Chapter 14

Bones, Muscles, and Skin

The BIG Idea

Structure and Function

How do the systems of the human body work together?

Chapter Preview

1 Body Organization and Homeostasis
Discover How Does Your Body Respond?
Try This How Is a Book Organized?

2 The Skeletal System
Discover Hard as a Rock?
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3 The Muscular System
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Skills Lab A Look Beneath the Skin

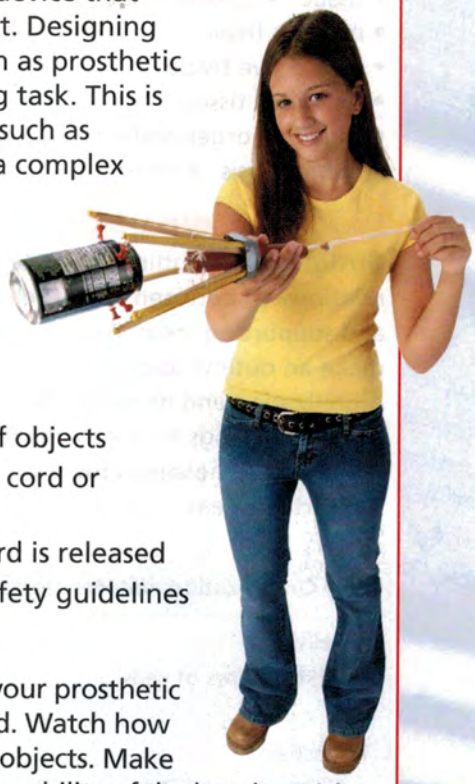
4 The Skin
Discover What Can You Observe About Skin?
Try This Sweaty Skin
Analyzing Data SPF Ratings
Design Your Own Lab Sun Safety

No matter your age or ability level, playing sports is fun and healthful.

Lab zone™ Chapter **Project**

Design and Build a Hand Prosthesis

A prosthesis is an artificial device that replaces a human body part. Designing artificial replacements, such as prosthetic hands, can be a challenging task. This is because even a simple act, such as picking up a pen, involves a complex interaction of body parts.



Your Goal To design, build, and test a replacement for a human hand

Your prosthesis must

- grasp and lift a variety of objects
- be activated by pulling a cord or string
- spring back when the cord is released
- be built following the safety guidelines in Appendix A

Plan It! Before you design your prosthetic hand, study the human hand. Watch how the fingers move to pick up objects. Make a list of devices that mimic the ability of the hand to pick up objects. Examples include tongs, tweezers, pliers, and chopsticks. Then, choose materials for your hand and sketch your design. When your teacher has approved your design, build and test your prosthetic hand.

Body Organization and Homeostasis

Reading Preview

Key Concepts

- What are the levels of organization in the body?
- What is homeostasis?

Key Terms

- cell • cell membrane
- nucleus • cytoplasm
- tissue • muscle tissue
- nervous tissue
- connective tissue
- epithelial tissue
- organ • organ system
- homeostasis • stress

Target Reading Skill

Outlining An outline shows the relationship between main ideas and supporting ideas. As you read, make an outline about body organization and homeostasis. Use the red headings for the main ideas and the blue headings for the supporting ideas.

Body Organization and Homeostasis

I. Cells
  A. Structures of cells
  B.
II. Tissues

Lab zone Discover Activity

How Does Your Body Respond?

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

Think It Over

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

The bell rings—lunchtime! You hurry down the noisy halls to the cafeteria. The unmistakable aroma of hot pizza makes your mouth water. At last, you balance your tray of pizza and salad while you pay the cashier. You look around the cafeteria for your friends. Then, you walk to the table, sit down, and begin to eat.

Think about how many parts of your body were involved in the simple act of getting and eating your lunch. Every minute of the day, whether you are eating, studying, walking, or even sleeping, your body is busily at work. Each part of the body has a specific job to do. And all the different parts of your body usually work together so smoothly that you don't even notice them.

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

Cells

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

Structures of Cells Most animal cells, including those in the human body, have a structure similar to the cell in Figure 1. The **cell membrane** forms the outside boundary of the cell. Inside the cell membrane is a large structure called the nucleus. The **nucleus** is the control center that directs the cell's activities and contains the information that determines the cell's form and function. When the cell divides, or reproduces, this information is passed along to the newly formed cells. The material within a cell apart from the nucleus is called the **cytoplasm** (SYT uh plaz um). The cytoplasm is made of a clear, jellylike substance containing many cell structures called organelles.

Functions of Cells Cells carry on the processes that keep organisms alive. Inside cells, for example, molecules from digested food undergo chemical reactions that release energy for the body's activities. Cells also grow and reproduce. And they get rid of waste products that result from these activities.

Reading Checkpoint **What is the function of the nucleus?**

Lab zone Try This Activity

How Is a Book Organized?

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

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

Making Models Which level of organization in the textbook represents cells? Which represents tissues? Organs? Organ systems?

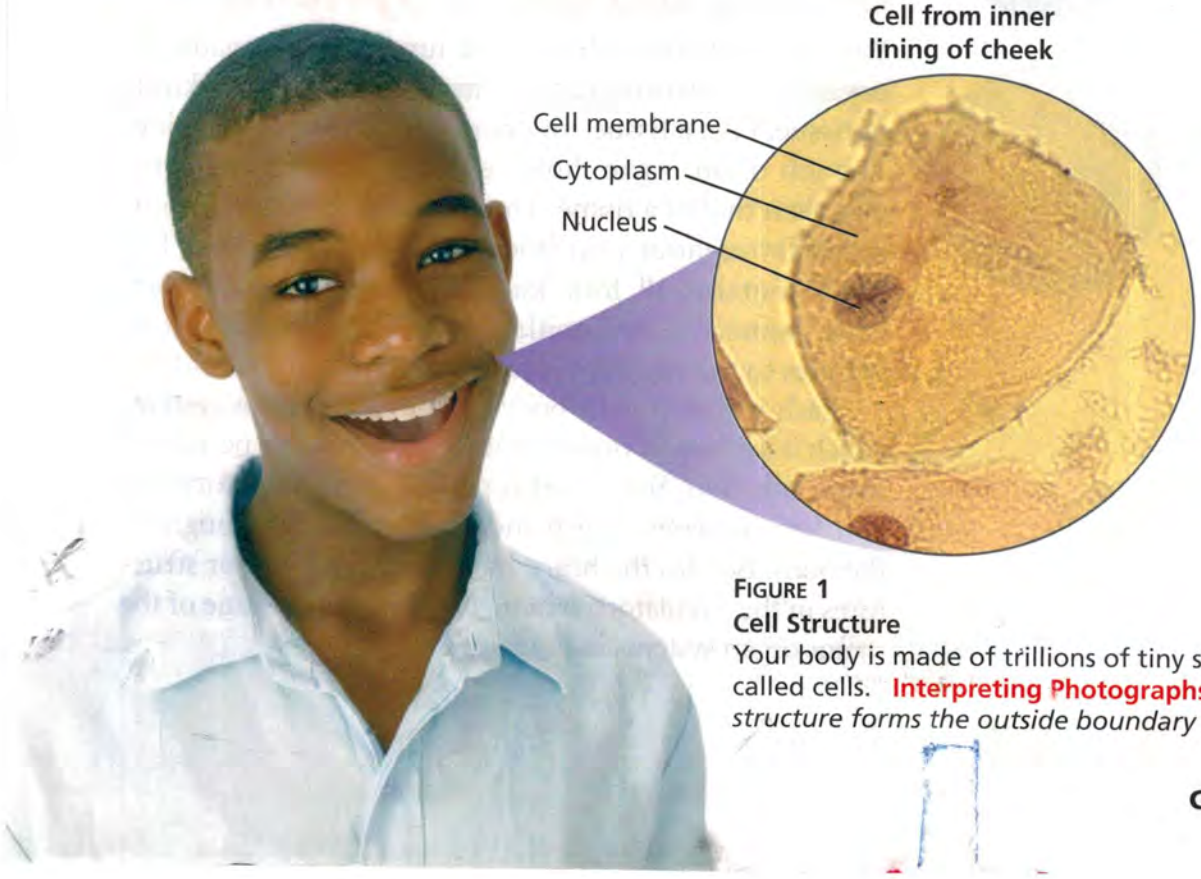


FIGURE 1
Cell Structure
Your body is made of trillions of tiny structures called cells. **Interpreting Photographs** *What structure forms the outside boundary of the cell?*

FIGURE 2

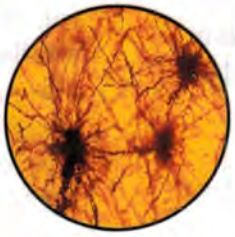
Types of Tissues

Your body contains four kinds of tissues: muscle, nervous, connective, and epithelial.

Comparing and Contrasting *How is the function of nervous tissue different from that of epithelial tissue?*

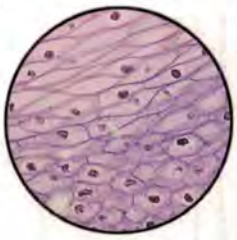
Muscle Tissue
Every movement you make depends on muscle tissue. The muscle tissue shown here allows your body to move.

Nervous Tissue
Nervous tissue, such as the brain cells shown here, enables you to see, hear, and think.



Connective Tissue
Connective tissue, such as the bone shown here, connects and supports parts of your body.

Epithelial Tissue
Epithelial tissue, such as the skin cells shown here, covers the surfaces of your body and lines your internal organs.



Tissues

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

Like the muscle cells that form it, **muscle tissue** can contract, or shorten. By doing this, muscle tissue makes parts of your body move. While muscle tissue carries out movement, **nervous tissue** directs and controls the process. Nervous tissue carries electrical messages back and forth between the brain and other parts of the body. Another type of tissue, **connective tissue,** provides support for your body and connects all its parts. Bone tissue and fat are connective tissues.

The surfaces of your body, inside and out, are covered by **epithelial tissue** (ep uh THEE lee ul). Some epithelial tissue, such as your skin, protects the delicate structures that lie beneath it. The lining of your digestive system consists of epithelial tissue that allows you to digest and absorb the nutrients in your food.

Reading Checkpoint **What is the job of muscle tissue?**

Organs and Organ Systems

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

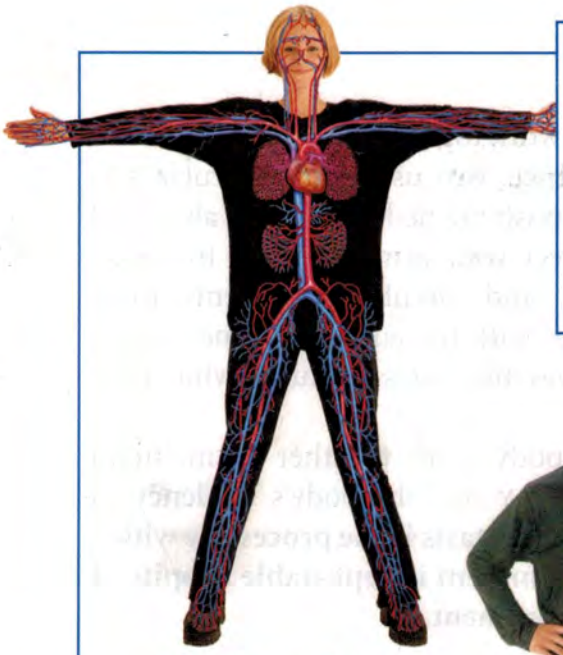
Each organ in your body is part of an **organ system,** which is a group of organs that work together to perform a major function. Your heart is part of your circulatory system, which carries oxygen and other materials throughout the body. Besides the heart, blood vessels are major structures in the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

FIGURE 3

Organ Systems

The human body is made up of eleven organ systems. Eight of the systems are shown here.

Interpreting Diagrams *Which two systems work together to get oxygen to your cells?*



Circulatory System
Transports materials to and from cells.

Digestive System
Breaks down food and absorbs nutrients.

Nervous System
Detects information from the environment and controls body functions.

Skeletal System
Supports and protects the body.

Endocrine System
Controls many body processes by means of chemicals.

Respiratory System
Takes in oxygen and eliminates carbon dioxide.

Muscular System
Enables movement of the body and internal organs.

Excretory System
Removes wastes.

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Homeostasis

The different organ systems work together and depend on one another. When you ride a bike, you use your muscular and skeletal systems to steer and push the pedals. But you also need your nervous system to direct your arms and legs to move. Your respiratory, digestive, and circulatory systems work together to fuel your muscles with the energy they need. And your excretory system removes the wastes produced while your muscles are hard at work.

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

Homeostasis in Action To see homeostasis in action, all you have to do is take your temperature when the air is cold. Then, take it again in an overheated room. No matter what the temperature of the air around you, your internal body temperature will be close to 37°C. Of course, if you become sick, your body temperature may rise. But when you are well again, it returns to 37°C.

Maintaining Homeostasis Your body has various ways of maintaining homeostasis. For example, when you are too warm, you sweat. Sweating helps to cool your body. On the other hand, when you are cold, you shiver. Shivering occurs when your muscles rapidly contract and relax. This action produces heat that helps keep you warm. Both of these processes help your body maintain homeostasis by regulating your temperature.

FIGURE 4
Maintaining Homeostasis
Regardless of the surrounding temperature, your body temperature remains fairly constant at about 37°C. Sweating (left) and shivering (right) help regulate your body temperature.
Applying Concepts *What is the term for the body's tendency to maintain a stable internal environment?*

Stress and Homeostasis Sometimes, things can happen to disrupt homeostasis. As a result, your heart may beat more rapidly or your breathing may increase. These reactions of your circulatory and respiratory systems are signs of stress. **Stress** is the reaction of your body to potentially threatening, challenging, or disturbing events.

Think about what happens when you leave the starting line in a bike race. As you pedal, your heart beats faster and your breathing increases. What is happening in your body? First, your endocrine system releases a chemical called adrenaline into your bloodstream. Adrenaline gives you a burst of energy and prepares your body to take action. As you pedal, your muscles work harder and require more oxygen. Oxygen is carried by the circulatory system, so your heart beats even faster to move more blood to your muscles. Your breath comes faster and faster, too, so that more oxygen can get into your body. Your body is experiencing stress.

If stress is over quickly, your body soon returns to its normal state. Think about the bike race again. After you cross the finish line, you continue to breathe hard for the next few minutes. Soon, however, your breathing and heart rate return to normal. The level of adrenaline in your blood returns to normal. Thus, homeostasis is restored after just a few minutes of rest.

Reading Checkpoint **What is stress?**

FIGURE 5
Stress
Your body reacts to stress, such as the start of a bike race, by releasing adrenaline and carrying more oxygen to body cells.

Section 1 Assessment

Target Reading Skill **Outlining** Use the information in your outline to help you answer the questions below.

Reviewing Key Concepts

1. a. **Identifying** List the four levels of organization in the human body from smallest to largest. Give an example of each level.
   b. **Comparing and Contrasting** What is the difference between tissues and organs?
   c. **Applying Concepts** What systems of the body are involved when you prepare a sandwich and then eat it?
2. a. **Defining** What is homeostasis?
   b. **Explaining** How does stress affect homeostasis?
   c. **Relating Cause and Effect** Describe what happens inside your body as you give an oral report in front of your class.

Writing in Science

Summary Write a paragraph that explains what body systems are involved when you sit down to do your homework. Be sure to begin your paragraph with a topic sentence and include supporting details.

Section 2

The Skeletal System

Reading Preview

Key Concepts

- What are the functions of the skeleton?
- What role do joints play in the body?
- What are the characteristics of bone, and how can you keep your bones strong and healthy?

Key Terms

- skeleton
- vertebrae
- joint
- ligament
- cartilage
- compact bone
- spongy bone
- marrow
- osteoporosis

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, answer your questions.

The Skeletal System

Question	Answer
What does the skeleton do?	The skeletal system provides shape . . .

Lab zone Discover Activity

Hard as a Rock?

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

Think It Over

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

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

Like a building, you also have an inner framework, but it isn't made up of steel. Your framework, or **skeleton,** is made up of all the bones in your body. The number of bones in your skeleton, or skeletal system, depends on your age. A newborn has about 275 bones. An adult, however, has about 206 bones. As a baby grows, some of the bones in the body fuse together. For example, as you grew, some of the bones in your skull fused together.

What the Skeletal System Does

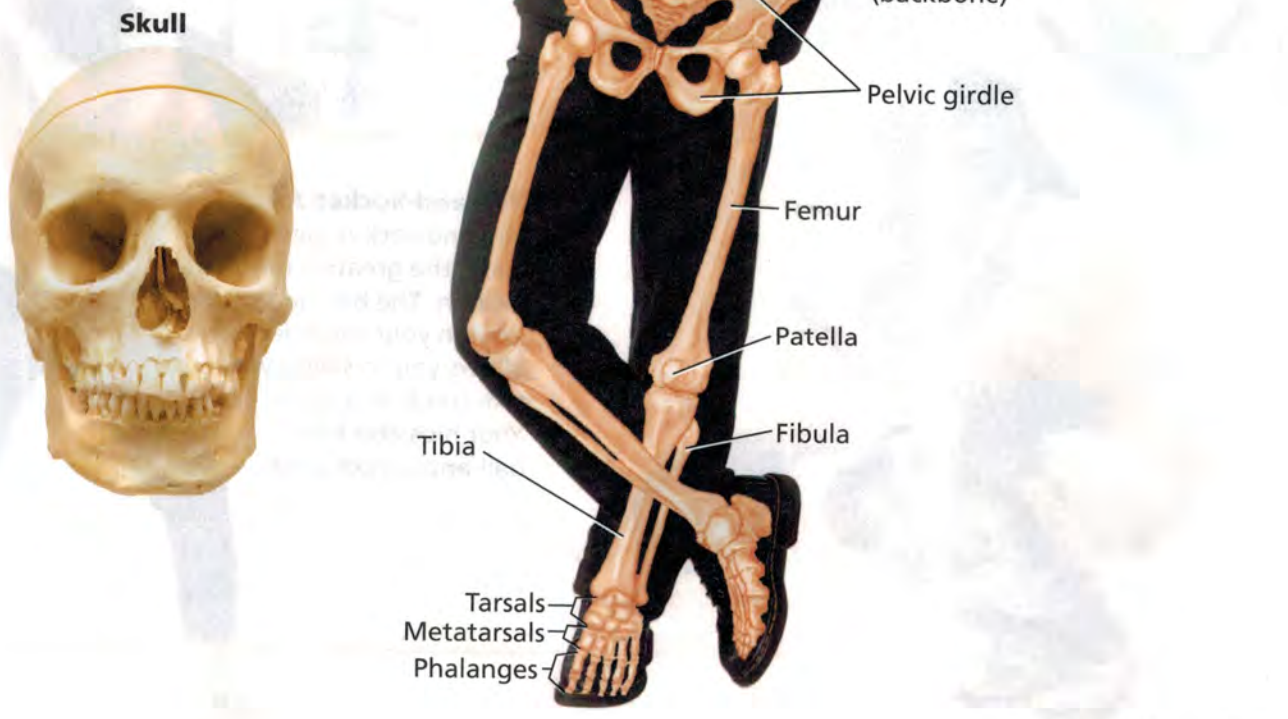
Just as a building could not stand without its frame, you would collapse without your skeleton. **Your skeleton has five major functions. It provides shape and support, enables you to move, protects your organs, produces blood cells, and stores minerals and other materials until your body needs them.**

Shape and Support Your skeleton determines the shape of your body, much as a steel frame determines the shape of a building. The backbone, or vertebral column, is the center of the skeleton. Locate the backbone in Figure 6. Notice that the bones in the skeleton are in some way connected to this column. If you move your fingers down the center of your back, you can feel the 26 small bones, or **vertebrae** (VUR tuh bray) (singular: *vertebra*), that make up your backbone. Bend forward at the waist and feel the bones adjust as you move. You can think of each individual vertebra as a bead on a string. Just as a beaded necklace is flexible and able to bend, so too is your vertebral column. If your backbone were just one bone, you would not be able to bend or twist.

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

FIGURE 6
The Skeleton

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



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

Production and Storage of Substances Some of your bones produce substances that your body needs. You can think of the long bones of your arms and legs as factories that make certain blood cells. Bones also store minerals such as calcium and phosphorus. When the body needs these minerals, the bones release small amounts of them into the blood.

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Joints of the Skeleton

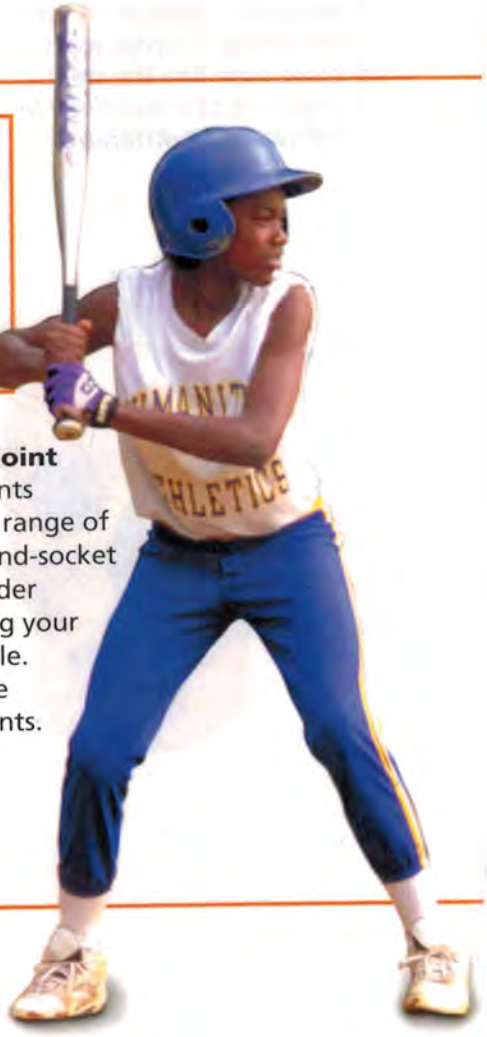
Suppose that a single long bone ran the length of your leg. How would you get out of bed or run for the school bus? Luckily, your body contains many small bones rather than fewer large ones. A **joint** is a place in the body where two bones come together. **Joints allow bones to move in different ways.** There are two kinds of joints—immovable joints and movable joints.

FIGURE 7
Movable Joints

Without movable joints, your body would be as stiff as a board. The different kinds of joints allow your body to move in a variety of ways.
Comparing and Contrasting *How is the movement of a hinge joint different from that of a ball-and-socket joint?*

Hinge Joint
A hinge joint allows forward or backward motion. Your knee is a hinge joint that allows you to bend and straighten your leg. Your elbow is also a hinge joint.

Ball-and-Socket Joint
Ball-and-socket joints allow the greatest range of motion. The ball-and-socket joint in your shoulder allows you to swing your arm freely in a circle. Your hips also have ball-and-socket joints.



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

Movable Joints Most of the joints in the body are movable joints. Movable joints allow the body to make a wide range of movements. Look at Figure 7 to see the variety of movements that these joints make possible.

The bones in movable joints are held together by strong connective tissues called **ligaments.** Most joints have a second type of connective tissue, called **cartilage** (KAHR tuh lij), which is more flexible than bone. Cartilage covers the ends of the bones and keeps them from rubbing against each other. For example, in the knee, cartilage acts as a cushion that keeps your femur (thighbone) from rubbing against the bones of your lower leg. In addition, a fluid lubricates the ends of the bones, allowing them to move smoothly over each other.

Reading Checkpoint **How are movable joints held together?**

Lab zone Skills Activity

Classifying

Perform these activities.

- Move your arm in a circle.
- Push open a door.
- Lift a book from a desk.
- Kneel down.
- Wave your hand.
- Twist your head from side to side.

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

Pivot Joint
A pivot joint allows one bone to rotate around another. The pivot joint in your neck allows you to turn your head from side to side.

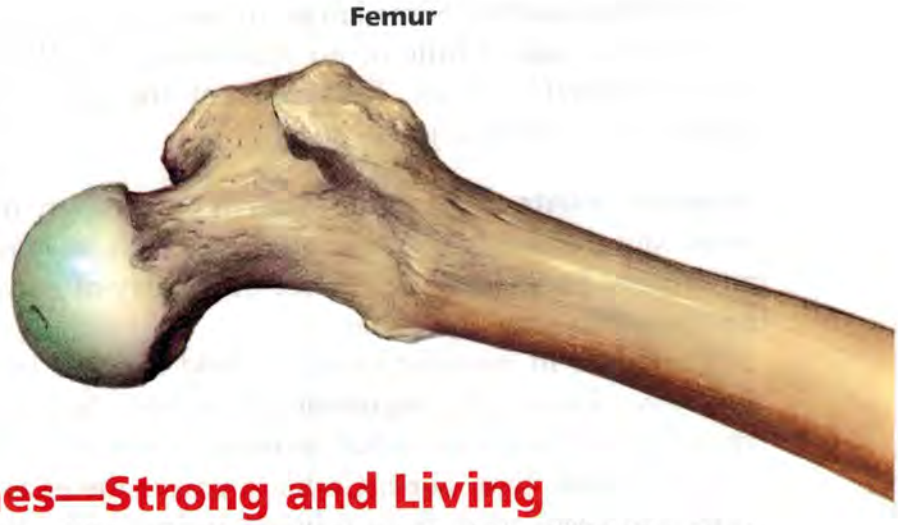
Gliding Joint
A gliding joint allows one bone to slide over another. The gliding joint in your wrist or ankle enables you to bend and flex as well as make limited side-to-side motions.

FIGURE 8

Bone Structure

The most obvious feature of a long bone, such as the femur, is its long shaft. Running through the compact bone tissue within the shaft is a system of canals. The canals bring materials to the living bone cells.

Interpreting Diagrams *What different tissues make up the femur?*



Bones—Strong and Living

When you think of a skeleton, you may think of the paper cut-outs that are used as decorations at Halloween. Many people connect skeletons with death. The ancient Greeks did, too. The word *skeleton* actually comes from a Greek word meaning "a dried body." The bones of your skeleton, however, are not dead at all. **Bones are complex living structures that undergo growth and development.**

Bone Structure Figure 8 shows the structure of the femur, or thighbone. The femur, which is the body's longest bone, connects the pelvic bones to the lower leg bones. Notice that a thin, tough membrane covers all of the bone except the ends. Blood vessels and nerves enter and leave the bone through the membrane. Beneath the bone's outer membrane is a layer of **compact bone,** which is hard and dense, but not solid. As you can see in Figure 8, small canals run through the compact bone. These canals carry blood vessels and nerves from the bone's surface to the living cells within the bone.

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

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

Reading Checkpoint **What are the two types of bone marrow?**

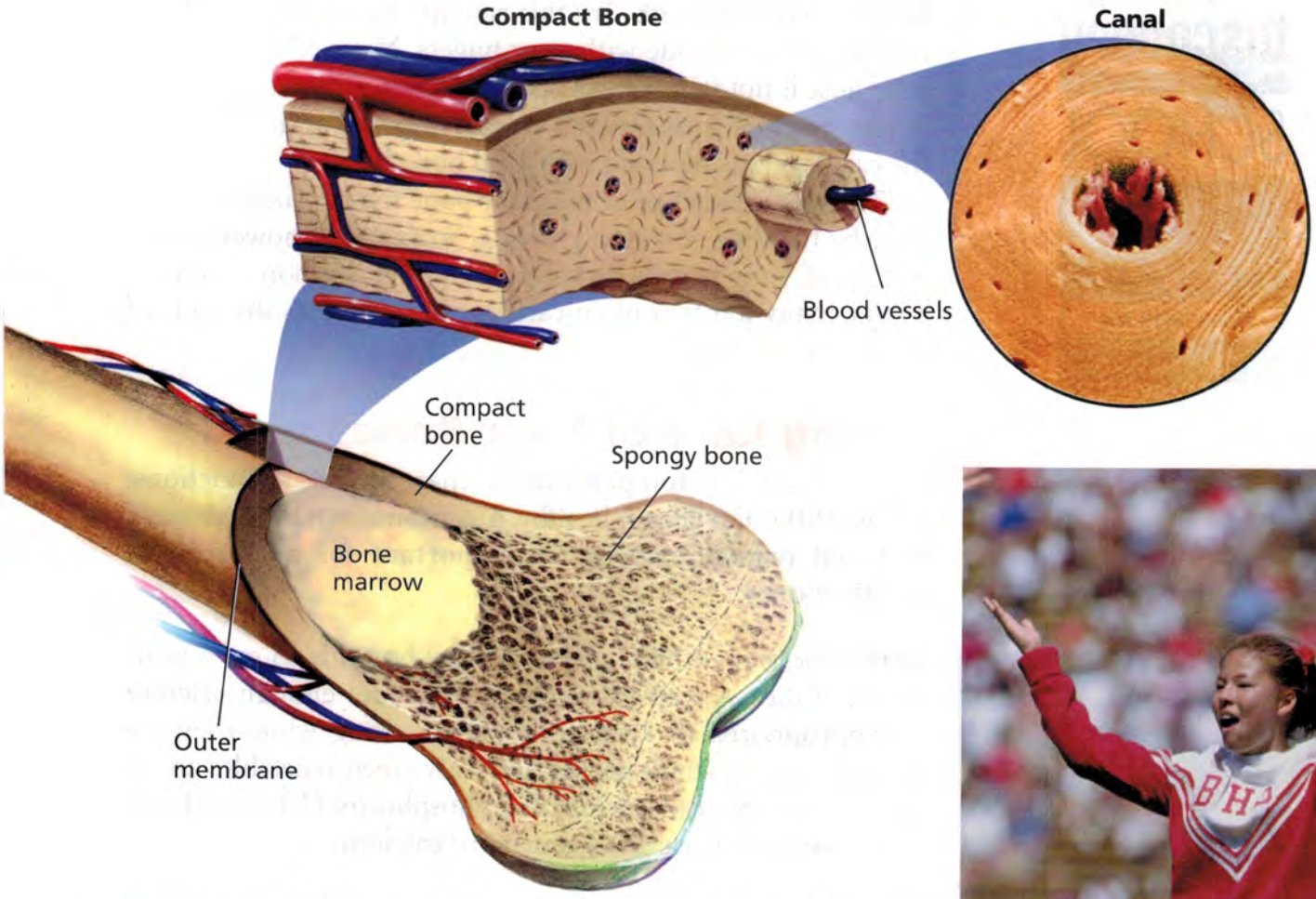
Lab zone Try This Activity

Soft Bones?

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

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

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



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

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

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

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

FIGURE 9
Bone Strength
You can jump up and down or turn cartwheels without breaking bones.

Bone Development Try this activity: Move the tip of your nose from side to side with your fingers. Notice that the tip of your nose is not stiff. That is because it contains cartilage. As an infant, much of your skeleton was cartilage. Over time, most of the cartilage was replaced with hard bone tissue.

The replacement of cartilage by bone tissue usually is complete by the time you stop growing. You've seen, however, that not all of your body's cartilage is replaced by bone. Even in adults, many joints contain cartilage that protects the ends of the bones.

Taking Care of Your Bones

Because your skeleton performs so many necessary functions, it is important to keep it healthy. **A combination of a balanced diet and regular exercise are important for a lifetime of healthy bones.**

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

Exercise Another way to build and maintain strong bones is to get plenty of exercise. During activities such as running, skating, or dancing, your bones support the weight of your entire body. These weight-bearing activities help your bones grow stronger and denser. To prevent injuries while exercising, be sure to wear appropriate safety equipment, such as a helmet and pads.

Reading Checkpoint **What are two ways to keep your bones healthy?**

FIGURE 10
Caring for Your Bones
Exercising regularly and eating a balanced diet help to keep your bones strong and healthy.

Healthy Bone

Bone With Osteoporosis

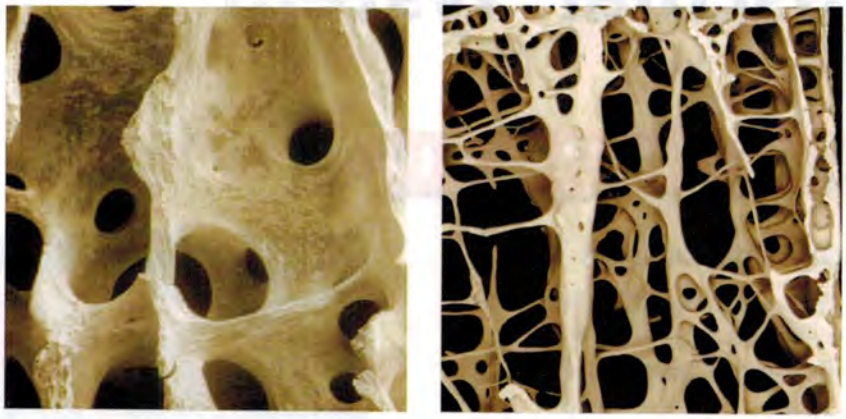


FIGURE 11
Osteoporosis
Without enough calcium in the diet, a person's bones weaken. These photos show how osteoporosis causes the bone to become less dense and more fragile than healthy bones.
Relating Cause and Effect *What can you do to prevent osteoporosis?*

Osteoporosis As people become older, their bones begin to lose some of the minerals they contain. Mineral loss can lead to **osteoporosis** (ahs tee oh puh ROH sis), a condition in which the body's bones become weak and break easily. These breaks, called fractures, can affect any bone in the body but occur most frequently in the hip, spine, and wrist. You can see the effect of osteoporosis in Figure 11. Osteoporosis is more common in women than in men. Evidence indicates that regular exercise throughout life can help prevent osteoporosis. A diet with enough calcium can also help prevent osteoporosis. If you eat enough calcium-rich foods now, during your teenage years, you may help prevent osteoporosis later in life.

Section 2 Assessment

Target Reading Skill **Asking Questions** Work with a partner to check the answers in your graphic organizer.

Reviewing Key Concepts

1. a. **Listing** What are five functions of the skeleton?
   b. **Explaining** How does the skeleton protect the body?
   c. **Predicting** How would your life be different if your backbone consisted of just one long bone?
2. a. **Naming** What are four types of movable joints?
   b. **Comparing and Contrasting** Compare immovable joints with movable joints.
   c. **Classifying** Which of your movable joints are ball-and-socket joints?
3. a. **Identifying** What are three layers within the femur?
   b. **Relating Cause and Effect** How does the structure of bones make them both strong and lightweight?
   c. **Applying Concepts** How do a well-balanced diet and weight-bearing exercise help keep bones strong?

Lab zone

At-Home Activity

Model Joints Choose two examples of movable joints from Figure 7. Ask a family member to perform separate movements that involve one joint and then the other. Make drawings to represent the joints and bones involved in each movement. Use the drawings to explain to your family how the motions of the two joints differ.

Section 3

The Muscular System

Reading Preview

Key Concepts

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

Key Terms

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

Target Reading Skill

Previewing Visuals When you preview, you look ahead at the material to be read. Preview Figure 12. Then, in a graphic organizer like the one below, write two questions that you have about the diagram. As you read, answer your questions.

Types of Muscle

Q. How does skeletal muscle help my body move?
A.
Q.

Lab zone Discover Activity

How Do Muscles Work?

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

Think It Over

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

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

There are about 600 muscles in your body. Muscles have many functions. For example, they keep your heart beating, pull your mouth into a smile, and move the bones of your skeleton. The girl doing karate on the next page uses many of her muscles to move her arms, legs, hands, feet, and head. Other muscles expand and contract her chest and allow her to breathe.

Types of Muscle

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

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

Your body has three types of muscle tissue—skeletal muscle, smooth muscle, and cardiac muscle. Some of these muscle tissues are involuntary, and some are voluntary. In Figure 12, you see a magnified view of each type of muscle in the body. Both skeletal and smooth muscles are found in many places in the body. Cardiac muscle is found only in the heart. Each muscle type performs specific functions in the body.

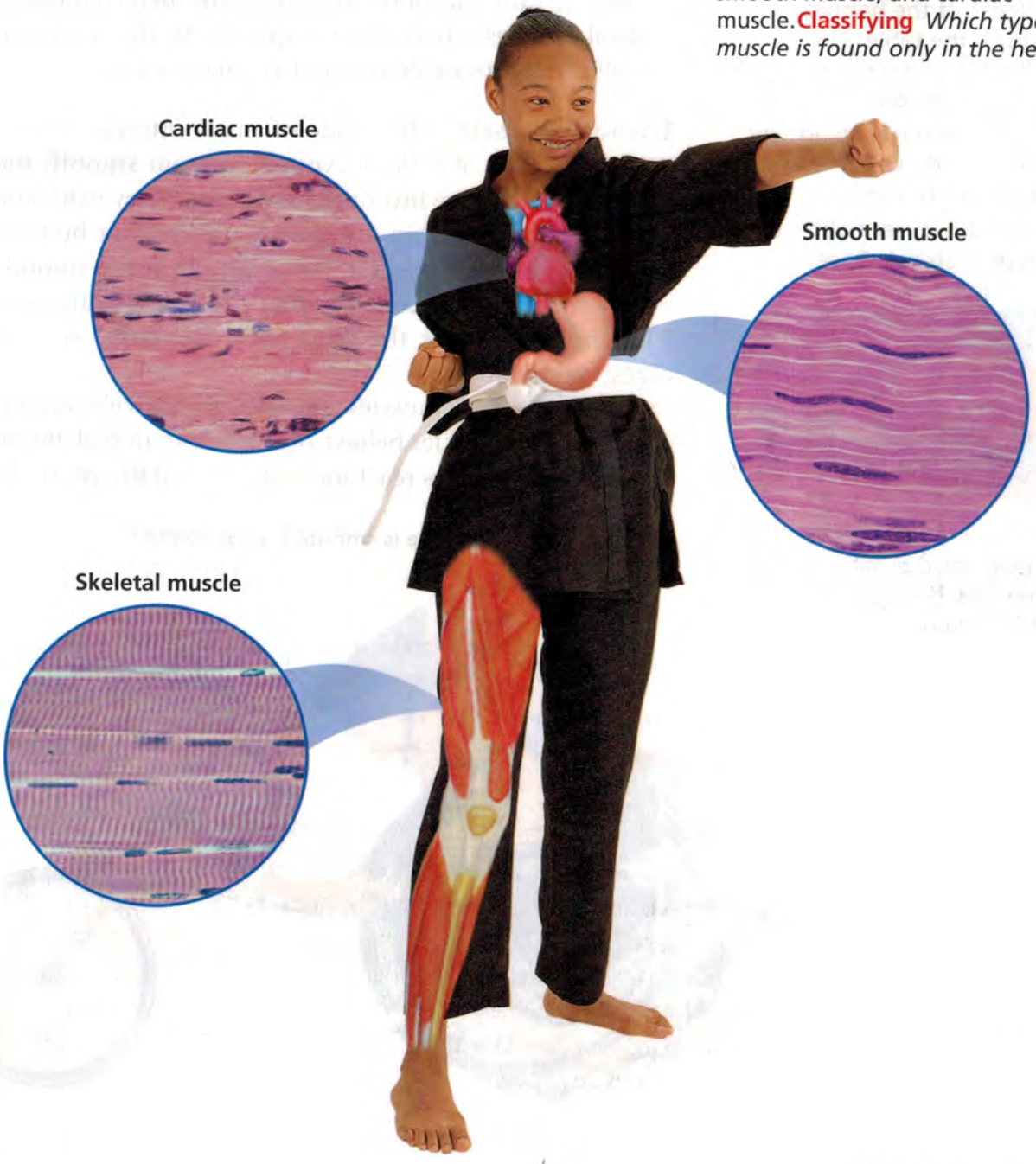


FIGURE 12
Types of Muscle
Your body has three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle. **Classifying** *Which type of muscle is found only in the heart?*

Lab zone **Try This Activity**

Get a Grip

Are skeletal muscles at work when you're not moving?

1. Hold a stirrer in front of you, parallel to a table top. Do not touch the table.
2. Have a partner place a hairpin on the stirrer.
3. Raise the stirrer until the "legs" of the hairpin just touch the table. The "head" of the hairpin should rest on the stirrer.
4. Hold the stirrer steady for 20 seconds. Observe what happens to the hairpin.
5. Grip the stirrer tighter and repeat Step 4. Observe.

Inferring Are the skeletal muscles in your hand at work when you hold your hand still? Explain.

Skeletal Muscle Every time you walk across a room, you are using skeletal muscles. **Skeletal muscles** are attached to the bones of your skeleton and provide the force that moves your bones. At each end of a skeletal muscle is a tendon. A **tendon** is a strong connective tissue that attaches muscle to bone. Skeletal muscle cells appear banded, or striated. For this reason, skeletal muscle is sometimes called **striated** (STRY ay tid) **muscle.**

Because you have conscious control of skeletal muscles, they are classified as voluntary muscles. One characteristic of skeletal muscles is that they react very quickly. Think about what happens during a swim meet. Immediately after the starting gun sounds, a swimmer's leg muscles push the swimmer off the block into the pool. However, another characteristic of skeletal muscles is that they tire quickly. By the end of the race, the swimmer's muscles are tired and need a rest.

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

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

Reading Checkpoint **Where is smooth muscle found?**

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

Muscles at Work

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

Muscles Work in Pairs Figure 13 shows the muscle action involved in bending the arm at the elbow. First, the biceps muscle on the front of the upper arm contracts to bend the elbow, lifting the forearm and hand. As the biceps contracts, the triceps on the back of the upper arm relaxes and returns to its original length. Then, to straighten the elbow, the triceps muscle contracts. As the triceps contracts to extend the arm, the biceps relaxes and returns to its original length. Another example of muscles that work in pairs are those in your thigh that bend and straighten the knee joint.

FIGURE 13
Muscle Pairs

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

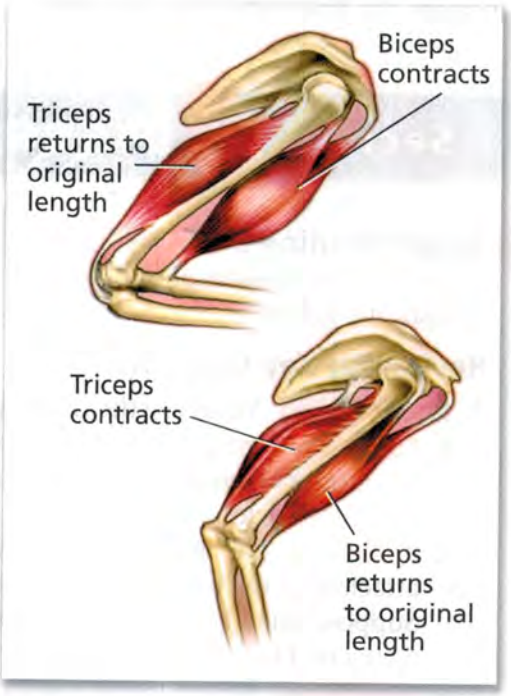


FIGURE 14
Preventing Muscle Injuries
When you warm up before exercising, you increase the flexibility of your muscles.

Muscular Strength and Flexibility Regular exercise is important for maintaining both muscular strength and flexibility. Exercise makes individual muscle cells grow in size. As a result, the whole muscle becomes thicker. The thicker a muscle is, the stronger the muscle is. When you warm up thoroughly before exercising, the blood flow to your muscles increases and they become more flexible. Stretching after you warm up helps prepare your muscles for the more vigorous exercise or play ahead.

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

Reading Checkpoint **What are two ways to prepare the muscles for exercise?**

Section 3 Assessment

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 12 to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Identifying** What are the three types of muscle tissue?
   b. **Comparing and Contrasting** How do voluntary and involuntary muscles differ? Give an example of each type of muscle.
   c. **Predicting** The muscles that move your fingers are attached to the bones in your fingers by tendons. Suppose one of the tendons in a person's index finger were cut. How would it affect movement in the finger?
2. a. **Identifying** Where might you find muscle pairs?
   b. **Describing** Describe how the muscles in your upper arm work together to bend and straighten your arm.
   c. **Applying Concepts** When exercising to build muscular strength, why is it important to exercise both muscles in a muscle pair equally?

Writing in Science

Comparison Paragraph Write a paragraph comparing smooth muscle tissue and skeletal muscle tissue. Include whether these muscle tissues are voluntary or involuntary, where they are found and what their functions are. In addition, describe what you might expect to see if you looked at these muscle tissues under a microscope.

Lab zone Skills Lab

A Look Beneath the Skin

Problem

What are some characteristics of skeletal muscles? How do skeletal muscles work?

Skills Focus

observing, inferring, classifying

Materials

- water
- paper towels
- scissors
- dissecting tray
- uncooked chicken wing, treated with bleach

Procedure

1. Put on goggles, an apron, and protective gloves. **CAUTION:** *Wear gloves whenever you handle the chicken.*
2. Your teacher will give you a chicken wing. Rinse it well with water, dry it with paper towels, and place it in a dissecting tray.
3. Carefully extend the wing to find out how many major parts it has. Draw a diagram of the external structure. Label the upper arm, elbow, lower arm, and hand (wing tip).
4. Use scissors to remove the skin. Cut only through the skin. **CAUTION:** *Cut away from your body and your classmates.*
5. Examine the muscles, which are the bundles of pink tissue around the bones. Find the two groups of muscles in the upper arm. Hold the arm down at the shoulder, and alternately pull on each muscle group. Observe what happens.
6. Find the two groups of muscles in the lower arm. Hold down the arm at the elbow, and alternately pull on each muscle group. Then, make a diagram of the wing's muscles.
7. Find the tendons—shiny white tissue at the ends of the muscles. Notice what parts the tendons connect. Add the tendons to your diagram.
8. Remove the muscles and tendons. Find the ligaments, which are the whitish ribbon-shaped structures between bones. Add them to your diagram.
9. Dispose of the chicken parts according to your teacher's instructions. Wash your hands.

Analyze and Conclude

1. **Observing** How does a chicken wing move at the elbow? How does the motion compare to how your elbow moves? What type of joint is involved?
2. **Inferring** What happened when you pulled on one of the arm muscles? What muscle action does the pulling represent?
3. **Classifying** Categorize the muscles you observed as smooth, cardiac, or skeletal.
4. **Communicating** Why is it valuable to record your observations with accurate diagrams? Write a paragraph in which you describe what your diagrams show.

More to Explore

Use the procedures from this lab to examine an uncooked chicken thigh and leg. Compare how the chicken leg and a human leg move. *Obtain your teacher's permission before carrying out your investigation.*

Section 4

The Skin

Reading Preview

Key Concepts

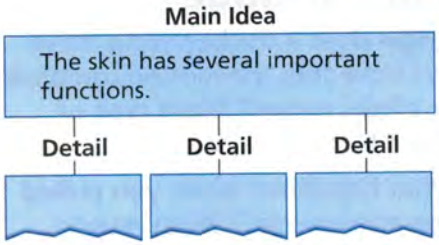
- What are the functions and the structures of skin?
- What habits can help keep your skin healthy?

Key Terms

- epidermis • melanin
- dermis • pore • follicle
- cancer

Target Reading Skill

Identifying Main Ideas As you read the section titled The Body's Tough Covering, write the main idea—the biggest or most important idea—in a graphic organizer like the one below. Then, write five supporting details. The supporting details give examples of the main idea.



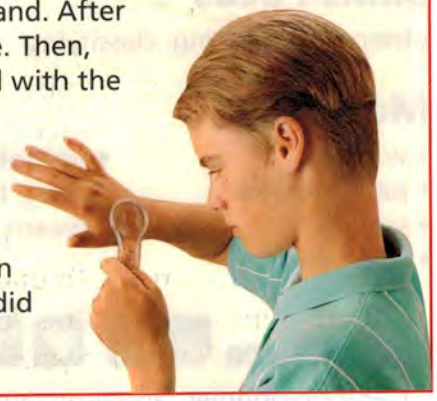
Lab zone **Discover Activity**

What Can You Observe About Skin?

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

Think It Over

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



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

The Body's Tough Covering

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

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

Maintaining Temperature Another function of the skin is to help the body maintain a steady temperature. Many blood vessels run throughout the skin. When you become too warm, these blood vessels enlarge and the amount of blood that flows through them increases. These changes allow heat to move from your body into the outside environment. In addition, sweat glands in the skin respond to excess heat by producing perspiration. As perspiration evaporates from your skin, your skin is cooled.

Eliminating Wastes Perspiration contains dissolved waste materials that come from the breakdown of chemicals during cellular processes. Thus, your skin is also helping to eliminate wastes whenever you perspire. For example, some of the wastes that come from the breakdown of proteins are eliminated in perspiration.

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

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

Reading Checkpoint **How does your skin gather information about the environment?**

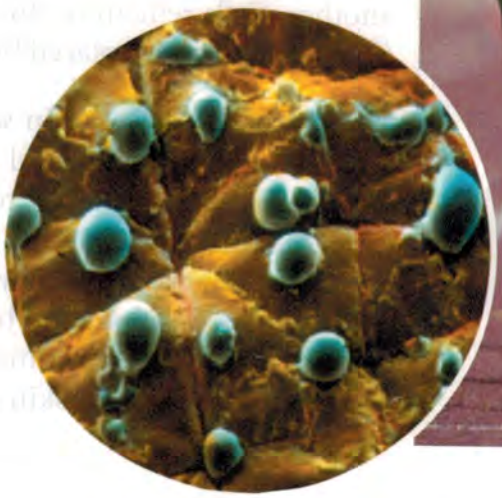


FIGURE 15
Eliminating Wastes
Sweat glands in the skin produce perspiration, which leaves the body through pores. The inset photo shows beads of sweat on skin.
Relating Cause and Effect *In addition to eliminating wastes, what is another important function of perspiration?*

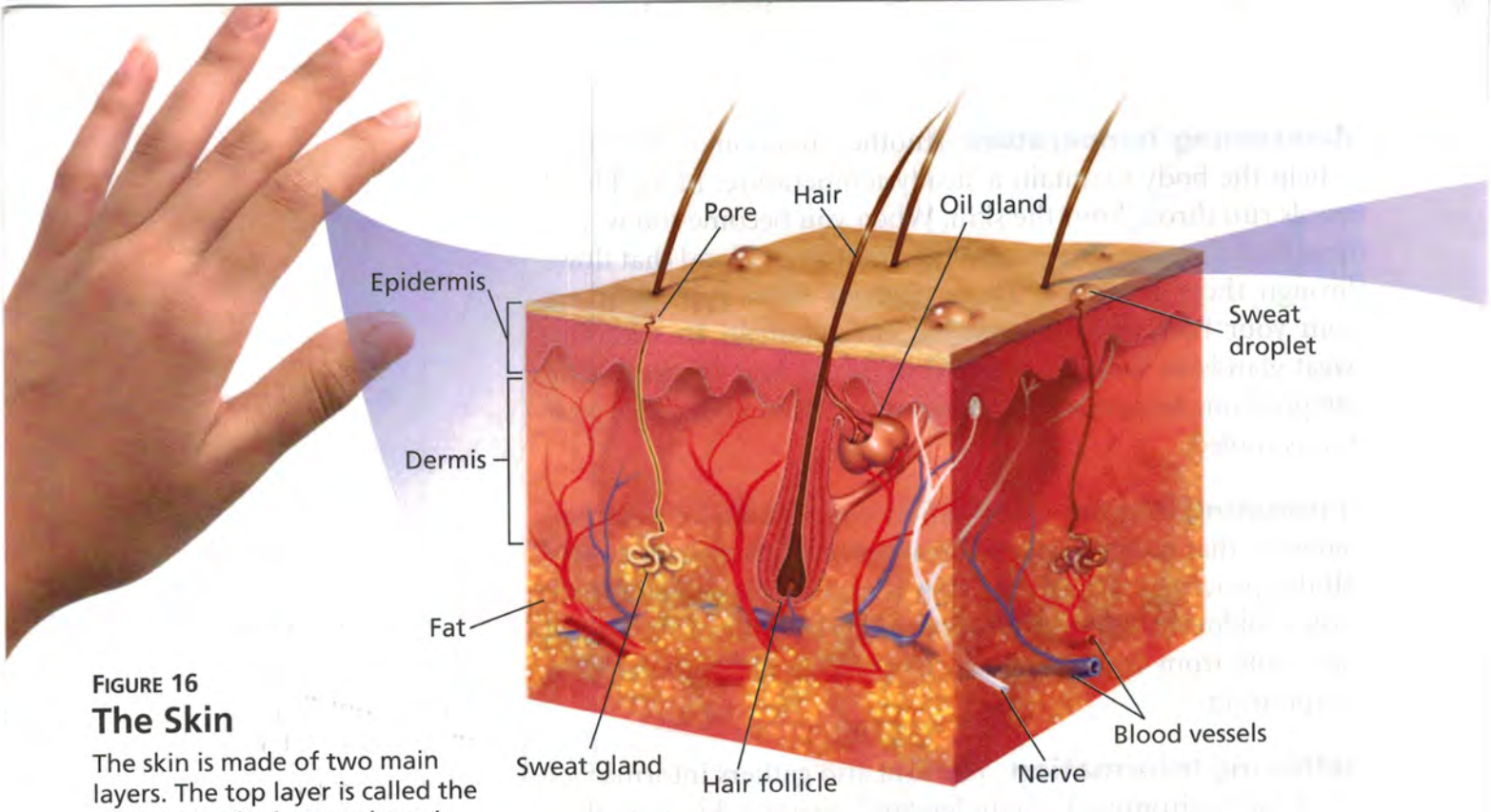


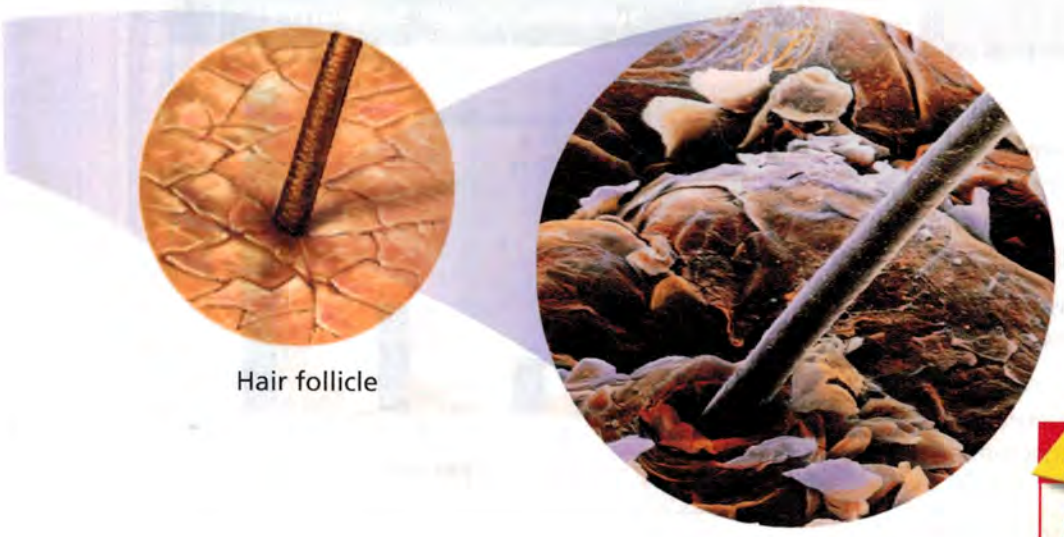
FIGURE 16
The Skin
The skin is made of two main layers. The top layer is called the epidermis. The bottom layer is called the dermis.
Interpreting Diagrams *In which layer of the skin do you find blood vessels?*

The Epidermis

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

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

Epidermis Function In some ways, the cells of the epidermis are more valuable dead than alive. Most of the protection provided by the skin is due to the layer of dead cells on the surface. The thick layer of dead cells on your fingertips, for example, protects and cushions your fingertips. Also, the shedding of dead cells carries away bacteria and other substances that settle on the skin. Every time you rub your hands together, you lose thousands of dead skin cells and any bacteria on them.



Hair follicle

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

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

The Dermis

The **dermis** is the inner layer of the skin. Find the dermis in Figure 16. Notice that it is located below the epidermis and above a layer of fat. This fat layer pads the internal organs and helps keep heat in the body.

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

Reading Checkpoint **What is the function of pores in the skin?**

Lab zone Try This Activity

Sweaty Skin

This activity illustrates one of the skin's functions.

1. Wrap a wet cotton ball around the bulb of one thermometer. Place a second thermometer next to the first one.

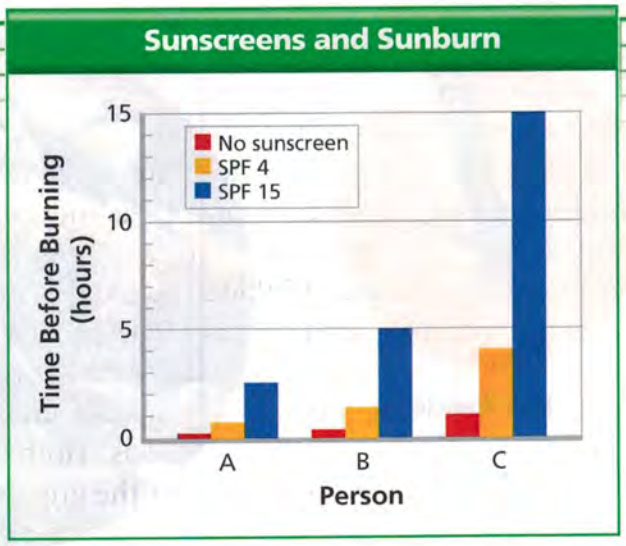
2. After two minutes, record the temperature reading on each thermometer.
3. Using a piece of cardboard, fan both of the thermometers for several minutes. The cardboard should be at least 10 cm from the thermometers. Record the temperatures.

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

Math Analyzing Data

Sunscreen Ratings

The graph shows how sunscreens with different sun protection factor (SPF) ratings extend the time three people can stay in the sun without beginning to get a sunburn.



1. **Reading Graphs** What does the height of each bar in the graph represent?
2. **Interpreting Data** How long can Person B stay in the sun without sunscreen before starting to burn? With a sunscreen of SPF 4? SPF 15?
3. **Inferring** Suppose that Person C was planning to attend an all-day picnic. Which sunscreen should Person C apply? Use data to support your answer.
4. **Calculating** Which is more effective at preventing sunburn—a sunscreen with SPF 4 or one with SPF 15? How much more effective is it? Show your work.
5. **Drawing Conclusions** What does the number in the SPF rating stand for? *(Hint:* Note the length of time each person can stay in the sun without sunscreen and compare this value to the length of time each can stay in the sun using SPF 4. Then, do the same for SPF 15.)

Caring for Your Skin

Because your skin has so many vital functions, taking care of it is important. **Three simple habits can help you keep your skin healthy. Eat a healthful diet. Keep your skin clean and dry. Limit your exposure to the sun.**

Healthful Diet Your skin is always active. Eating a well-balanced diet provides the energy and raw materials needed for the growth and replacement of hair, nails, and skin cells. In addition to what you eat, a healthful diet also includes drinking plenty of water. That way, you can replace the water lost in perspiration.

Keeping Skin Clean When you wash your skin with mild soap, you get rid of dirt and harmful bacteria. Washing your skin also helps to control oiliness.

Good washing habits are particularly important during the teenage years when oil glands are more active. When glands become clogged with oil, the blackheads and whiteheads of acne can form. If acne becomes infected by skin bacteria, your doctor may prescribe an antibiotic to help control the infection.

Go Online
SCILINKS NSTA
For: Links on the skin
Visit: www.SciLinks.org
Web Code: scn-0415

Limiting Sun Exposure It is important to protect your skin from the harmful effects of the sun. Repeated exposure to sunlight can damage skin cells, and possibly lead to skin cancer. **Cancer** is a disease in which some cells in the body divide uncontrollably. In addition, repeated exposure to the sun can cause the skin to become leathery and wrinkled.

There are many things you can do to protect your skin from damage by the sun. When you are outdoors, always wear a hat, sunglasses, and use a sunscreen on exposed skin. Choose clothing made of tightly woven fabrics for the greatest protection. In addition, avoid exposure to the sun between the hours of 10 A.M. and 4 P.M. That is the time when sunlight is the strongest.

Reading Checkpoint **What health problems can result from repeated sun exposure?**

FIGURE 17
Skin Protection
This person is wearing a hat to protect his skin from the sun.
Applying Concepts *What other behaviors can provide protection from the sun?*

Section 4 Assessment

Target Reading Skill **Identifying Main Ideas** Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Listing** What are five important functions of the skin?
   b. **Identifying** How does the epidermis protect the body? What structure in the dermis helps to maintain body temperature?
   c. **Inferring** What could happen if the pores in your dermis become blocked?
2. a. **Identifying** What are three things you can do to keep your skin healthy?
   b. **Explaining** Why is it important to use sunscreen to protect your skin when outside?
   c. **Making Judgments** Do you think it is possible to wash your skin too much and damage it as a result? Why or why not?

Lab zone At-Home Activity

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

Sun Safety

Problem

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

Skills Focus

observing, predicting, interpreting data, drawing conclusions

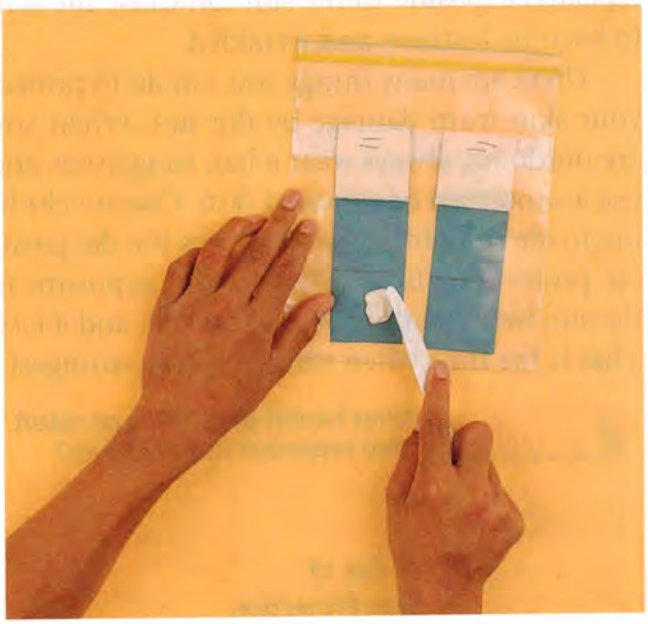
Materials

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

Procedure

PART 1 Sunscreen Protection

1. Read over the procedure for Part 1. Then, write a prediction about how well each of the sunscreens will protect against the sun.
2. Use scissors to cut two strips of photosensitive paper that measure 5 cm by 15 cm.
3. Divide each strip into thirds by drawing lines across the strips.
4. Cover one third of each strip with a square of white construction paper. Staple each square down.
5. Use a pencil to write the lower SPF rating on the back of the first strip. Write the other SPF rating on the back of the second strip.



6. Place the two strips side by side in a plastic bag. Seal the bag, then staple through the white squares to hold the strips in place.
7. With a plastic knife, spread a thin layer of each sunscreen on the bag over the bottom square of its labeled strip. This is shown in the photo above. Make certain each strip has the same thickness of sunscreen. Be sure not to spread sunscreen over the middle squares.
8. Place the strips in sunlight until the color of the middle squares stops changing. Make sure the bag is sunscreen-side up when you place it in the sunlight.
9. Remove the staples from the bag, and then take out the strips. Take off the construction paper. Rinse the strips for one minute in cold water, then dry them flat.
10. Observe all the squares. Then, record your observations.

PART 2 Fabric Protection

11. Your teacher will provide three fabric pieces of different thicknesses.
12. Based on the procedure in Part 1, design an experiment to test how effective the three fabrics are in protecting against the sun. Write a prediction about which fabric you think will be most effective, next most effective, and least effective.
13. Obtain your teacher's approval before carrying out your experiment. Record all of your observations.

Analyze and Conclude

1. **Observing** Did the sunscreens protect against sun exposure? How do you know?
2. **Predicting** Which sunscreen provided more protection? Was your prediction correct? How would you predict a sunscreen with an SPF of 15 would compare to the sunscreens you tested?
3. **Interpreting Data** Did the fabrics protect against sun exposure? How do you know?
4. **Drawing Conclusions** Which of the fabrics provided the most protection? The least protection? How did your results compare with your predictions?
5. **Communicating** What advice would you give people about protecting their skin from the sun? Create a pamphlet in which you address this question by comparing the different sunscreens and fabrics you tested.

More to Explore

Design another experiment, this time to find out whether ordinary window glass protects skin against sun exposure. *Obtain your teacher's permission before carrying out your investigation.*

Chapter 14 Study Guide

The BIG Idea **Structure and Function** The human body is composed of eleven organ systems that work together to carry out life processes and maintain homeostasis.

1 Body Organization and Homeostasis

Key Concepts

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

Key Terms

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

2 The Skeletal System

Key Concepts

- Your skeleton provides shape and support, enables you to move, protects your organs, produces blood cells, and stores minerals and other materials until your body needs them.
- Joints allow bones to move in different ways.
- Bones are complex living structures that undergo growth and development.
- A balanced diet and regular exercise are important for a lifetime of healthy bones.

Key Terms

skeleton
vertebrae
joint
ligament
cartilage
compact bone
spongy bone
marrow
osteoporosis

3 The Muscular System

Key Concepts

- Your body has three types of muscle tissue—skeletal, smooth, and cardiac.
- Skeletal muscles work in pairs. While one muscle contracts, the other muscle in the pair relaxes to its original length.

Key Terms

involuntary muscle
voluntary muscle
skeletal muscle
tendon
striated muscle
smooth muscle
cardiac muscle

4 The Skin

Key Concepts

- The skin has several functions: protection, maintaining temperature, eliminating wastes, gathering information, and making vitamin D.
- The two skin layers are epidermis and dermis.
- Three simple habits can help you keep your skin healthy. Eat a healthful diet. Keep your skin clean and dry. Limit your sun exposure.

Key Terms

epidermis
melanin
dermis
pore
follicle
cancer

Review and Assessment

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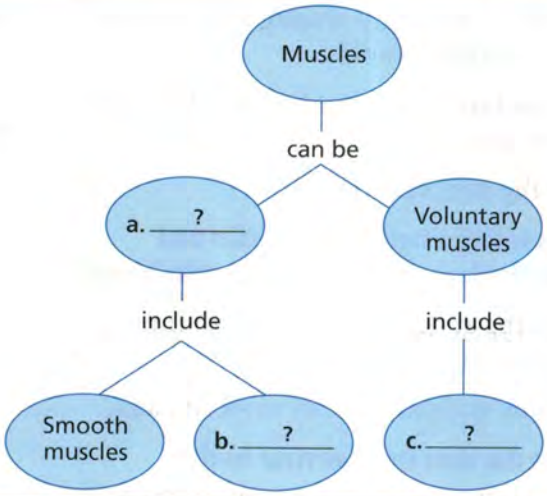
Organizing Information

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



Reviewing Key Terms

Choose the letter of the best answer.

1. A group of similar cells that perform a similar function is called a(n)
   a. cell. **b.** organ.
   c. tissue. **d.** organ system.
2. Which type of body tissue covers the surfaces of the body?
   a. muscle tissue
   b. nervous tissue
   c. connective tissue
   d. epithelial tissue
3. A soft, connective tissue found inside some bones is
   a. cytoplasm.
   b. marrow.
   c. cartilage.
   d. osteoporosis.
4. Muscles that help the skeleton move are
   a. cardiac muscles.
   b. smooth muscles.
   c. skeletal muscles.
   d. involuntary muscles.
5. A colored substance that helps to keep the skin from burning is
   a. the dermis. **b.** the epidermis.
   c. melanin. **d.** a follicle.

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

6. The cytoplasm directs the cell's activities.
7. Spongy bone is filled with cartilage.
8. Skeletal muscle is called striated muscle.
9. The epidermis contains nerve endings and blood vessels.
10. Strands of hair grow within the dermis in structures called pores.

Writing in Science

Descriptive Paragraph Pretend you are a writer for a science magazine for children. Write a few paragraphs that compare the characteristics of cartilage with the characteristics of bones. Be sure to explain the advantages of both types of materials.

Discovery Channel School
Bones, Muscles, and Skin
Video Preview
Video Field Trip
▶ Video Assessment

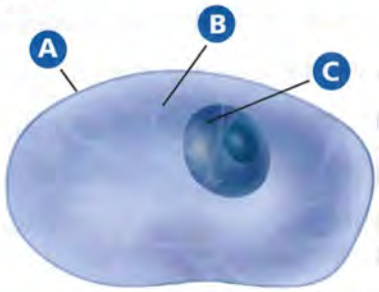
Review and Assessment

Checking Concepts

11. Explain the relationship among cells, tissues, organs, and organ systems.
12. List the four kinds of movable joints. Describe the type of movement each joint allows.
13. Describe the structure of a bone.
14. How does eating a well-balanced diet and exercising regularly contribute to healthy bones?
15. How does the appearance of smooth muscle differ from that of skeletal muscle?
16. Explain how skeletal muscles work in pairs.
17. How does the skin protect your body?

Thinking Critically

18. **Classifying** Identify each of the labeled parts of the cell.



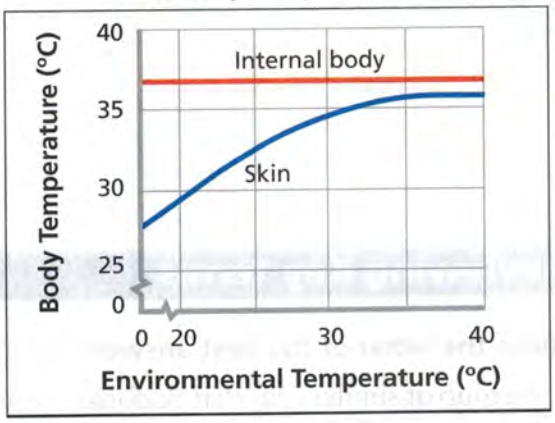
19. **Inferring** In addition to bone, cartilage, and fat, scientists classify blood as a connective tissue. Explain why.
20. **Making Generalizations** How is homeostasis important to survival?
21. **Predicting** If smooth muscle had to be controlled consciously, what problems could you foresee in day-to-day living?
22. **Making Judgments** Suppose a member of your running team suggests eliminating "warm-up time" because it takes too much time away from practice. Do you think this suggestion is a good idea? Why or why not?
23. **Relating Cause and Effect** A person who is exposed to excessive heat may suffer from heatstroke. The first sign of heatstroke is that the person stops sweating. Why is heatstroke a life-threatening emergency?

Applying Skills

Use the graph to answer Questions 24–26.

The graph below shows the effects of the temperature of the environment on a boy's skin temperature and on the temperature inside his body.

Environmental Temperature vs. Body Temperature



24. **Interpreting Data** As the temperature of the environment rises, what happens to the boy's internal body temperature? How does this demonstrate homeostasis?
25. **Inferring** What happens to the temperature of the boy's skin? Why is this pattern different from the pattern shown by the boy's internal body temperature?
26. **Predicting** Suppose the boy went outdoors on a chilly fall morning. Predict what would happen to his internal body temperature and his skin temperature. Explain.

Lab zone Chapter Project

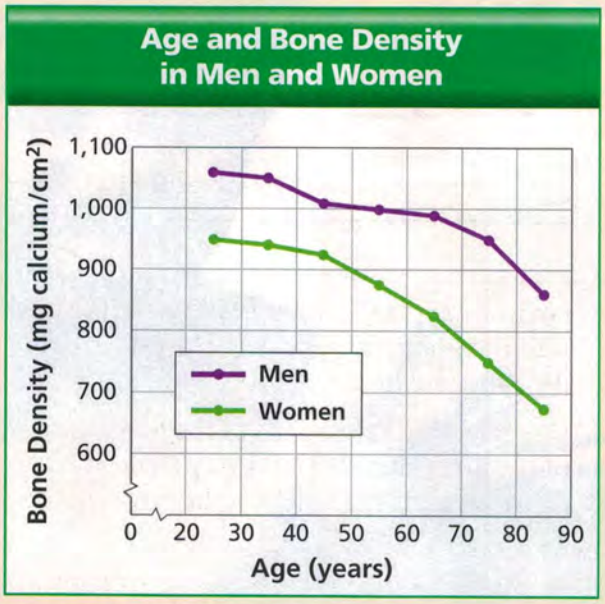
Performance Assessment Before testing your prosthetic hand, explain to your classmates how and why you designed the hand the way you did. When you test the hand, observe how it picks up objects. How does it compare with a real human hand? How could you improve the function of your prosthetic hand?

Standardized Test Prep

Test-Taking Tip

Interpreting a Graph

If a question asks you to interpret a line graph, look first at the graph's title. This tells you the subject of the graph. Next, look at the labels on the axes. The labels tell you what relationship is plotted on the graph—in other words, what variables are being compared. Then, look at the line or lines on the graph to see what trend is shown.



Sample Question

Which of the following relationships is plotted on the graph?

A how exercise affects bone density
B how bone density changes with age
C how calcium intake affects bone density
D how calcium intake changes with age

Answer

The correct answer is **B.** Both the graph title and the labels on the axes tell you that the graph shows the relationship between age and bone density. Choices **A, C,** and **D** are incorrect because the graph does not include any information on exercise or calcium intake.

Choose the letter of the best answer.

1. Which of the following statements is true according to the graph shown at left?
   A The bones of women are more dense than the bones of men.
   B The bones of men contain less calcium than do the bones of women.
   C The bone density of both men and women decreases as they age.
   D An average 55-year-old woman has stronger bones than an average 55-year-old man.
2. Which of the following is a function of the skin?
   F eliminates wastes
   G produces vitamin D
   H protects the body against microorganisms
   J all of the above
3. The muscles that you use to lift a book are
   A cardiac muscles.
   B smooth muscles.
   C involuntary muscles.
   D skeletal muscles.
4. Which of the following is *not* an important function of the skeletal system?
   F It protects internal organs.
   G It stores minerals until they are needed by the body.
   H It allows the body to move.
   J It regulates body temperature.
5. Which of the following represents the smallest level of organization in the body?
   A cardiac muscle tissue
   B the heart
   C a muscle cell
   D the circulatory system

Constructed Response

6. Compare the dermis and the epidermis layers of the skin. Discuss the following: their thickness, location, nerves, blood vessels, sweat glands, and cell life cycle.

Chapter

15

Food and Digestion

The BIG Idea

Structure and Function

How does the digestive system obtain nutrients for the body?

Chapter Preview

1 Food and Energy

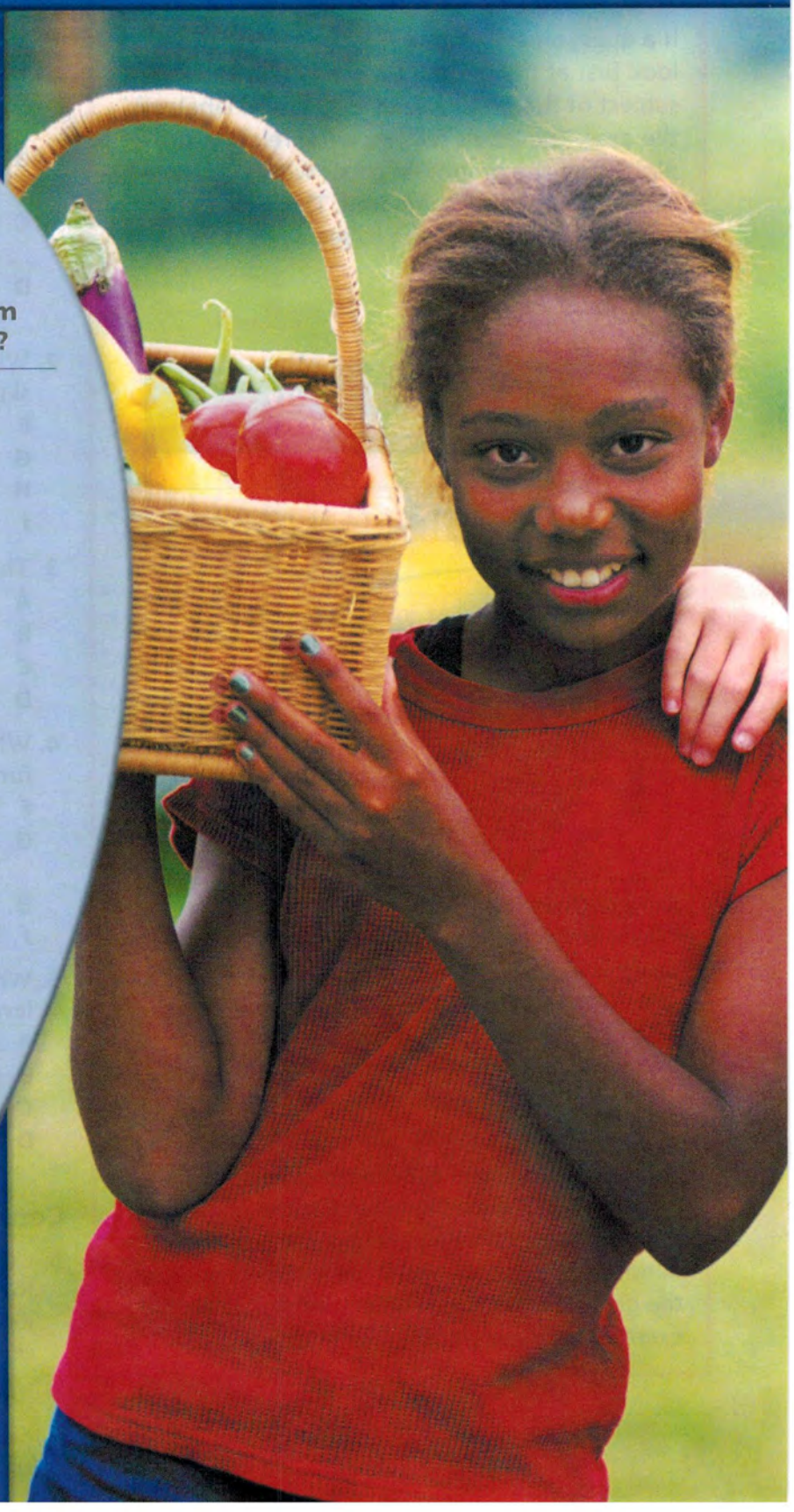
Discover Food Claims—Fact or Fiction?
Skills Activity Predicting
Math Skills Percentage
Active Art Reading a Food Pyramid
Consumer Lab Raisin' the Raisin Question

2 The Digestive Process Begins

Discover How Can You Speed Up Digestion?
Try This Modeling Peristalsis
Analyzing Data Protein Digestion
At-Home Activity First Aid for Choking
Skills Lab As the Stomach Churns

3 Final Digestion and Absorption

Discover Which Surface Is Larger?
Try This Break Up!



Let's eat! These baskets of vegetables offer a wide choice of tasty and healthful foods. ▶

Discovery CHANNEL SCHOOL

Food and Digestion

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

What's for Lunch?

When you're hungry and grab a snack, what do you choose? In this project, you'll take a close look at the foods you select each day.

Your Goal To compare your eating pattern to the recommendations in the USDA MyPyramid Plan

To complete this project successfully, you must

- keep an accurate record of everything you eat and drink for three days
- create graphs to compare your eating pattern with the recommendations of the U.S. Department of Agriculture (USDA)
- make changes in your diet, if needed, during another three-day period

Plan It! Before you begin, study this chapter to understand how foods are grouped. Then, visit the USDA Web site at www.MyPyramid.gov to get your recommended plan. Next, decide how to keep an accurate, complete food log. How will you make sure you record everything you eat and drink? How will you determine serving sizes? After your teacher approves your plan, start keeping your food log.

Food and Energy

Reading Preview

Key Concepts

- Why does your body need food?
- How do the six nutrients needed by the body help carry out essential processes?
- How can food pyramids and food labels help you have a healthy diet?

Key Terms

- nutrient • calorie
- carbohydrate • glucose • fat
- protein • amino acid
- vitamin • mineral
- Percent Daily Value
- Dietary Reference Intakes (DRIs)

Target Reading Skill

Outlining As you read, make an outline about the six groups of nutrients needed by the body. Use the red headings for the main ideas and the blue headings for the supporting ideas.

Food and Energy
I. Why You Need Food
A. Nutrients
B.
II. Carbohydrates
A.

Lab zone Discover Activity

Food Claims—Fact or Fiction?

1. Examine the list of statements at the right. Copy the list onto a separate sheet of paper.
2. Next to each statement, write *agree* or *disagree*. Give a reason for your response.
3. Discuss your responses with a small group of classmates. Compare the reasons you gave for agreeing or disagreeing with each statement.

Fact or Fiction?

a. Athletes need more protein in their diets than other people do.

b. The only salt that a food contains is the salt that you have added to it.

c. As part of a healthy diet, everyone should take vitamin supplements.

Think It Over

Posing Questions List some other statements about nutrition that you have heard. How could you find out whether the statements are true?

Imagine a Thanksgiving dinner. You see roast turkey on a platter, delicious stuffing, lots of vegetables, and pumpkin pie. The dinner includes an abundance of colors and delicious aromas. Food is a central part of many celebrations, of times shared with friends and family. Food is also essential. Every living thing needs food to stay alive.

Why You Need Food

Food provides your body with materials for growing and for repairing tissues. Food also provides energy for everything you do. For example, running, playing a musical instrument, reading, and even sleeping require energy. Food also helps your body maintain homeostasis, or a stable internal environment. By filling your energy needs, food enables your body to keep this balance during all your activities.

Nutrients Your body breaks down the foods you eat into nutrients. **Nutrients** (NOO tree unts) are the substances in food that provide the raw materials and energy the body needs to carry out all its essential processes. There are six groups of nutrients necessary for human health—carbohydrates, fats, proteins, vitamins, minerals, and water.

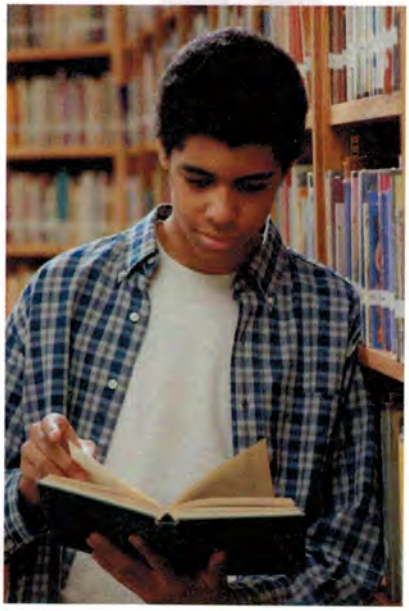
Energy When nutrients are used by the body for energy, the amount of energy they release can be measured in units called calories. One **calorie** is the amount of energy needed to raise the temperature of one gram of water by one degree Celsius. Most foods contain many thousands of calories of energy. Biologists use the term *Calorie,* with a capital *C,* to measure the energy in foods. One Calorie is the same as 1 kilocalorie (kcal) or 1,000 calories. For example, one serving of popcorn may contain 60 Calories (60 kcal), or 60,000 calories, of energy. The more Calories a food has, the more energy it contains.

You need to eat a certain number of Calories each day to meet your body's energy needs. Your daily energy requirement depends on your level of physical activity. Your needs also change as you grow and age. As an infant and child, you grew very rapidly, so you likely had very high energy needs. Your current growth and level of physical activity affect the number of Calories you need now. The more active you are, the greater your energy needs are.

Reading Checkpoint **How is energy in foods measured?**

Playing basketball

Walking



Reading

FIGURE 1
Burning Calories
The number of Calories you burn depends on your weight as well as your level of activity. The more active you are, the more Calories you burn.
Applying Concepts *Which activity do you think burns the most Calories per hour—playing basketball, walking, or reading?*

FIGURE 2

Carbohydrates

Simple carbohydrates, or sugars, are found in fruits, milk, and some vegetables. Sugars are also added to cookies, candies, and soft drinks. Complex carbohydrates are found in rice, corn, pasta, and bread. Fruits, vegetables, nuts, and whole-grain foods also contain fiber.

Applying Concepts *Why is fiber important in the diet?*

Simple Carbohydrates

Brownie (1 square)

Total Carbohydrates	**18 g**
Sugars	10 g
Starches	7 g
Fiber	1 g

Watermelon (1 slice)

Total Carbohydrates	**22 g**
Sugars	18 g
Starches	3 g
Fiber	1 g

Milk (1 cup)

Total Carbohydrates	**12 g**
Sugars	12 g
Starches	0 g
Fiber	0 g

Carbohydrates

The nutrients called **carbohydrates** (kahr boh HY drayts), which are composed of carbon, oxygen, and hydrogen, are a major source of energy. One gram of carbohydrate provides your body with four Calories of energy. **In addition to providing energy, carbohydrates provide the raw materials to make cell parts.** Based on their chemical structure, carbohydrates are divided into simple carbohydrates and complex carbohydrates.

Simple Carbohydrates Simple carbohydrates are also known as sugars. One sugar, **glucose** (GLOO kohs), is the major source of energy for your body's cells. However, most foods do not contain large amounts of glucose. The body converts other types of sugars, such as the sugar found in fruits, into glucose. Glucose is the form of sugar the body can most easily use.

Complex Carbohydrates Complex carbohydrates are made up of many sugar molecules linked together in a chain. Starch is a complex carbohydrate found in foods from plants, such as potatoes, rice, wheat, and corn. To use starch as an energy source, your body first breaks it down into smaller, individual sugar molecules. Only then can your body release the molecules' energy.

Like starch, fiber is a complex carbohydrate found in plants. But unlike starch, fiber cannot be broken down into sugar molecules by your body. Instead, fiber passes through the body and is eliminated.

Complex Carbohydrates

Yellow Corn (1 ear)	
Total Carbohydrates	19 g
Sugars	2 g
Starches	15 g
Fiber	2 g

Pasta (1 cup)	
Total Carbohydrates	40 g
Sugars	1 g
Starches	37 g
Fiber	2 g

Wheat Bread (1 slice)	
Total Carbohydrates	17 g
Sugars	3.5 g
Starches	12.0 g
Fiber	1.5 g

Because your body cannot digest it, fiber is not considered a nutrient. Fiber is an important part of the diet, however, because it helps keep the digestive system functioning properly.

Nutritionists' Recommendations Nutritionists recommend that 45 to 65 percent of the Calories in a diet come from carbohydrates. It is better to eat more complex carbohydrates, such as whole grains, than simple carbohydrates. Foods made with whole grains usually contain a variety of other nutrients. Foods made with a lot of sugar, such as candy and soft drinks, have few valuable nutrients. Also, while sugars can give you a quick burst of energy, starches provide a more even, long-term energy source.

Reading Checkpoint **What are two types of carbohydrates? Give an example of each.**

Fats

Like carbohydrates, **fats** are energy-containing nutrients that are composed of carbon, oxygen, and hydrogen. However, fats contain more than twice the energy of an equal amount of carbohydrates. One gram of fat provides your body with nine Calories of energy. **In addition to providing energy, fats have other important functions. Fats form part of the cell membrane, the structure that forms the boundary of a cell. Fatty tissue protects and supports your internal organs and insulates your body.**

Lab zone Skills Activity

Predicting

You can do a test to see which foods contain starch.

1. Put on your apron.
2. Obtain food samples from your teacher. Predict which ones contain starch. Write down your predictions.
3. Use a plastic dropper to add three drops of iodine to each food sample. **CAUTION:** *Iodine can stain skin and clothing.* Handle it carefully. If the iodine turns blue-black, starch is present.

Which foods contain starch? Were your predictions correct?

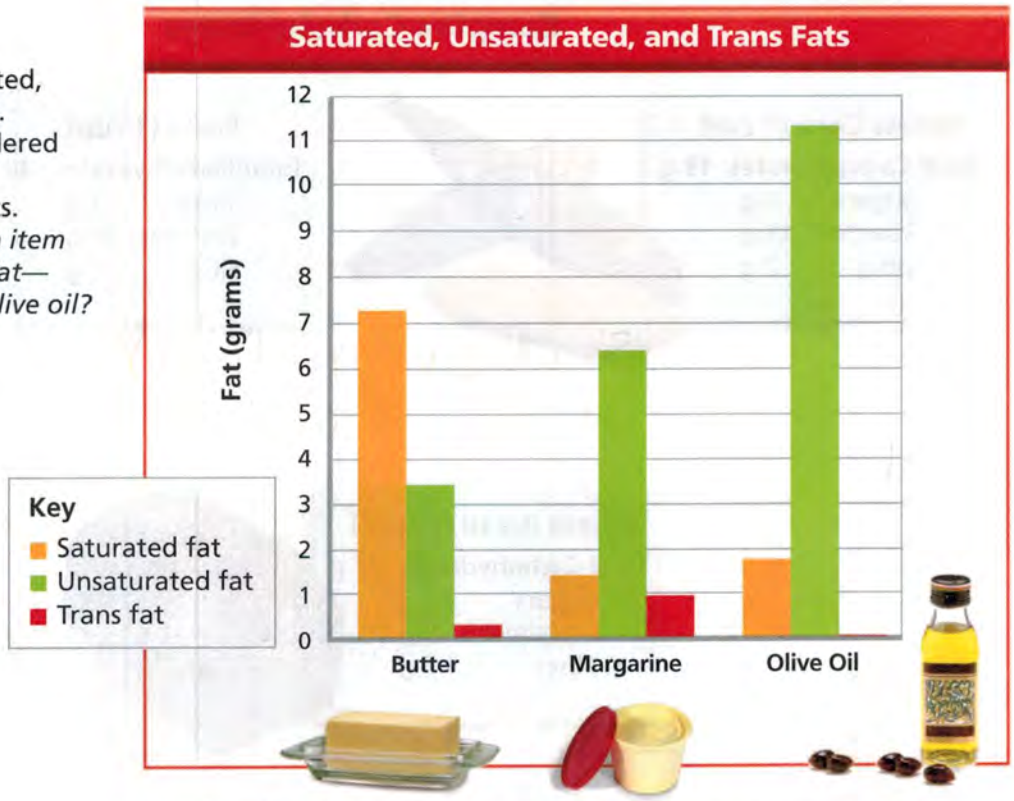


FIGURE 3
Many foods contain saturated, unsaturated, and trans fats. Unsaturated fats are considered to be more healthful than saturated fats and trans fats.
Interpreting Graphs *Which item has the most unsaturated fat—butter, tub margarine, or olive oil?*

Kinds of Fats Fats may be classified as unsaturated or saturated based on their chemical structure. Unsaturated fats are usually liquid at room temperature. Most cooking oils are unsaturated fats. Saturated fats are usually solid at room temperature. Meat and dairy products contain relatively large amounts of saturated fat.

You may have heard about trans fat. Trans fats are made by adding hydrogen to vegetable oils. This allows foods like margarine and chips to stay fresh longer. Compared to unsaturated fats that are beneficial in proper amounts, saturated and trans fats are not. Cities including New York City and Philadelphia have banned the use of trans fats in restaurants.

Cholesterol Cholesterol (kuh LES tur awl) is a waxy, fatlike substance found only in animal products. Like fats, cholesterol is an important part of your body's cells. Your liver can make the cholesterol your body needs, making it an unneccessary part of the diet.

Nutritionists' Recommendations Nutritionists recommend that no more than 30 percent of the Calories eaten each day come from fats. A diet high in fat and cholesterol can lead to a buildup of fatty material in the blood vessels and cause heart disease.

Reading Checkpoint **What is cholesterol?**

FIGURE 4
Complete and Incomplete Proteins Animal products such as meats and eggs contain complete proteins. Incomplete proteins are found in beans, nuts, and grains.

Proteins

Proteins are nutrients that contain nitrogen as well as carbon, hydrogen, and oxygen. **Proteins are needed for tissue growth and repair. They also play an important part in chemical reactions within cells.** Proteins can serve as a source of energy, but they are a less important source of energy than carbohydrates or fats. About 10 to 35 percent of your daily Calorie intake should come from proteins.

Amino Acids Proteins are made up of small units called **amino acids** (uh MEE noh), which are linked together chemically to form large protein molecules. Thousands of different proteins are built from only about 20 different amino acids. Your body can make about half of the amino acids it needs. The others, called essential amino acids, must come from the foods you eat.

Complete and Incomplete Proteins Foods from animal sources, such as meat and eggs, are sources of complete proteins because these foods contain all the essential amino acids. Proteins from plant sources, such as beans, grains, and nuts, are called incomplete proteins because they are missing one or more essential amino acid. Different plant sources lack different amino acids. Therefore, to obtain all the essential amino acids from plant sources alone, people need to eat a wide variety of plant foods.

Reading Checkpoint **What are the units that make up proteins?**

Math Skills

Percentage

A percentage (%) is a ratio that compares a number to 100. For example, 30% means 30 out of 100.

Suppose that a person eats a total of 2,000 Calories in one day. Of those Calories, 300 come from protein. Follow these steps to calculate the percentage of Calories that come from protein.

1. Write the comparison as a fraction:

$$\frac{300}{2{,}000}$$

2. Multiply the fraction by 100% to express it as a percentage:

$$\frac{300}{2{,}000} \times 100\% = 15\%$$

Practice Problem Suppose that 540 Calories of the person's 2,000 Calorie total come from fats. What percentage of the Calories comes from fats?

Go Online
SCILINKS NSTA
For: Links on foods and energy
Visit: www.SciLinks.org
Web code: scn-0421

Vitamins and Minerals

Two kinds of nutrients—vitamins and minerals—are needed by the body in very small amounts. Unlike the other nutrients, vitamins and minerals do not provide the body with energy or raw materials. Instead, they help the body carry out various processes.

Vitamins act as helper molecules in a variety of chemical reactions in the body. Vitamin K, for example, helps your blood to clot when you get a cut or a scrape. Figure 6 lists the vitamins necessary for health. The body can make a few of these vitamins. For example, your skin can make vitamin D when exposed to sunlight. Most vitamins, however, must be obtained from foods.

Fat-Soluble and Water-Soluble Vitamins Vitamins are classified as either fat-soluble or water-soluble. Fat-soluble vitamins dissolve in fat, and they are stored in fatty tissues in the body. Vitamins A, D, E, and K are all fat-soluble vitamins. Water-soluble vitamins dissolve in water and are not stored in the body. This fact makes it especially important to include sources of water-soluble vitamins—vitamin C and all of the B vitamins—in your diet every day.

FIGURE 5
Eat Your Vegetables!
Fresh vegetables are full of vitamins and are fun to pick as well.

Importance of Vitamins Although vitamins are only needed in small amounts, a lack of certain vitamins in the diet can lead to health problems. In the 1700s, sailors on long voyages survived on hard, dry biscuits, salted meat, and not much else. Because of this limited diet, many sailors developed a serious disease called scurvy. People with scurvy suffer from bleeding gums, stiff joints, and sores that do not heal. Some may even die.

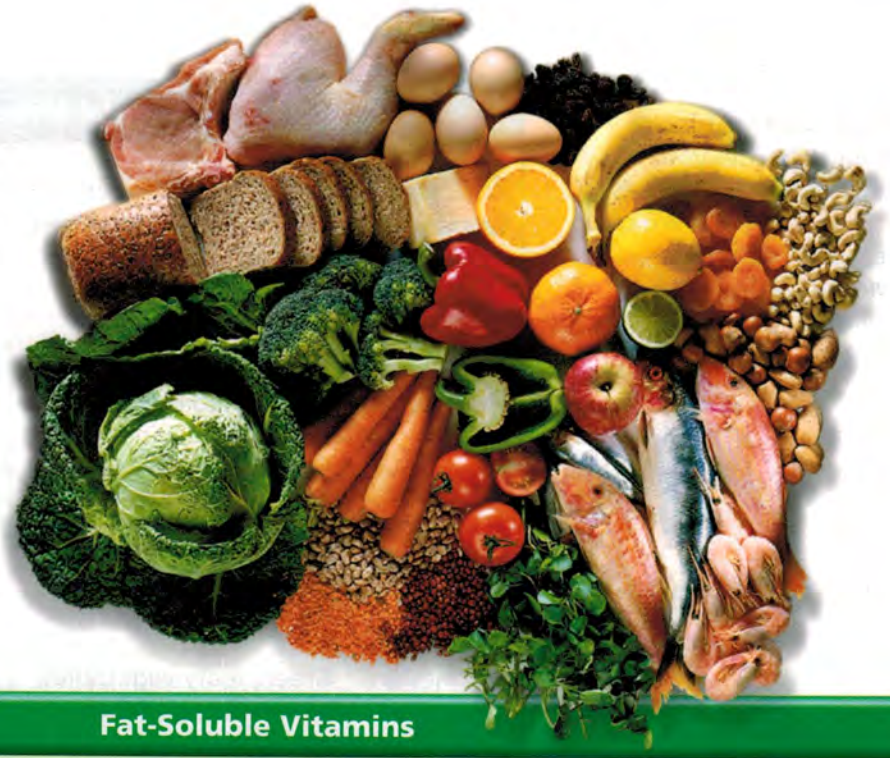
A Scottish doctor, James Lind, hypothesized that scurvy was the result of the sailors' poor diet. Lind divided sailors with scurvy into groups and fed different foods to each group. The sailors who were fed citrus fruits—oranges and lemons—recovered from the disease. Lind recommended that all sailors eat citrus fruits. When Lind's recommendations were carried out, scurvy disappeared. Today scientists know that scurvy is caused by the lack of vitamin C, which is found in citrus fruits.

Reading Checkpoint **List the fat-soluble vitamins.**

FIGURE 6

Essential Vitamins

Both fat-soluble vitamins and water-soluble vitamins are necessary to maintain health.
Interpreting Tables *What foods provide a supply of both vitamins E and K?*



Fat-Soluble Vitamins

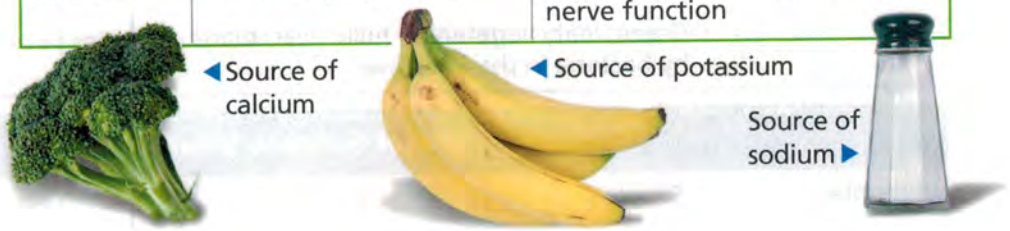
Vitamin	Sources	Function
A	Dairy products; eggs; liver; yellow, orange, and dark green vegetables; fruits	Maintains healthy skin, bones, teeth, and hair; aids vision in dim light
D	Fortified dairy products; fish; eggs; liver; made by skin cells in presence of sunlight	Maintains bones and teeth; helps in the use of calcium and phosphorus
E	Vegetable oils; margarine; green, leafy vegetables; whole-grain foods; seeds; nuts	Aids in maintenance of red blood cells
K	Green, leafy vegetables; milk; liver; made by bacteria in the intestines	Aids in blood clotting

Water-Soluble Vitamins

Vitamin	Sources	Function
B1 (thiamin)	Pork; liver; whole-grain foods; legumes; nuts	Needed for breakdown of carbohydrates
B2 (riboflavin)	Dairy products; eggs; whole-grain breads and cereals; green, leafy vegetables	Needed for normal growth
B3 (niacin)	Many protein-rich foods; milk; eggs; meat; fish; whole-grain foods; nuts; peanut butter	Needed for release of energy
B6 (pyridoxine)	Green, leafy vegetables; meats; fish; legumes; fruits; whole-grain foods	Helps in the breakdown of proteins, fats, and carbohydrates
B12	Meats; fish; poultry; dairy products; eggs	Maintains healthy nervous system; needed for red blood cell formation
Biotin	Liver; meat; fish; eggs; legumes; bananas; melons	Aids in the release of energy
Folic acid	Green, leafy vegetables; legumes; seeds; liver	Needed for red blood cell formation
Pantothenic acid	Liver; meats; fish; eggs; whole-grain foods	Needed for the release of energy
C	Citrus fruits; tomatoes; potatoes; dark green vegetables; mangoes	Needed to form connective tissue and fight infection

FIGURE 7
Eating a variety of foods each day provides your body with the minerals it needs.
Interpreting Tables *Which minerals play a role in regulating water levels in the body?*

Essential Minerals		
Mineral	**Sources**	**Function**
Calcium	Milk; cheese; dark green, leafy vegetables; tofu; legumes	Helps build bones and teeth; aids in blood clotting; muscle and nerve function
Chlorine	Table salt; soy sauce	Helps maintain water balance
Fluorine	Fluoridated drinking water; fish	Helps form bones and teeth
Iodine	Seafood, iodized salt	Helps in the release of energy
Iron	Red meats; seafood; green, leafy vegetables; legumes; dried fruits	Needed for red blood cell function
Magnesium	Green, leafy vegetables; legumes; nuts; whole-grain foods	Aids in muscle and nerve function; helps in the release of energy
Phosphorus	Meat; poultry; eggs; fish; dairy products	Helps produce healthy bones and teeth; helps in the release of energy
Potassium	Grains; fruits; vegetables; meat; fish	Helps maintain water balance; muscle and nerve function
Sodium	Table salt; soy sauce	Helps maintain water balance; nerve function



Importance of Minerals Nutrients that are not made by living things are called **minerals.** Minerals are present in soil and are absorbed by plants through their roots. You obtain minerals by eating plant foods or animals that have eaten plants. Figure 7 lists some minerals you need. You probably know that calcium is needed for strong bones and teeth. Iron is needed for the proper functioning of red blood cells.

Both vitamins and minerals are needed by your body in small amounts to carry out chemical processes. If you eat a wide variety of foods, you probably will get enough vitamins and minerals. Most people who eat a balanced diet do not need to take vitamin or mineral supplements.

Reading Checkpoint **What are minerals?**

FIGURE 8
Water—An Essential Nutrient
All living things need water. Without regular water intake, an organism would not be able to carry out the processes that keep it alive.

Water

Imagine that a boat is sinking. The people on board are getting into a lifeboat. They have room for only one of these items: a bag of fruit, a can of meat, a loaf of bread, or a jug of water. Which item should they choose?

You might be surprised to learn that the lifeboat passengers should choose the water. Although people can probably survive for weeks without food, they will die within days without fresh water. Water is the most abundant substance in the body. It accounts for about 65 percent of the average person's body weight.

Water is the most important nutrient because the body's vital processes—including chemical reactions such as the breakdown of nutrients—take place in water. All the cells in your body are composed mostly of water. Water makes up most of the body's fluids, including blood. Nutrients and other important substances are carried throughout the body dissolved in the watery part of the blood. The water in blood also carries waste materials that must be removed from your body.

On a hot day or after exercising, your body produces perspiration, or sweat. Perspiration consists of chemicals dissolved in water. The water in perspiration comes from body tissues. Sweat glands in your skin release the water on the surface of your body. Perspiration helps regulate body temperature by cooling the body. Some waste chemicals are dissolved in perspiration. Therefore, when you perspire, you are also removing wastes.

Under normal conditions, you need to take in about 2 liters of water every day. When you perspire a lot, you need more water. You can obtain water by drinking water and other beverages. In addition, you take in water when you eat foods that contain a lot of water. Fruits and vegetables such as melons and tomatoes have a large amount of water.

Reading Checkpoint **What is the most abundant substance in the body?**

Guidelines for a Healthy Diet

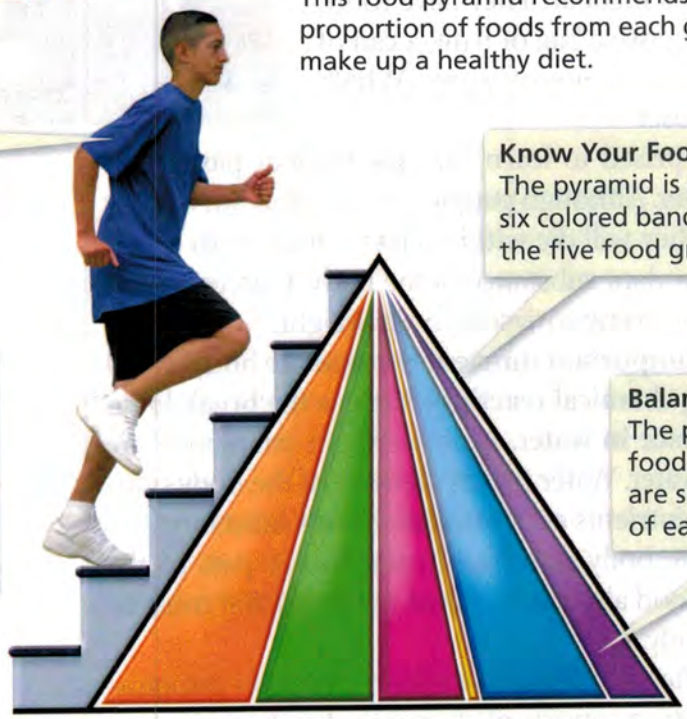
In 2005, the United States Department of Agriculture (USDA) introduced a new set of guidelines to promote healthy eating and physical activity. **The USDA guidelines provide a personalized way to help people make healthy food choices based on their age, sex, and amount of physical activity.** You can get more information about the USDA dietary guidelines by visiting its Web site on the Internet.

Go Online
active art

For: Reading a Food Pyramid activity
Visit: PHSchool.com
Web Code: cep-4022

FIGURE 9
Reading a Food Pyramid

This food pyramid recommends the proportion of foods from each group that make up a healthy diet.



Stay Active
Daily physical activity is an important part to staying healthy.

Know Your Food Groups
The pyramid is divided into six colored bands, representing the five food groups, plus oils.

Know Your Calorie Needs
Depending on physical activity, a 13-year-old girl needs 1600–2200 Calories per day. A 13-year-old boy needs 1800–2400 Calories per day.

Balance Your Diet
The proportions of each food group you need daily are shown by the width of each band.

GRAINS	VEGETABLES	FRUITS	OILS	MILK	MEAT & BEANS
Make half the grains you eat whole grains.	Vary your vegetables. Include dark green and orange veggies more often.	Eat a variety of fruits. Limit juices and canned fruits with added sugar.	Limit solid fats. Choose oils from plant sources most often.	Get plenty of calcium-rich foods. Eat mostly low-fat dairy products.	Vary your protein sources. Choose lean meats and poultry. Eat more fish, beans, and nuts.
For a 2,000-Calorie diet, you need to eat the amounts shown below from each food group every day. To find the amounts that are right for you, go to **MyPyramid.gov.**					
6 ounces	2 cups	2 cups	6 teaspoons	3 cups	5½ ounces

Food Labels

After a long day, you and your friends stop into a store on your way home from school. What snack should you buy? How can you make a wise choice? One thing you can do is to read the information provided on food labels. **Food labels allow you to evaluate a single food as well as to compare the nutritional value of two different foods.**

How to Read a Food Label Figure 10 shows a food label that might appear on a box of cereal. Refer to that label as you read about some of the important nutritional information it contains.

1 Serving Size This information tells you the size of a single serving and the number of servings in the container. The information on the rest of the label is based on serving size. If you eat twice the serving size, then you'll consume twice the number of Calories.

2 Calories This information tells you how much energy you get from one serving of this food, including how many Calories come from fat.

3 Percent Daily Value The **Percent Daily Value** shows you how the nutritional content of one serving fits into the recommended diet for a person who consumes 2,000 Calories per day. For example, one serving of this cereal contains 12% of the total amount of sodium a person should consume in one day. You might eat more or less than 2,000 Calories per day. But, you can still use this percentage as a general guide.

4 Ingredients The ingredients are listed in order by weight, starting with the main ingredient. The list can alert you to substances that have been added to a food to improve its flavor or color, or to keep it from spoiling. In addition, reading ingredients lists can help you avoid substances that make you ill.

Using Food Labels Food labels can help you make healthful food choices. Suppose you are shopping for breakfast cereals. By reading the labels, you might find that one cereal contains little fat and a high percentage of the Daily Values for complex carbohydrates and several vitamins. Another cereal might have fewer complex carbohydrates and vitamins, and contain significant amounts of fat. You can see that the first cereal would be a better choice as a regular breakfast food.

FIGURE 10
Food Label
By law, specific nutritional information must be listed on food labels.
Calculating *How many servings of this product would you have to eat to get 90% of the Daily Value for iron?*

FIGURE 11
Reading Food Labels
Food labels allow you to compare the nutritional content of similar kinds of foods.

Dietary Reference Intakes Food labels can also help you monitor the nutrients in your diet. Guidelines that show the amounts of nutrients that are needed every day are known as **Dietary Reference Intakes (DRIs).** For example, the DRIs for vitamins recommend that people your age get 45 milligrams of vitamin C every day.

DRIs also show how the Calories that people eat each day should be split among carbohydrates, fats, and proteins. The Percent Daily Values listed on food labels can help you make sure that you are meeting the DRIs for different nutrients.

Reading Checkpoint **What are Dietary Reference Intakes?**

Section 1 Assessment

Target Reading Skill **Outlining** Use the information in your outline about nutrients to help you answer the questions below.

Reviewing Key Concepts

1. a. **Identifying** Name two ways in which foods are used by the body.
   b. **Defining** What is a calorie? How does it relate to the amount of energy in foods?
   c. **Inferring** Why do young children and active teenagers have high energy needs?
2. a. **Listing** List the six nutrients that are needed by the body.
   b. **Summarizing** For each nutrient you listed, briefly describe the role it plays in the body.
   c. **Applying Concepts** Why is it especially important that vegetarians eat a varied diet?
3. a. **Reviewing** What kinds of information are found in food pyramids and on food labels?
   b. **Applying Concepts** How can you use this information to plan a healthy meal?

Math Practice

4. **Percentage** Suppose that a person eats 2,500 Calories in one day. Of those Calories, 1,200 are from carbohydrates, 875 are from fat, and the rest are from protein. What percentages of the person's Calories are from carbohydrates, from fats, and from proteins?

Lab zone **Consumer Lab**

Raisin' the Raisin Question

Problem

Raisins are a good source of the mineral iron. Which raisin bran cereal contains the most raisins?

Skills Focus

measuring, calculating, controlling variables

Materials

- balance
- paper towels
- beaker (250 mL)
- raisin bran cereals (several brands)

Procedure

1. Use a balance to find the mass of a clean 250-mL beaker. Record the mass in a data table like the one below.
2. Fill the beaker to the top with one of the brands of raisin bran cereal, but do not pack down the cereal. **CAUTION:** *Do not put any cereal in your mouth.* Write the brand name in the data table. Measure and record the mass of the beaker plus cereal. Subtract the mass of the empty beaker to get the mass of the cereal alone. Record the result.
3. Pour the cereal onto a paper towel. Separate the raisins from the bran and place the raisins back in the beaker. Measure and record the mass of the beaker plus raisins. Subtract the mass of the empty beaker to get the mass of the raisins alone. Record the result.
4. Repeat Steps 1–3 with each of the other brands of cereal.

Analyze and Conclude

1. **Measuring** Why did you first measure the mass of an empty beaker and then the mass of the beaker plus cereal?
2. **Calculating** Calculate the percentage mass of raisins in each cereal as follows:

$$\%\ \text{Mass of raisins} = \frac{\text{Mass of raisins}}{\text{Mass of cereal}} \times 100\,\%$$

   Record the results in your data table.
3. **Interpreting Data** Based on your observations, which brand of cereal had the greatest percentage of raisins by mass?
4. **Controlling Variables** Was it important that all of the cereal samples were collected in the same-size beaker? Why or why not?
5. **Communicating** Based on your results, write a paragraph that could be printed on a box of raisin bran cereal that would help consumers understand that this brand is the best source of iron.

Design an Experiment

In this investigation, you examined a *sample* of cereal rather than the contents of the entire box. Scientists often use samples because it is a more practical way to make observations. Redesign this experiment to improve upon the sampling technique and increase the accuracy of your results. *Obtain your teacher's permission before carrying out your investigation.*

Data Table

Cereal Brand	Mass (g)					Percentage Mass of Raisins (%)
	Empty Beaker	Beaker plus Cereal	Cereal	Beaker plus Raisins	Raisins	

Section 2

The Digestive Process Begins

Reading Preview

Key Concepts

- What functions are carried out in the digestive system?
- What roles do the mouth, esophagus, and stomach play in digestion?

Key Terms

- digestion • absorption
- saliva • enzyme • epiglottis
- esophagus • mucus
- peristalsis • stomach

Target Reading Skill

Using Prior Knowledge Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about the digestive system in a graphic organizer like the one below. As you read, continue to write in what you learn.

What You Know
1. Food is digested in the stomach. 2.

What You Learned
1. 2.

Lab zone

Discover Activity

How Can You Speed Up Digestion?

1. Obtain two plastic jars with lids. Fill the jars with equal amounts of water at the same temperature.
2. Place a whole sugar cube into one jar. Place a crushed sugar cube into the other jar.
3. Fasten the lids on the jars. Holding one jar in each hand, shake the two jars gently and for equal amounts of time.
4. Place the jars on a flat surface. Observe whether the whole cube or the crushed cube dissolves faster.

Think It Over

Predicting Use the results of this activity to predict which would take longer to digest: a large piece of food or one that has been cut up into many small pieces. Explain your answer.

In 1822, a man named Alexis St. Martin was wounded in the stomach. Dr. William Beaumont saved St. Martin's life. The wound, however, left an opening in St. Martin's stomach that never healed completely. Beaumont realized that by looking through the opening in St. Martin's abdomen, he could observe what was happening inside the stomach.

Beaumont observed that food changed chemically inside the stomach. He hypothesized that chemical reactions in the stomach broke down foods into smaller particles. Beaumont removed liquid from St. Martin's stomach and analyzed it. The stomach liquid contained an acid that played a role in the breakdown of foods into simpler substances.

Functions of the Digestive System

Beaumont's observations helped scientists understand the role of the stomach in the digestive system. **The digestive system has three main functions. First, it breaks down food into molecules the body can use. Then, the molecules are absorbed into the blood and carried throughout the body. Finally, wastes are eliminated from the body.** Figure 12 shows the organs of the digestive system, which is about 9 meters long from beginning to end.

Digestion The process by which your body breaks down food into small nutrient molecules is called **digestion.** There are two kinds of digestion—mechanical and chemical. In mechanical digestion, foods are physically broken down into smaller pieces. Mechanical digestion occurs when you bite into a sandwich and chew it into small pieces.

In chemical digestion, chemicals produced by the body break foods into their smaller chemical building blocks. For example, the starch in bread is broken down into individual sugar molecules.

Absorption and Elimination After your food is digested, the molecules are ready to be transported throughout your body. **Absorption** (ab SAWRP shun) is the process by which nutrient molecules pass through the wall of your digestive system into your blood. Materials that are not absorbed, such as fiber, are eliminated from the body as wastes.

Reading Checkpoint **What is chemical digestion?**

Go Online
SCILINKS NSTA
For: Links on digestion
Visit: www.SciLinks.org
Web Code: scn-0423

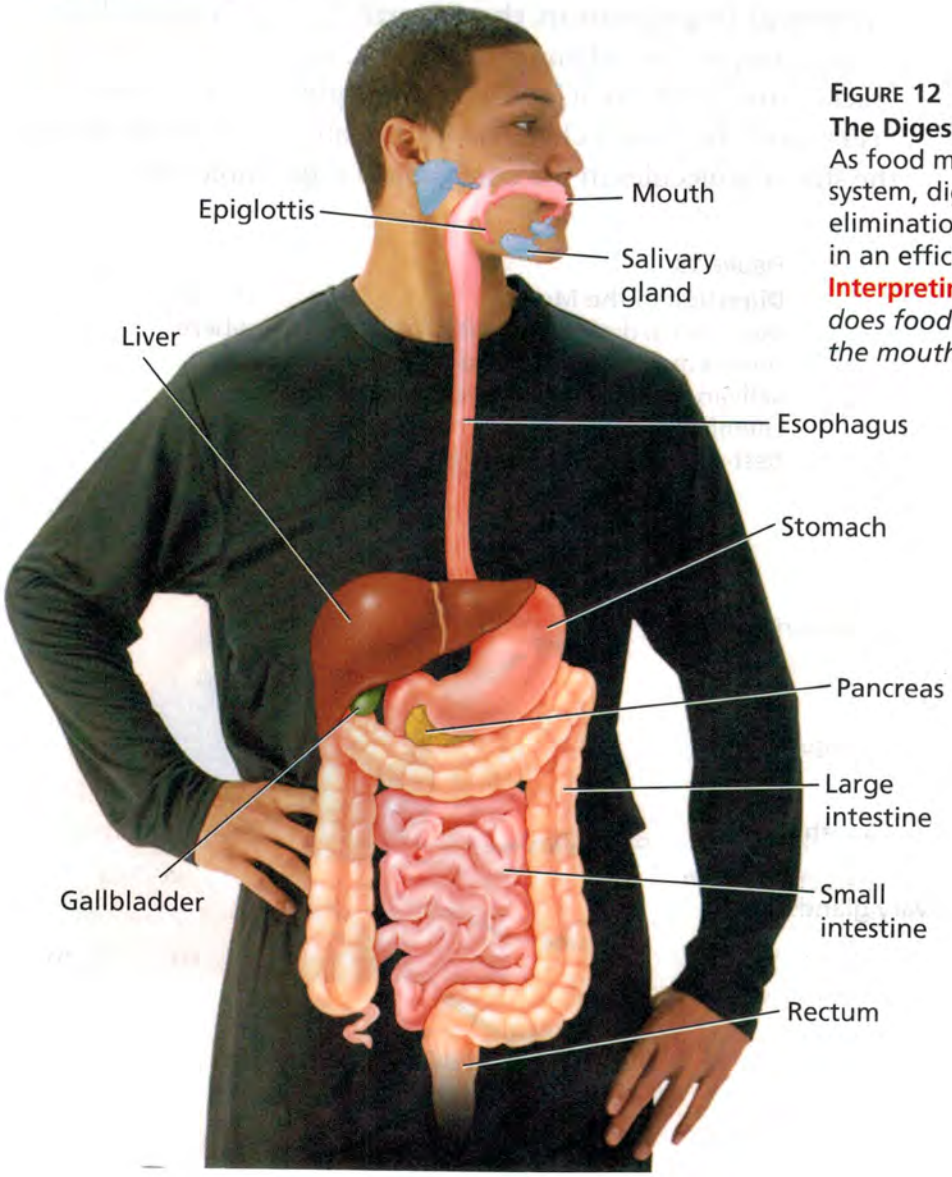


FIGURE 12
The Digestive System
As food moves through the digestive system, digestion, absorption, and elimination occur one after the other in an efficient, continuous process.
Interpreting Diagrams *Which organs does food pass through after leaving the mouth?*

The Mouth

Have you ever walked past a bakery or restaurant and noticed your mouth watering? Smelling or even just thinking about food when you're hungry is enough to start your mouth watering. This response isn't accidental. When your mouth waters, your body is preparing for the delicious meal it expects. **Both mechanical and chemical digestion begin in the mouth.** The fluid released when your mouth waters is **saliva** (suh LY vuh). Saliva plays an important role in both kinds of digestion.

Mechanical Digestion in the Mouth Your teeth carry out the first stage of mechanical digestion. Your center teeth, or incisors (in SY zurz), cut the food into bite-sized pieces. On either side of the incisors there are sharp, pointy teeth called canines (KAY nynz). These teeth tear and slash the food into smaller pieces. Behind the canines are the premolars and molars, which crush and grind the food. As the teeth do their work, saliva moistens the pieces of food into one slippery mass.

Chemical Digestion in the Mouth As mechanical digestion begins, so does chemical digestion. If you take a bite of a cracker and suck on it, the cracker begins to taste sweet. It tastes sweet because a chemical in the saliva has broken down the starch molecules in the cracker into sugar molecules.

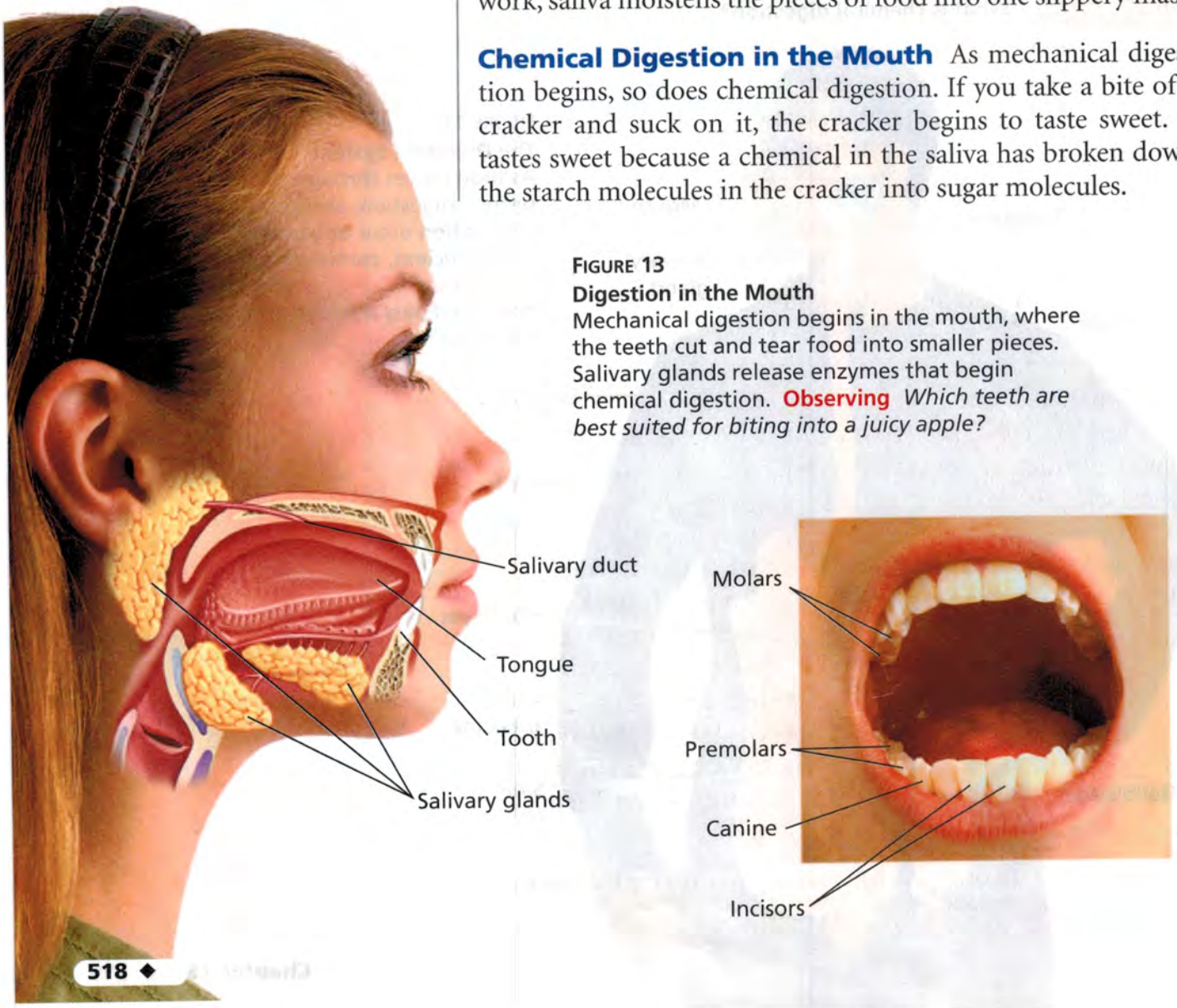
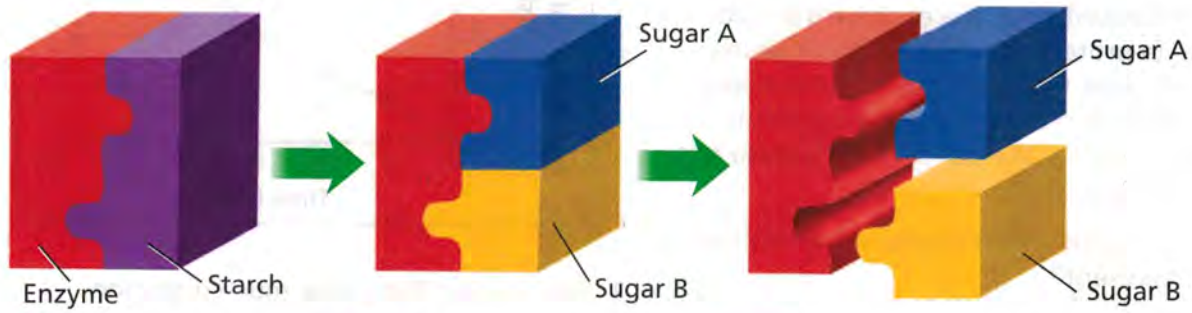


FIGURE 13
Digestion in the Mouth
Mechanical digestion begins in the mouth, where the teeth cut and tear food into smaller pieces. Salivary glands release enzymes that begin chemical digestion. **Observing** *Which teeth are best suited for biting into a juicy apple?*

FIGURE 14
How Enzymes Work
The shape of an enzyme molecule is specific to the shape of the food molecule it breaks down. Here, an enzyme breaks down a starch into sugars.



1. The shape of the enzyme fits the starch molecule.
2. A chemical reaction occurs between the enzyme and starch molecule.
3. The starch molecule has been broken down into sugar molecules.

The chemical in saliva that digests starch is an enzyme. **Enzymes** are proteins that speed up chemical reactions in the body. Your body produces many different enzymes. Each enzyme has a specific chemical shape. Its shape enables it to take part in only one kind of chemical reaction. An example of enzyme action is shown in Figure 14.

The Esophagus

If you've ever choked on food, your food may have "gone down the wrong way." That's because there are two openings at the back of your mouth. One opening leads to your windpipe, which carries air into your lungs. As you swallow, a flap of tissue called the **epiglottis** (ep uh GLAHT is) seals off your windpipe, preventing the food from entering. The food goes into the **esophagus** (ih SAHF uh gus), a muscular tube that connects the mouth to the stomach. The esophagus is lined with **mucus,** a thick, slippery substance produced by the body. Mucus makes food easier to swallow and move along.

Food remains in the esophagus for only about 10 seconds. **After food enters the esophagus, contractions of smooth muscles push the food toward the stomach.** These involuntary waves of muscle contraction are called **peristalsis** (pehr ih STAWL sis). Peristalsis also occurs in the stomach and farther down the digestive system. These muscular waves keep food moving in one direction.

Reading Checkpoint **How is food prevented from entering the windpipe?**

Lab zone Try This Activity

Modeling Peristalsis

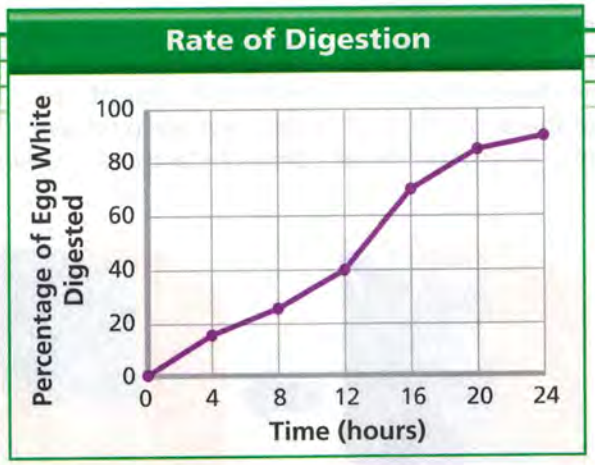
1. Obtain a clear, flexible plastic straw.
2. Hold the straw vertically and insert a small bead into the top of the straw. The bead should fit snugly into the straw. **CAUTION:** *Do not put the straw in your mouth or blow into the straw.*
3. Pinch the straw above the bead so the bead begins to move down the length of the tubing.
4. Repeat Step 3 until the bead exits the straw.

Making Models How does this action compare with peristalsis? What do the bead and the straw represent?

Math Analyzing Data

Protein Digestion

A scientist performed an experiment to determine the amount of time needed to digest protein. He placed small pieces of hard-boiled egg white (a protein) in a test tube containing hydrochloric acid, water, and the enzyme pepsin. He measured the rate at which the egg white was digested over a 24-hour period. His data are recorded in the graph.



1. **Reading Graphs** What do the values on the *y*-axis represent?
2. **Interpreting Data** After about how many hours would you estimate that half of the protein was digested?
3. **Interpreting Data** How much digestion occurred in 16 hours?
4. **Drawing Conclusions** During which 4-hour period did the most digestion take place?

The Stomach

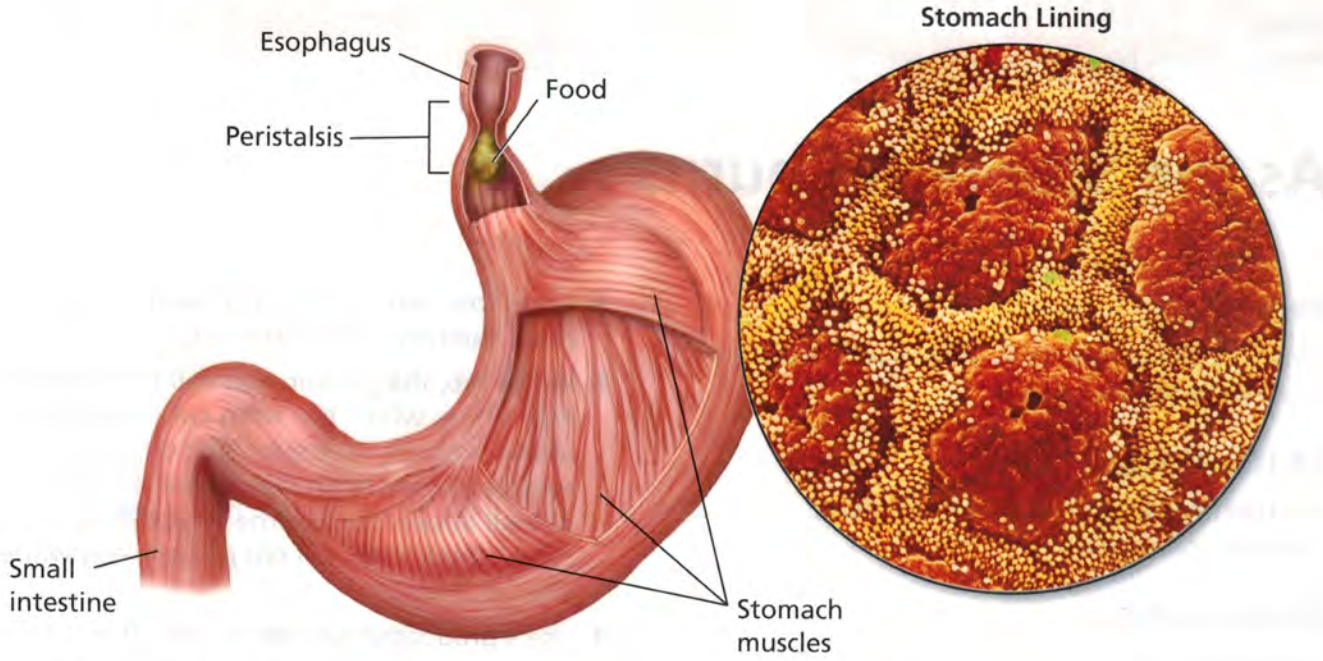
When food leaves the esophagus, it enters the **stomach,** a J-shaped, muscular pouch located in the abdomen. As you eat, your stomach expands to hold all of the food that you swallow. **Most mechanical digestion and some chemical digestion occur in the stomach.**

Mechanical Digestion in the Stomach The process of mechanical digestion occurs as three strong layers of smooth muscle contract to produce a churning motion. This action mixes the food with fluids in somewhat the same way that clothes and soapy water are mixed in a washing machine.

Chemical Digestion in the Stomach Chemical digestion occurs as the churning food makes contact with digestive juice, a fluid produced by cells in the lining of the stomach. Digestive juice contains the enzyme pepsin. Pepsin chemically digests the proteins in your food, breaking them down into short chains of amino acids.

Digestive juice also contains hydrochloric acid, a very strong acid. Without this strong acid, your stomach could not function properly. First, pepsin works best in an acid environment. Second, the acid kills many bacteria that you swallow with your food.

Why doesn't stomach acid burn a hole in your stomach? The reason is that cells in the stomach lining produce a thick coating of mucus, which protects the stomach lining. Also, the cells that line the stomach are quickly replaced as they are damaged or worn out.



Food remains in the stomach until all of the solid material has been broken down into liquid form. A few hours after you finish eating, the stomach completes mechanical digestion of the food. By that time, most of the proteins have been chemically digested into shorter chains of amino acids. The food, now a thick liquid, is released into the next part of the digestive system. That is where final chemical digestion and absorption will take place.

Reading Checkpoint **What is pepsin?**

FIGURE 15
The Stomach
The stomach has three layers of muscle that help to break down foods mechanically. The inset photo shows a microscopic view of the stomach lining. The yellow dots are mucus.
Relating Cause and Effect *What role does mucus play inside the stomach?*

Section 2 Assessment

Target Reading Skill **Using Prior Knowledge** Review your graphic organizer and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. a. **Listing** What are the functions of the digestive system?
   b. **Comparing and Contrasting** Distinguish between mechanical and chemical digestion.
   c. **Inferring** Why must mechanical digestion start before chemical digestion?
2. a. **Reviewing** What key chemicals do the mouth and stomach contain?
   b. **Describing** How do pepsin and hydrochloric acid work together to digest food in the stomach?
   c. **Predicting** What could happen if your stomach didn't produce enough mucus? Explain.

Lab zone At-Home Activity

First Aid for Choking Explain to your family what happens when people choke on food. With your family, find out how to recognize when a person is choking and what to do to help the person. Learn about the Heimlich maneuver and how it is used to help someone who is choking.

Lab zone Skills Lab

As the Stomach Churns

Problem

What conditions are needed for the digestion of proteins in the stomach?

Skills Focus

interpreting data, controlling variables, drawing conclusions

Materials

- test-tube rack
- pepsin
- water
- 4 strips blue litmus paper
- cubes of boiled egg white
- 10-mL plastic graduated cylinder
- 4 test tubes with stoppers
- marking pencil
- diluted hydrochloric acid
- plastic stirrers

Procedure

1. In this lab, you will investigate how acidic conditions affect protein digestion. Read over the entire lab to see what materials you will be testing. Write a prediction stating which conditions you think will speed up protein digestion. Then, copy the data table into your notebook.
2. Label four test tubes A, B, C, and D, and place them in a test-tube rack.
3. In this lab, the protein you will test is boiled egg white, which has been cut into cubes about 1 cm on each side. Add 3 cubes to each test tube. Note and record the size and overall appearance of the cubes in each test tube. **CAUTION:** *Do not put any egg white into your mouth.*
4. Use a graduated cylinder to add 10 mL of the enzyme pepsin to test tube A. Observe the egg white cubes to determine whether an immediate reaction takes place. Record your observations under Day 1 in your data table. If no changes occur, write "no immediate reaction."
5. Use a clean graduated cylinder to add 5 mL of pepsin to test tube B. Then rinse out the graduated cylinder and add 5 mL of water to test tube B. Observe whether or not an immediate reaction takes place.
6. Use a clean graduated cylinder to add 10 mL of hydrochloric acid to test tube C. Observe whether or not an immediate reaction takes place. **CAUTION:** *Hydrochloric acid can burn skin and clothing. Avoid direct contact with it. Wash any splashes or spills with plenty of water, and notify your teacher.*

Data Table

Test Tube	Egg White Appearance		Litmus Color	
	Day 1	Day 2	Day 1	Day 2
A				
B				
C				
D				

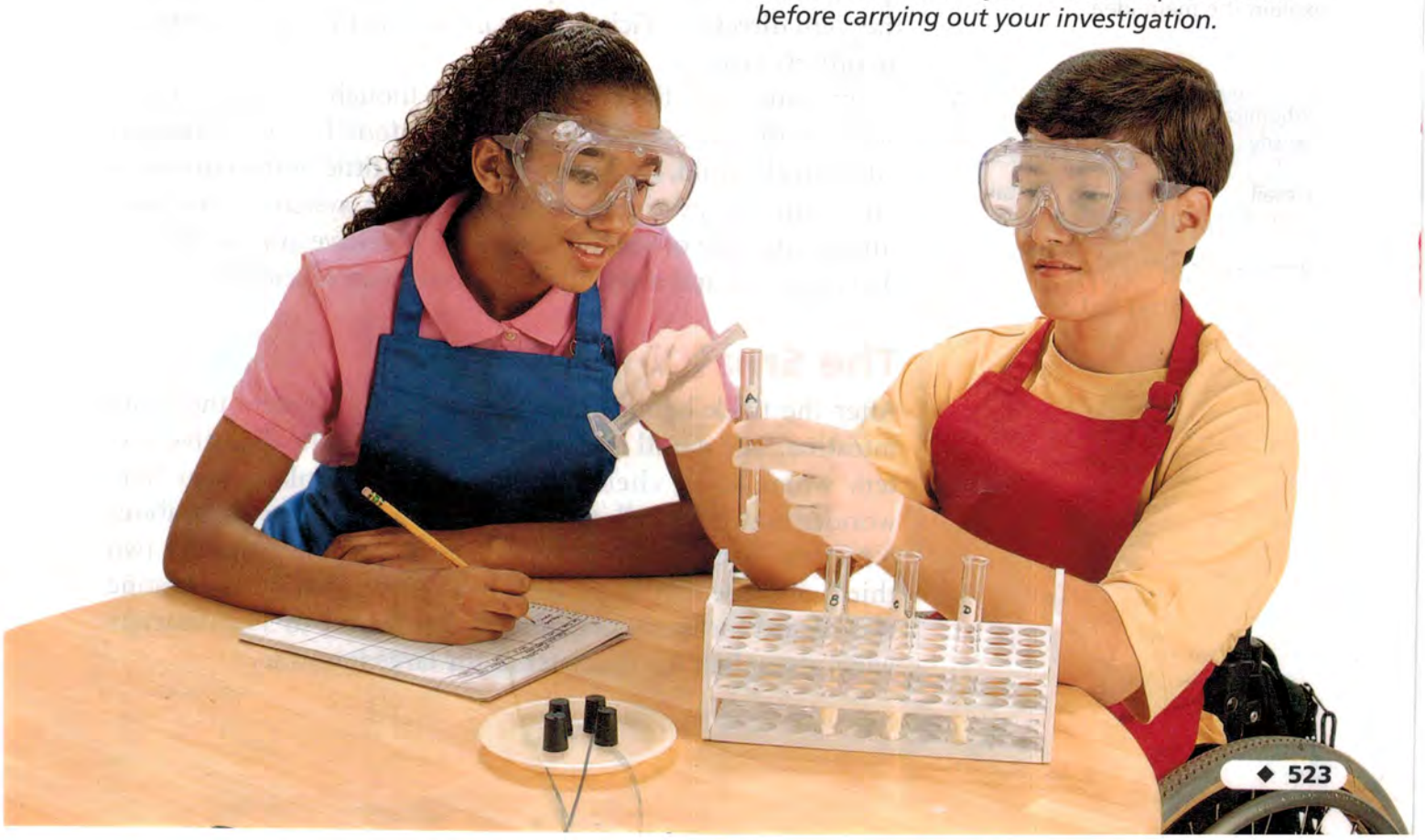
7. Use a clean graduated cylinder to add 5 mL of pepsin to test tube D. Then, rinse the graduated cylinder and add 5 mL of hydrochloric acid to test tube D. Observe whether or not an immediate reaction takes place. Record your observations.
8. Obtain four strips of blue litmus paper. (Blue litmus paper turns pink in the presence of an acid.) Dip a clean plastic stirrer into the solution in each test tube, and then touch the stirrer to a piece of litmus paper. Observe what happens to the litmus paper. Record your observations.
9. Insert stoppers in the four test tubes and store the test tube rack as directed by your teacher.
10. The next day, examine the contents of each test tube. Note any changes in the size and overall appearance of the egg white cubes. Then, test each solution with litmus paper. Record your observations in your data table.

Analyze and Conclude

1. **Interpreting Data** Which materials were the best at digesting the egg white? What observations enabled you to determine this?
2. **Inferring** Is the chemical digestion of protein in food a fast or a slow reaction? Explain.
3. **Controlling Variables** Why was it important that the cubes of egg white all be about the same size?
4. **Drawing Conclusions** What did this lab show about the ability of pepsin to digest protein?
5. **Communicating** Write a paragraph in which you describe the purpose of test tube A and test tube C as they relate to the steps you followed in the procedure.

Design an Experiment

Design a way to test whether protein digestion is affected by the size of the food pieces. Write down your hypothesis and the procedure you will follow. *Obtain your teacher's permission before carrying out your investigation.*



Section 3

Final Digestion and Absorption

Reading Preview

Key Concepts

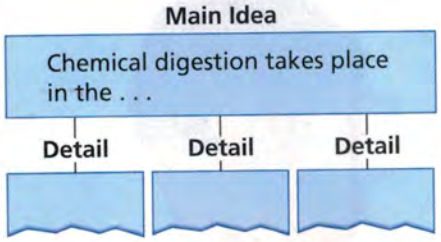
- What digestive processes occur in the small intestine, and how are other digestive organs involved?
- What role does the large intestine play in digestion?

Key Terms

- small intestine • liver • bile
- gallbladder • pancreas
- villus • large intestine
- rectum • anus

Target Reading Skill

Identifying Main Ideas As you read the section titled The Small Intestine, write the main idea in a graphic organizer like the one below. Then, write three supporting details that further explain the main idea.



Lab zone Discover Activity

Which Surface Is Larger?

1. Work with a partner to carry out this investigation.
2. Begin by placing your hand palm-side down on a table. Keep your thumb and fingers tightly together. Lay string along the outline of your hand. Have your partner help you determine how long a string you need to outline your hand.
3. Use a metric ruler to measure the length of that string.

Think It Over

Predicting How long would you expect your hand outline to be if you spread out your thumb and fingers? Use string to test your prediction. Compare the two string lengths.

Have you ever been part of a huge crowd attending a concert or sports event? Barriers and passageways often guide people in the right direction. Ticket takers make sure that people enter in an orderly fashion.

In some ways, the stomach can be thought of as the "ticket taker" of the digestive system. Once the food has been changed into a thick liquid, the stomach releases a little of the liquid at a time into the next part of the digestive system. This slow, smooth passage of food through the digestive system ensures that digestion and absorption can take place efficiently.

The Small Intestine

After the thick liquid leaves the stomach, it enters the small intestine. The **small intestine** is the part of the digestive system where most chemical digestion takes place. You may wonder how the small intestine got its name. After all, at about 6 meters—longer than some full-sized cars—it makes up two thirds of the length of the digestive system. The small intestine was named for its small diameter. It is from 2 to 3 centimeters wide, about half the diameter of the large intestine.

When food reaches the small intestine, it has already been mechanically digested into a thick liquid. But chemical digestion has just begun. Starches and proteins have been partially broken down, but fats haven't been digested at all. **Almost all chemical digestion and absorption of nutrients takes place in the small intestine.** As the liquid moves into the small intestine, it mixes with enzymes and secretions that are produced by the small intestine, the liver, and the pancreas. The liver and the pancreas deliver their substances to the small intestine through small tubes.

The Liver As you can see in Figure 16, the **liver** is located in the upper right portion of the abdomen. It is the largest organ inside the body. The liver is like an extremely busy chemical factory and plays a role in many body processes. For example, it breaks down medicines, and it helps eliminate nitrogen from the body. **The role of the liver in the digestive system is to produce bile.**

Bile is a substance that breaks up fat particles. Bile flows from the liver into the **gallbladder,** the organ that stores bile. After you eat, bile passes through a tube from the gallbladder into the small intestine.

Bile is not an enzyme. It does not chemically digest foods. It does, however, physically break up large fat particles into smaller fat droplets. You can compare the action of bile on fats with the action of soap on a greasy frying pan. Soap physically breaks up the grease into small droplets that can mix with the soapy water and be washed away. Bile mixes with the fats in food to form small fat droplets. The droplets can then be chemically broken down by enzymes produced in the pancreas.

Lab zone **Try This Activity**

Break Up!

You can model the breakup of fat particles in the small intestine.

1. Fill two plastic jars half full of water. Add a few drops of oil to each jar.
2. Add about $\frac{1}{4}$ spoonful of baking soda to one jar.
3. Stir the contents of both jars. Record your observations.

Observing In which jar did the oil begin to break up? What substance does the baking soda represent?

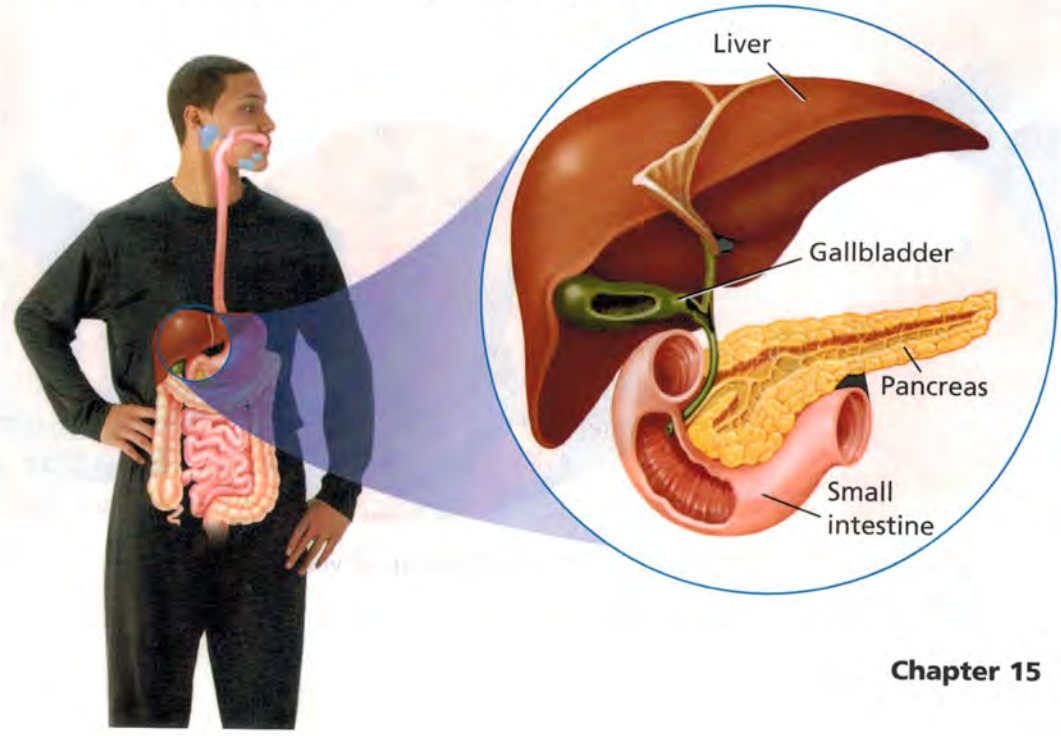


FIGURE 16
The Liver and Pancreas
Substances produced by the liver and pancreas aid in digestion.
Predicting *How would digestion be affected if the tube leading from the gallbladder to the small intestine became blocked?*

Go Online
PHSchool.com
For: More on the digestive system
Visit: PHSchool.com
Web Code: ced-4024

The Pancreas The **pancreas** is a triangular organ that lies between the stomach and the first part of the small intestine. Like the liver, the pancreas plays a role in many body processes. **As part of the digestive system, the pancreas produces enzymes that flow into the small intestine and help break down starches, proteins, and fats.**

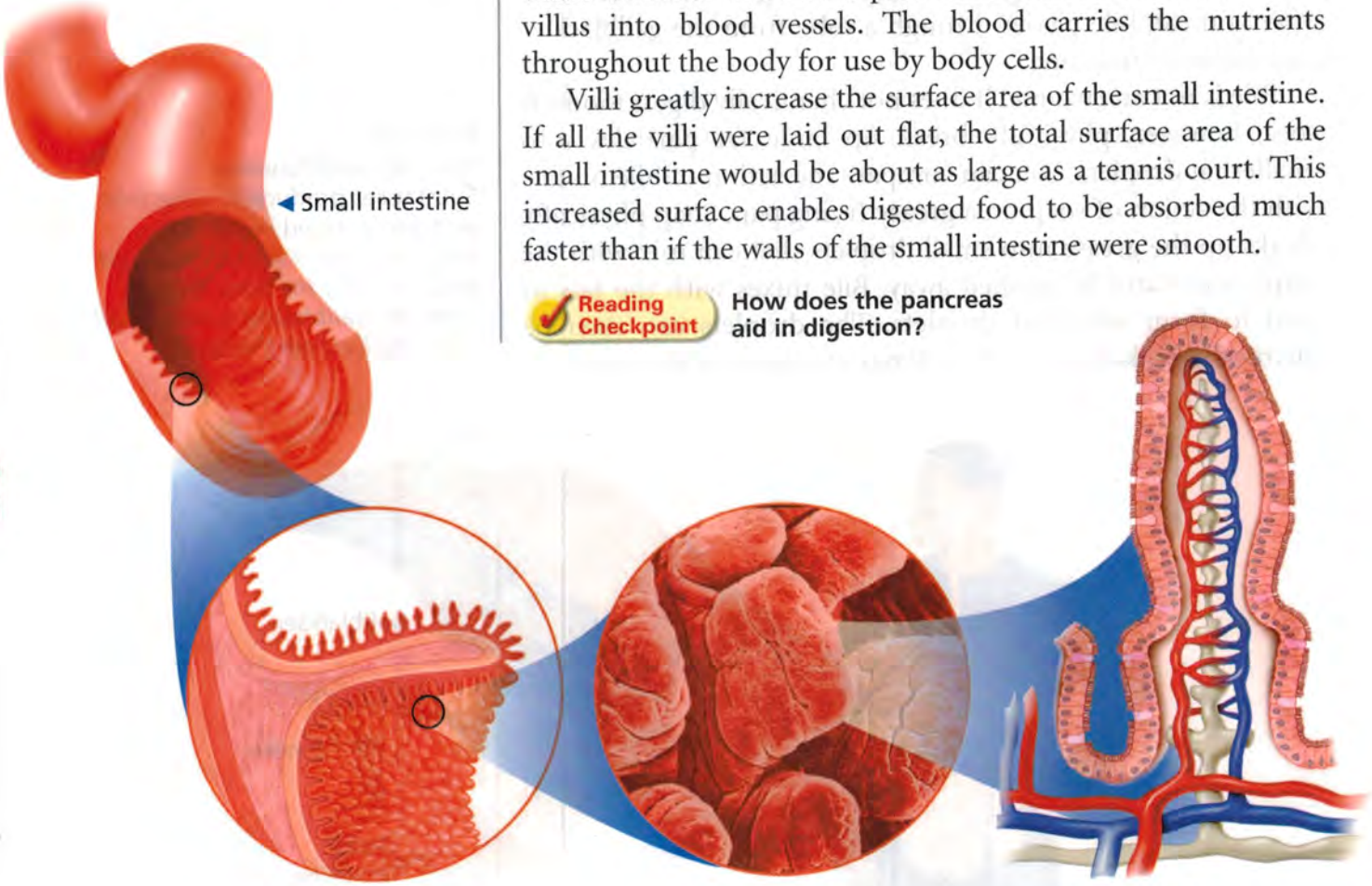
Digestive enzymes do not break down all food substances. Recall that the fiber in food isn't broken down. Instead, fiber thickens the liquid material in the intestine. This thickening makes it easier for peristalsis to push the material forward.

Absorption in the Small Intestine After chemical digestion takes place, the small nutrient molecules are ready to be absorbed by the body. The structure of the small intestine makes it well suited for absorption. The inner surface, or lining, of the small intestine looks bumpy. Millions of tiny finger-shaped structures called **villi** (VIL eye) (singular *villus*) cover the surface. The villi absorb nutrient molecules. Notice in Figure 17 that tiny blood vessels run through the center of each villus. Nutrient molecules pass from cells on the surface of a villus into blood vessels. The blood carries the nutrients throughout the body for use by body cells.

Villi greatly increase the surface area of the small intestine. If all the villi were laid out flat, the total surface area of the small intestine would be about as large as a tennis court. This increased surface enables digested food to be absorbed much faster than if the walls of the small intestine were smooth.

Reading Checkpoint **How does the pancreas aid in digestion?**

FIGURE 17
The Small Intestine
Tiny finger-shaped projections called villi line the inside of the small intestine. Blood vessels in the villi are covered by a single layer of cells.
Relating Cause and Effect *How does the structure of the villi help them carry out their function?*



The Large Intestine

By the time material reaches the end of the small intestine, most nutrients have been absorbed. The remaining material moves from the small intestine into the large intestine. The **large intestine** is the last section of the digestive system. It is about 1.5 meters long—about as long as the average bathtub. It runs up the right-hand side of the abdomen, across the upper abdomen, and then down the left-hand side. The large intestine contains bacteria that feed on the material passing through. These bacteria normally do not cause disease. In fact, they are helpful because they make certain vitamins, including vitamin K.

The material entering the large intestine contains water and undigested food. **As the material moves through the large intestine, water is absorbed into the bloodstream. The remaining material is readied for elimination from the body.**

The large intestine ends in a short tube called the **rectum.** Here, waste material is compressed into a solid form. This waste material is eliminated from the body through the **anus,** a muscular opening at the end of the rectum.

FIGURE 18
The Large Intestine
As material passes through the large intestine, most of the water is absorbed by the body. The remaining material will be eliminated from the body.

Reading Checkpoint **What role do bacteria play in the large intestine?**

Section 3 Assessment

Target Reading Skill

Identifying Main Ideas Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Reviewing** What two digestive processes occur in the small intestine?
   b. **Explaining** Explain how bile produced by the liver and enzymes produced in the pancreas function in the small intestine.
   c. **Relating Cause and Effect** Some people are allergic to a protein in wheat. When these people eat foods made with wheat, a reaction destroys the villi in the small intestine. What problems would you expect these people to experience?
2. a. **Identifying** Which key nutrient is absorbed in the large intestine?
   b. **Describing** What happens as food moves through the large intestine?
   c. **Applying Concepts** Diarrhea is a condition in which waste material that is eliminated contains too much water. How might diarrhea upset homeostasis in the body? How could a person reduce the effects of diarrhea on the body?

Writing in Science

Sequence of Events Describe the journey of a bacon, lettuce, and tomato sandwich through a person's digestive system, starting in the mouth and ending with absorption. Include where digestion of fats, carbohydrates, and proteins take place. Use words like *first*, *next*, and *finally* in your writing.

Chapter 15 Study Guide

The BIG Idea **Structure and Function** The digestive system breaks food down into small nutrient molecules that are then absorbed into the blood and carried throughout the body.

1 Food and Energy

Key Concepts

- Food provides the body with raw materials and energy.
- Carbohydrates provide energy as well as the raw materials to make cell parts.
- Fats provide energy and form part of the cell membrane. Fatty tissue protects and insulates the body.
- Proteins are needed for tissue growth and repair. They also play an important part in chemical reactions within cells.
- Vitamins and minerals are needed in small amounts to carry out chemical processes.
- Water is the most important nutrient because the body's vital processes take place in water.
- The USDA guidelines provide a personalized way to help people make healthy food choices based on their age, sex, and amount of physical activity.

Key Terms

nutrient
calorie
carbohydrate
glucose
fat
protein
amino acid
vitamin
mineral
Percent Daily Value
Dietary Reference Intakes (DRIs)

2 The Digestive Process Begins

Key Concepts

- The digestive system breaks down food into molecules the body can use. Then, the molecules are absorbed into the blood and carried throughout the body. Finally, wastes are eliminated.
- Both mechanical and chemical digestion begin in the mouth.
- In the esophagus, contractions of smooth muscles push the food toward the stomach.
- Most mechanical digestion and some chemical digestion occur in the stomach.

Key Terms

• digestion • absorption • saliva • enzyme • epiglottis • esophagus • mucus • peristalsis • stomach

3 Final Digestion and Absorption

Key Concepts

- Almost all chemical digestion and absorption of nutrients takes place in the small intestine.
- The liver produces bile, which breaks up fats.
- The pancreas produces enzymes that help break down starches, proteins, and fats.
- In the large intestine, water is absorbed into the bloodstream. The remaining material is readied for elimination.

Key Terms

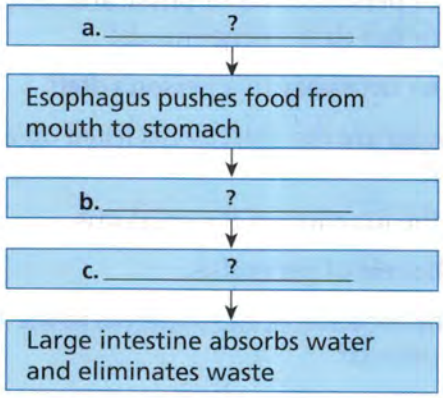
• small intestine • liver • bile • gallbladder • pancreas • villus • large intestine • rectum • anus

Review and Assessment

Go Online PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cha-3150

Organizing Information

Sequencing Copy the flowchart about digestion onto a separate sheet of paper. Then, complete it and add a title. (For more on Sequencing, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. The building blocks of proteins are
   a. vitamins.
   b. minerals.
   c. amino acids.
   d. fats.
2. Which of the following groups of nutrients is a major source of energy for the body?
   a. proteins
   b. vitamins
   c. minerals
   d. carbohydrates
3. The enzyme in saliva chemically breaks down
   a. fats.
   b. proteins.
   c. glucose.
   d. starches.
4. Most mechanical digestion takes place in the
   a. liver.
   b. esophagus.
   c. stomach.
   d. small intestine.
5. Bile is produced by the
   a. liver.
   b. pancreas.
   c. small intestine.
   d. large intestine.

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

6. Proteins that come from animal sources are incomplete proteins.
7. Vitamins are nutrients that are not made by living things.
8. To determine which of two cereals supplies more iron, check the Percent Daily Value on the food label.
9. Absorption moves food through the digestive system.
10. Most materials are absorbed into the bloodstream in the large intestine.

Writing in Science

Information Sheet You are a nutritionist assigned to work with a family trying to eat a more healthful diet. Write an instruction sheet outlining what kinds of foods they should eat. Provide some examples of each kind of food.

Discovery CHANNEL SCHOOL

Food and Digestion
Video Preview
Video Field Trip
▶ Video Assessment

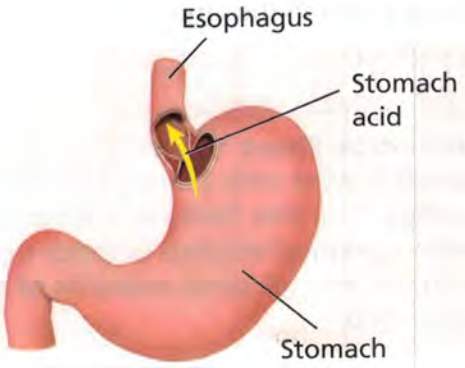
Review and Assessment

Checking Concepts

11. How does a person's level of physical activity affect his or her daily energy needs?
12. Why is fiber necessary in a person's diet?
13. In what order are the ingredients listed on a food label?
14. Describe the function of the epiglottis.
15. Explain the role of peristalsis.
16. What is the function of the pancreas in the digestive process?
17. What is the function of villi?

Thinking Critically

18. **Applying Concepts** Before winter, animals that hibernate often prepare by eating foods high in fat. How is this behavior helpful?
19. **Predicting** Suppose a medicine killed all the bacteria in your body. How might this affect vitamin production in your body?
20. **Inferring** Why is it important for people to chew their food thoroughly before swallowing?
21. **Relating Cause and Effect** How does the condition illustrated in the diagram below affect the esophagus?



22. **Comparing and Contrasting** The digestive system is sometimes said to be "an assembly line in reverse." Identify some similarities and some differences between your digestive system and an assembly line.

Math Practice

23. **Percentage** Your aunt eats 250 Calories of protein and 1,800 Calories total for the day. Did she get enough protein on that particular day? Show your calculations.

Applying Skills

Use the table to answer Questions 24–27.

Comparing Nutrient Data

Food (1 cup)	Calcium (% Daily Value)	Calories	Calories From Fat
Chocolate milk	30	230	80
Low-fat milk	35	110	20
Plain yogurt	35	110	35

24. **Classifying** To which group in a food pyramid do the foods in the chart belong? How does the body benefit from calcium in the diet?
25. **Interpreting Data** How many cups of low-fat milk provide 100% of the day's Daily Value for calcium?
26. **Calculating** Which of the foods meet the recommendation that no more than 30 percent of a food's Calories come from fat? Explain.
27. **Making Judgments** Which of the foods would be the most healthful choice for an afterschool snack? Explain your reasoning.

Lab zone Chapter Project

Performance Assessment Write a summary of what you've learned from keeping a food log. How close were your eating patterns to those recommended in your USDA MyPyramid Plan? How successful were you in making changes in your diet to match the MyPyramid Plan?

Standardized Test Prep

Test-Taking Tip

Watching for Qualifiers

You may be asked to answer a question that uses a qualifying word such as *most, least, best,* or *except for.* For example, you may be asked what the *best* conclusion is according to experimental data. When you see this type of question, read the answer choices very carefully. More than one choice may be partially correct. Look for the answer choice that offers the best or most complete answer.

Sample Question

According to the USDA guidelines, the *most* healthful diet includes limiting one's intake of

A sugar and fats.
B water.
C grains.
D fruits and vegetables.

Answer

Choice **A** is correct because sugars and fats should be eaten sparingly, as recommended by the USDA guidelines. Choice **B** is incorrect because the body cannot function without water. Choices **C** and **D** are incorrect because the USDA guidelines recommend eating these foods more often.

Choose the letter of the best answer.

1. Which of the following parts of the digestive system is *best* paired with its function?

A esophagus—digests carbohydrates
B stomach—digests fats
C small intestine—absorbs water
D liver—produces bile

2. A food label on a cereal box gives you the following information: a serving size equals one cup and there are 110 Calories per serving. You measure the amount of cereal you plan to eat and find that it measures 1 1/2 cups. How many Calories will you consume?

F 110 Calories
G 165 Calories
H 220 Calories
J 1,100 Calories

Use the table below and your knowledge of science to answer Questions 3 and 4.

Length of Time Food Stays in Organ

Organ	Time
Mouth	Less than 1 minute
Esophagus	Less than 1 minute
Stomach	1–3 hours
Small Intestine	1–6 hours
Large Intestine	12–36 hours

3. If a meal is eaten at noon, what is happening to the food at 1 P.M.?

A Saliva is breaking down starch into sugar.
B Proteins are being digested into short chains of amino acids.
C Fats are being digested.
D Digested food is being absorbed into the blood.

4. For food eaten at noon, absorption cannot have begun by

F 1 P.M.
G 7 P.M.
H 9 P.M.
J noon the next day.

5. Which of the following organs is *not* just a digestive organ?

A stomach
B liver
C small intestine
D large intestine

Constructed Response

6. Compare the processes of mechanical and chemical digestion. How are they similar? How are they different? In what parts of the digestive system do the two processes take place? How do the processes occur?