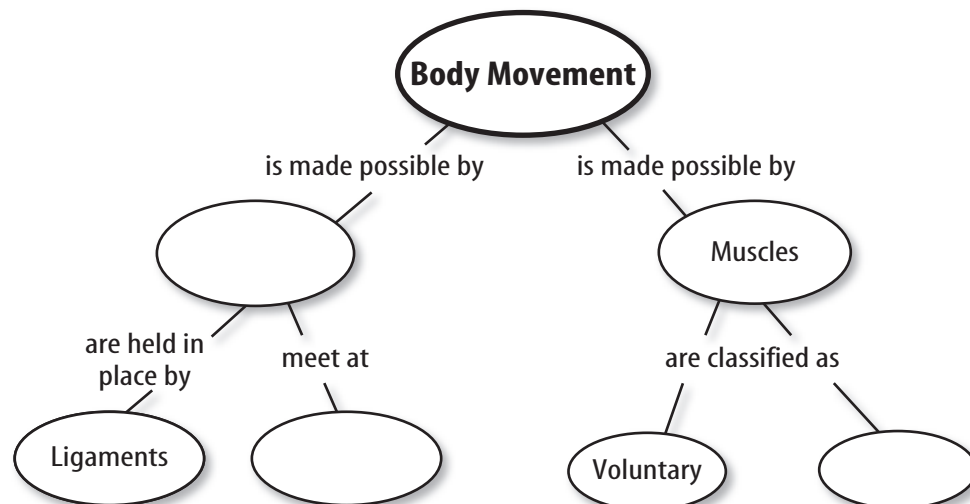
1. Bones are living structures that protect, support, make blood, store minerals, and provide for muscle attachment.
2. Joints are either immovable or moveable.

Section 4 The Nervous System

1. The nervous system responds to stimuli to maintain homeostasis.
2. A neuron is the basic unit of structure and function of the nervous system.
3. A reflex is an automatic response.
4. The central nervous system is the brain and spinal cord. The peripheral nervous system includes cranial and spinal nerves.
5. Your senses enable you to react to your environment.
6. Many drugs affect your nervous system.

Visualizing Main Ideas

Copy and complete the following concept map on body movement.



Using Vocabulary

cartilage p.445	melanin p.435
central nervous system p.451	neuron p.450
dermis p.434	periosteum p.445
epidermis p.434	peripheral nervous system p.451
involuntary muscle p.439	synapse p.450
joint p.446	tendon p.440
ligament p.446	voluntary muscle p.439

Match the definitions with the correct vocabulary word.

- outer layer of skin
- thick band of tissue that attaches muscle to a bone
- a muscle that you control
- basic functioning unit of the nervous system
- small space across which an impulse moves
- tough outer covering of bone
- a tough band of tissue that holds two bones together

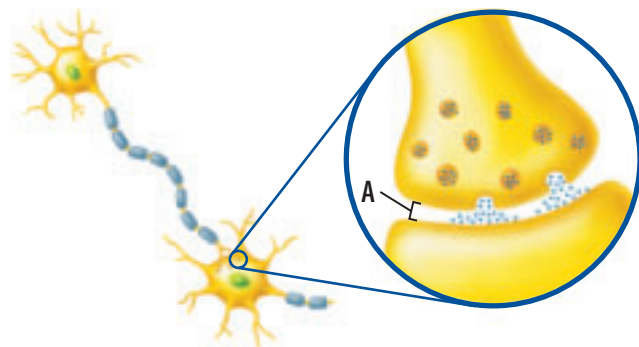
Checking Concepts

Choose the word or phrase that best answers the question.

- Where are blood cells made?
A) compact bone C) cartilage
B) periosteum D) marrow
- What are the ends of bones covered with?
A) cartilage C) ligaments
B) tendons D) muscle
- Where are human immovable joints found?
A) at the elbow C) in the wrist
B) at the neck D) in the skull
- Which vitamin is made in the skin?
A) A C) D
B) B D) K

- Which of the following structures helps retain fluids in the body?
A) bone C) skin
B) muscle D) joint
- How do impulses cross synapses between neurons?
A) by osmosis
B) through interneurons
C) through a cell body
D) by a chemical
- What are the neurons called that detect stimuli in the skin and eyes?
A) interneurons C) motor neurons
B) synapses D) sensory neurons
- What does the somatic system of the PNS control?
A) gland C) skeletal muscles
B) heart D) salivary glands
- What part of the eye is light finally focused on?
A) lens C) pupil
B) retina D) cornea
- Which of the following is in the inner ear?
A) anvil C) eardrum
B) hammer D) cochlea

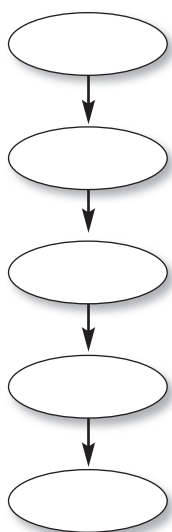
Use the illustration below to answer question 18.



- What is the name given to A?
A) axon C) synapse
B) dendrite D) nucleus

Thinking Critically

19. **Infer** why an infant's skull joints are flexible, but those of a teenager have fused together and are immovable.
20. **Predict** what would happen if a person's sweat glands didn't produce sweat.
21. **Compare and contrast** the functions of ligaments and tendons.
22. **Form a Hypothesis** Your body has about 3 million sweat glands. Make a hypothesis about where these sweat glands are on your body. Are they distributed evenly throughout your body?
23. **Draw Conclusions** If an impulse traveled down one neuron but failed to move on to the next neuron, what might you conclude about the first neuron?
24. **Concept Map** Copy and complete this events-chain concept map to show the correct sequence of the structures through which light passes in the eye.



25. **List** what factors a doctor might consider before choosing a method of skin repair for a severe burn victim.

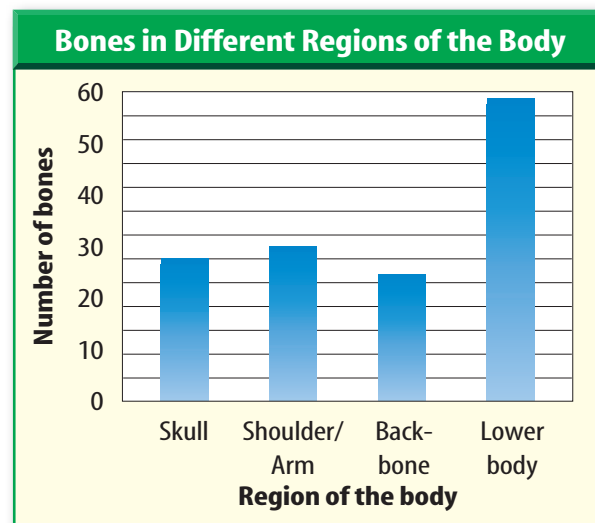
26. **Explain** why skin might not be able to produce enough vitamin D.

Performance Activities

27. **Illustrate** While walking on a sandy beach, a pain suddenly shoots through your foot. You look down and see that you stepped on the sharp edge of a broken shell. Draw and label the reflex arc that results from this stimulus.

Applying Math

Use the graph below to answer question 28.



28. **Bone Tally** The total number of bones in the human body is 206. Approximately what percentage of bones is located in the backbone?
 A) 2% C) 50%
 B) 12% D) 75%
29. **Fireworks** You see the flash of fireworks and then four seconds later, you hear the boom. Light travels so fast that you see far away things instantaneously. Sound, on the other hand, travels at 340 m/s. How far away are you from the fireworks?

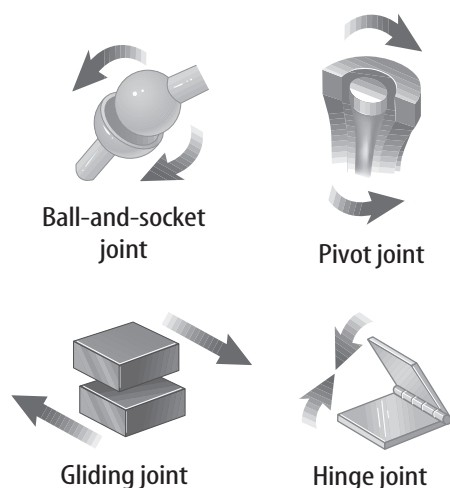
Part 1 Multiple Choice

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

1. Which of the following is NOT released by sweat glands?

A. water C. waste products
B. salt D. oil

Use the illustration below to answer questions 2 and 3.



2. Which type of joint do your elbows have?
A. hinge C. ball and socket
B. gliding D. pivot
3. 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
4. An internal or external change that brings about a response is called a
A. reflex C. receptor
B. stimulus D. heartbeat

Test-Taking Tip

Rest to be Alert Get plenty of sleep—at least eight hours every night—the week before the test and during test week.

Use the table below to answer questions 5 and 6.

Approximate Blood Alcohol Percentage for Men								
Drinks	Body Weight in Kilograms							
	45.4	54.4	63.5	72.6	81.6	90.7	99.8	108.9
1	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02
2	0.08	0.06	0.05	0.05	0.04	0.04	0.03	0.03
3	0.11	0.09	0.08	0.07	0.06	0.06	0.05	0.05
4	0.15	0.12	0.11	0.09	0.08	0.08	0.07	0.06
5	0.19	0.16	0.13	0.12	0.11	0.09	0.09	0.08

Subtract 0.01% for each 40 min of drinking. One drink is 40 mL of 80-proof liquor, 355 mL of beer, or 148 mL of table wine.

5. In Michigan underage drivers can be arrested for drinking and driving if their blood alcohol percentage is more than 0.02 percent. According to the table above, how many drinks would it take for a 72-kg man to exceed this limit?
A. three C. one
B. two D. zero
6. In some states, the legal blood alcohol percentage limit for driving while under the influence of alcohol is 0.08 percent. According to the table above, how many drinks would it take for a 54-kg man to exceed this limit?
A. four C. two
B. three D. one
7. A 90-kg man has been tested for blood alcohol content. His blood alcohol percentage is 0.08. Based upon the information in the table, about how much has he had to drink?
A. three drinks
B. 120 mL of 80-proof liquor
C. 396 mL of table wine
D. 1,420 mL of beer

Part 2 Short Response/Grid In

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

8. One in seven people in the United States suffers from arthritis. Calculate the percentage of people that suffer from arthritis.
9. Explain the difference between voluntary and involuntary muscles.

Use the table below to answer questions 10–12.

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

10. Head injuries are the most serious injuries that are found in people who died in bicycle accidents. Ninety percent of the deaths were in people who were not wearing bicycle helmets. Using the data in the table, approximately how many of the people (male and female) who died in bicycle accidents in 1998 were wearing bicycle helmets?
11. In 2000, what percentage of the people who died were women?
12. Which of the years from 1996 to 2000 had the greatest total number of bicycle deaths?
13. Explain why alcohol is classified as a depressant.
14. The brain is made up of approximately 100 billion neurons, which is about 10% of all neurons in the body. How many neurons are there in the human body?

Part 3 Open Ended

Record your answers on a sheet of paper.

15. Explain how bone cells help maintain homeostasis.
16. 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.
17. Inez and Maria went to the ice cream parlor. They both ordered strawberry sundaes. Marie thought that the sundae was made with fresh strawberries, because it tasted so great. Inez thought that her sundae didn't have much flavor. What could be the reason that Inez's sundae was tasteless? Explain.

Use the photograph below to answer question 18.



18. The person with this foot sore has diabetes. People with diabetes often lose sensation in their feet. Explain why a sore like the one in the photograph might develop if skin sensory receptors were not working properly.
19. What might happen to your body temperature if blood vessels in the skin did not contain smooth muscle?
20. Sam bumped into another player during soccer practice and bruised his leg. Describe the sequence of events from the time of injury until the injury disappears.