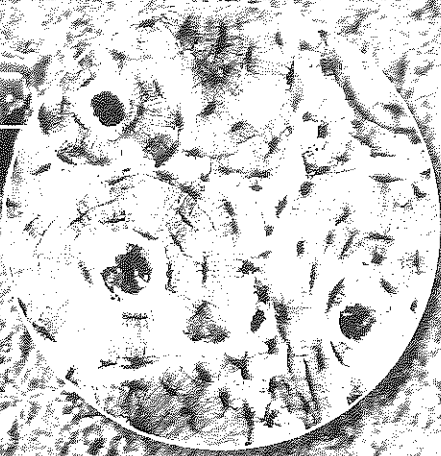


Bone Cells
EM Magnification: 40x



Bones in the
Joint of the knee



THEME FOCUS Structure and Function
Specialized functions of the integumentary, skeletal, and muscular systems maintain homeostasis within the human body.

Idea These systems work together to maintain homeostasis by protecting, supporting, and moving the body.

Section 1 • The Integumentary System

Section 2 • The Skeletal System

Section 3 • The Muscular System

Section 1

Reading Preview

Essential Questions

- What are the four tissue types that are found in the integumentary system?
- What are the functions of the integumentary system?
- What are the two layers of skin composed of?
- What are the events that occur when skin is repaired?

Review Vocabulary

integument: an enveloping layer of an organism

New Vocabulary

epidermis
keratin
melanin
dermis
hair follicle
sebaceous gland

Multilingual eGlossary

FOLDABLES

Incorporate information from this section into your Foldable.

The Integumentary System

KEY TAKEAWAY Skin is a multilayered organ that covers and protects the body.

Real-World Reading Link The skin on the tips of fingers and toes is thick and is composed of curving ridges that form the basis of fingerprints. Fingerprints were first used in criminal investigations in 1860 by Henry Faulds, a Scottish medical missionary. Your skin is not just a simple covering that keeps your body together. It is complex and is essential for your survival. Your ridges are uniquely yours!

The Structure of Skin

The integumentary (ihn TEG yuh MEN tuh ree) system is the organ system that covers and protects the body. Skin is the main organ of the integumentary system and is composed of four types of tissues: epithelial tissue, connective tissue, muscle tissue, and nerve tissue. Epithelial tissue covers body surfaces, and connective tissue provides support and protection. Muscle tissue is involved in body movement. Nerve tissue forms the body's communication network. You will learn more about muscle tissue in Section 3.

The epidermis Refer to **Figure 1**, which illustrates the two main layers of skin as seen through a microscope. The outer superficial layer of skin is the **epidermis**. The epidermis consists of epithelial cells and is about 10 to 30 cells thick, or about as thick as this page. The outer layers of epidermal cells contain **keratin** (KER uh tun), a protein which waterproofs and protects the cells and tissues that lie underneath. These dead, outer cells are constantly shed. **Figure 2** shows that some of the dust in a house are dead skin cells. As much as an entire layer of skin cells can be lost each month.

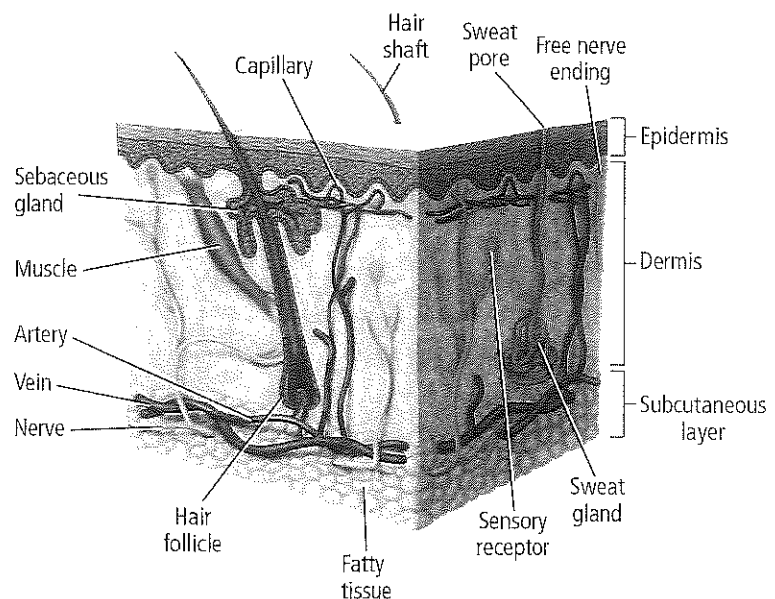


Figure 1 Skin is an organ because it consists of different types of tissues joined together for specific purposes.


Summarize *what types of tissues make up the skin.*

The inner layer of the epidermis contains cells that continually are dividing by mitosis to replace cells that are lost or die. Some cells in the inner layer of the epidermis provide protection from harmful ultraviolet radiation by making a pigment called melanin. **Melanin** is a pigment that absorbs light energy, which protects deeper cells from the damaging effects of ultraviolet rays of sunlight. The amount of melanin that is produced also influences the color of a person's skin. A suntan results when melanin is produced in response to exposure to the ultraviolet radiation in sunlight.

The dermis Directly beneath the epidermis is the **dermis**, the second layer of skin. The thickness of the dermis varies but usually is 15–40 times thicker than the epidermis. The dermis consists of connective tissue, a type of tissue that prevents the skin from tearing and also enables the skin to return to its normal state after being stretched. This layer contains other structures including nerve cells, muscle fibers, sweat glands, oil glands, and hair follicles. Beneath the dermis is the subcutaneous layer, a layer of connective tissue that stores fat and helps the body retain heat.

Hair and nails Hair, fingernails, and toenails also are parts of the integumentary system. Both hair and nails contain keratin and develop from epithelial cells. Hair cells grow out of narrow cavities in the dermis called **hair follicles**. Cells at the base of a hair follicle divide and push cells away from the follicle, causing hair to grow.

Hair follicles usually have sebaceous or oil glands associated with them, as shown in **Figure 3**. **Sebaceous glands** lubricate skin and hair. When glands produce too much oil, the follicles can become blocked. The blockage can close the opening of a follicle, causing a whitehead, blackhead, or acne—an inflammation of the sebaceous glands.

 **Reading Check** **Summarize** the differences in structure and function of the epidermis and the dermis.

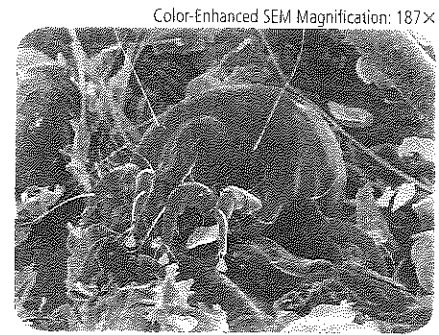
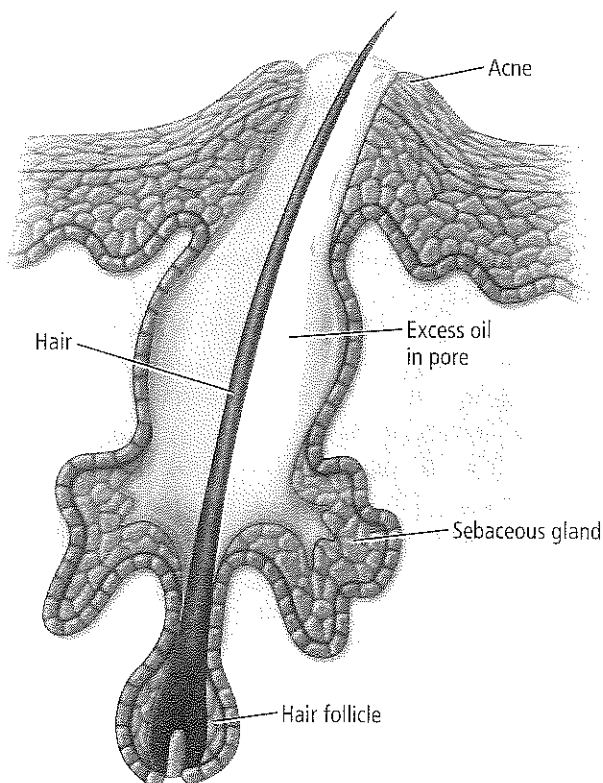


Figure 2 The dust mite pictured here is feeding on dead skin cells—a major component of dust.

Study Tip

Chart Make a chart with *Skin*, *Bones*, and *Muscles* as row labels, and *Components and structure* and *Function and purpose* as the column labels. Work in small groups to complete your chart as you review the text.

Figure 3 Oil, dirt, and bacteria can become trapped in follicles and erupt and spread to the surrounding area, causing localized inflammation.



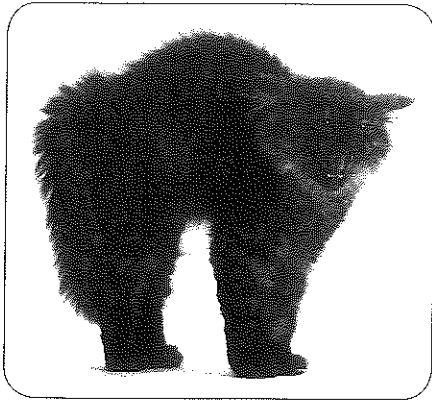


Figure 4 Muscles in the skin cause the hair of some mammals to stand on end, and cause “goose bumps” on human skin.

Relate *what environmental changes produce “goose bumps.”*

Fingernails and toenails grow from specialized epithelial cells at the base of each nail. As cells at the base of a nail divide, older dead cells are compacted and pushed out. Nails grow about 0.5 to 1.2 mm per day. You might have heard that nails and hair continue to grow for several days after death. This is a myth; cells surrounding the nail and hair cells dehydrate causing the cells to shrink and pull away from nails and hair. This makes both appear longer.

Functions of the Integumentary System

Skin serves several important functions including regulation of body temperature, production of vitamin D, protection, and perception of one’s surroundings.

Temperature regulation What happens when a person is working outside on a hot summer day? In order to regulate body temperature, the person sweats. As sweat evaporates it absorbs body heat, thereby cooling the body. What happens to skin when a person gets cold or frightened? “Goose bumps” are caused by the contraction of muscle cells in the dermis. In other mammals, when these muscles contract, the hair (fur) stands on end.

Notice the frightened cat in **Figure 4**. The cat appears larger, perhaps as a way to scare off enemies. This also is a mechanism for trapping air, which insulates or warms the mammal. Humans do not have as much hair as most other mammals, but “goose bumps” are caused by the same type of muscles that make a cat’s fur stand on end. Humans rely on fat in the subcutaneous layer instead of hair to keep warm.

Mini Lab 1

Examine Skin



How is chicken skin similar to human skin? The skin of chicken has characteristics similar to human skin. Using the chicken wing from the Launch Lab, you will further examine the characteristics of skin.

Procedure 

1. Read and complete the lab safety form.
2. Wear disposable **lab gloves**. Remove the **chicken wing** from the **self-sealing bag** and place it in a **dissecting pan**.
3. Use a **dissecting kit** to remove the skin from the wing. Use **scissors** to carefully snip a hole in the skin that is loosely attached to the wing.
4. Make a cut about 6 cm in length. Pull the skin away from the wing. Use scissors and the **scalpel** to cut through the transparent membrane that attaches the skin to the muscles.
5. Try to remove the skin without making any more holes. Look for pockets of fat, blood vessels, and muscle fibers attached to the skin. Note the strength of the skin.
6. Dispose of the skin and used gloves as directed by your teacher. Clean your dissecting tools and dissecting pan with **warm, soapy water**. Save the skinned wing to use in the next MiniLab.

Analysis

1. **Think Critically** about follicles. Human skin contains hair follicles. What type of follicles might you find on chicken skin?
2. **Explain** why it is important for skin to be strong and elastic.

Vitamin production Skin also responds to exposure to ultraviolet light rays from the Sun by producing vitamin D. Vitamin D increases absorption of calcium into the bloodstream and is essential for proper bone formation. Many food products are now fortified with vitamin D.


Protection and senses Intact skin prevents the entry of microorganisms and other foreign substances. Skin helps maintain body temperature by preventing excessive water loss. Melanin in the skin protects against ultraviolet rays. Information about changes in the environment, such as pain, pressure, and temperature changes, is relayed to the brain.

Damage to the Skin

Skin has the remarkable ability to repair itself. Without a repair mechanism, the body would be subject to invasion by microbes through breaks in the skin.

Cuts and scrapes Sometimes, as in the case of a minor scrape, only the epidermis is injured. Cells deep in the epidermis divide to replace the lost or injured cells. When the injury is deep, blood vessels might be injured, resulting in bleeding. Blood flows out of the wound and a clot is formed. Blood clots form a scab to close the wound, and cells beneath the scab multiply and fill in the wound. At the same time, infection-fighting white blood cells will help get rid of any bacteria that might have entered the wound.

Effects of the Sun and burns As people age, the elasticity of their skin decreases and they start to get wrinkles. Exposure to ultraviolet rays from the Sun accelerates this process and can result in burning of the skin and other damage.

Connection to  Burns, whether caused by the Sun, heat, or chemicals, usually are classified according to their severity. The types of burns are summarized in **Table 1**. First-degree burns generally are mild and involve only cells in the epidermis. A burn that blisters or leaves a scar is a second-degree burn and involves damage to both the epidermis and dermis. Third-degree burns are the most severe. Muscle tissue and nerve cells in both the epidermis and dermis might be destroyed, and skin function is lost. Healthy skin might have to be transplanted from another place on the body in order to restore the protective layer of the body.

VOCABULARY

Function

action, purpose

One function of the skin is to protect the body.

CAREERS IN BIOLOGY

Physical Therapist A physical therapist helps injured or disabled people to improve or regain physical functions using techniques such as exercise and massage.

Table 1

Classification of Burns

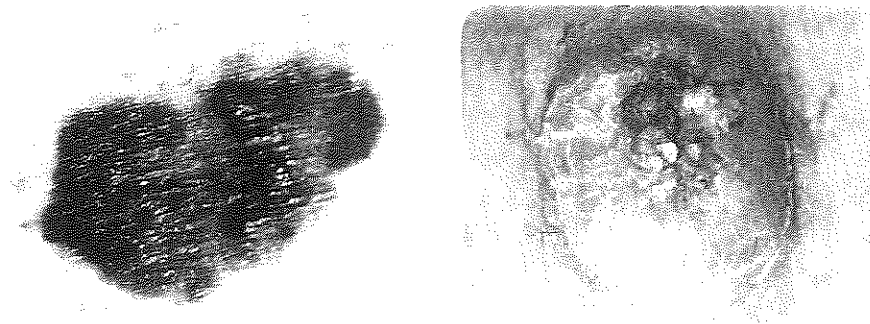


Interactive Table

| Severity of burn | Damage | Effect |
|------------------|--|---|
| First-degree | Cells in the epidermis are injured and may die. | <ul style="list-style-type: none"> • Redness and swelling • Mild pain |
| Second-degree | Cells deeper in the epidermis die. Cells in the dermis are injured and may die. | <ul style="list-style-type: none"> • Blisters • Pain |
| Third-degree | Cells in the epidermis and dermis die. Nerve cells and muscle cells are injured. | <ul style="list-style-type: none"> • Skin function lost • Healthy skin needs to be transplanted • No pain because of nerve cell damage |



Figure 5 Warning signs of skin cancer include any obvious change in a wart or mole, or moles that are irregularly shaped, varied in color, or are larger than the diameter of a pencil.



Skin cancer Exposure to ultraviolet radiation, whether it is from the Sun or from artificial sources such as tanning beds, is recognized as an important risk factor for the development of skin cancer. Ultraviolet radiation can damage the DNA in skin cells, causing those cells to grow and divide uncontrollably. When this happens, skin cancer results. Refer to **Figure 5** to see some warning signs of skin cancer.

Skin cancer is the most common cancer in the United States. There are two main categories of skin cancer: melanoma and nonmelanoma. Melanoma begins in melanocytes, the cells that produce the pigment melanin. Melanoma is the deadliest form of skin cancer. Melanoma can spread to internal organs and the lymphatic system. It is estimated that one person dies from melanoma every hour in the United States. Teens are at greater risk for melanoma because as they grow, their skin cells divide more rapidly than they will when they reach adulthood.

Anyone can get skin cancer. However, individuals with light skin, light-colored eyes, light hair color, and a tendency to burn or freckle are at the greatest risk. Everyone should try to avoid prolonged exposure to the Sun, especially between 10 A.M. and 4 P.M. when the Sun's rays are the strongest. Other preventative measures include wearing protective clothing or sunscreen with a Sun Protection Factor (SPF) of at least 15.

Section 1 Assessment

Section Summary

- The skin is the major organ of the integumentary system.
- Maintaining homeostasis is one function of the integumentary system.
- There are four types of tissues in the integumentary system.
- Hair, fingernails, and toenails develop from epithelial cells.
- Burns are classified according to the severity of the damage to skin tissues.

Understand Main Ideas

1. **Diagram** the two layers of the skin.
2. **Summarize** the types of tissues in the integumentary system and their functions.
3. **Generalize** different ways the integumentary system helps a human survive.
4. **Sequence** the process of skin repair in response to a cut.
5. **Compare** effects of first-degree, second-degree, and third-degree burns.

Think Critically

6. **Evaluate** the labels of two name-brand skin creams to compare how the two products claim to benefit the skin.

MATH in Biology

7. To determine how long an SPF will protect a person from burning in the Sun, multiply the amount of time the person can spend in the Sun before starting to burn by the SPF rating. If an individual who usually burns in 10 min uses a product with an SPF of 15, how long will the protection last?



Section 2

Reading Preview

Essential Questions

- What are the differences between the bones of the axial and appendicular skeletons?
- How is new bone formed?
- What are the functions of the skeletal system?

Review Vocabulary

cartilage: tough, flexible connective tissue that forms the skeletons of embryos and later covers the surface of bones that move against each other in joints

New Vocabulary

axial skeleton
 appendicular skeleton
 compact bone
 osteocyte
 spongy bone
 red bone marrow
 yellow bone marrow
 osteoblast
 ossification
 osteoclast
 ligament

 Multilingual eGlossary

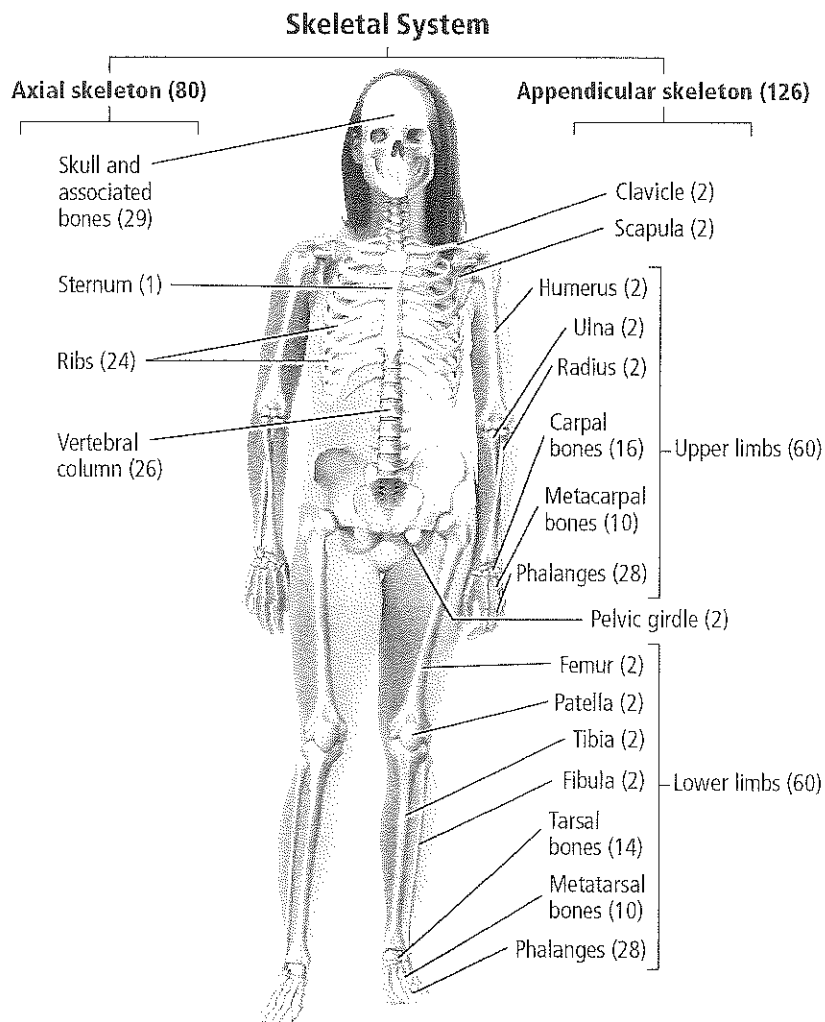
The Skeletal System

MARK **idea** The skeleton provides a structural framework for the body and protects internal organs such as the heart, lungs, and brain.

Real-World Reading Link Framing is an early stage of building a house. A person can walk through a house at that stage and know the plan of the house because of the framework. The skeletal system can be compared to the framework of a house. The framework provides structure and protection.

Structure of the Skeletal System

Notice all the bones in the adult skeleton pictured in **Figure 6**. If you counted them, you would find that there are 206 bones. The human skeleton consists of two divisions—the axial skeleton and the appendicular skeleton. The **axial skeleton** includes the skull, the vertebral column, the ribs, and the sternum. The **appendicular skeleton** includes the bones of the shoulders, arms, hands, hips, legs, and feet.



 Personal Tutor

Figure 6 The axial skeleton includes the bones of the head, back, and chest. Bones in the appendicular skeleton are related to movement of the limbs.



CAREERS IN BIOLOGY

Medical Illustrator A medical illustrator combines a talent in art with an interest in biology to illustrate procedures or to create teaching models.

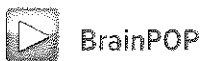
Compact and spongy bone Bone is a connective tissue that has many shapes and sizes. Bones are classified as long, short, flat, or irregular. Refer to **Figure 6**. Arm and leg bones are examples of long bones, and wrist bones are examples of short bones. Flat bones make up the skull. Facial bones and vertebrae are irregular bones.

The outer layers of all bones are composed of compact bone. **Compact bone** is dense and strong; it provides strength and protection. Running the length of compact bones are tubelike structures called osteons, or Haversian systems, which contain blood vessels and nerves. The blood vessels provide oxygen and nutrients to **osteocytes**—living bone cells.

The centers of bones can differ greatly, as illustrated in **Figure 7**. As the name suggests, **spongy bone** is less dense and has many cavities that contain bone marrow. Spongy bone is found in the center of short or flat bones and at the end of long bones. Spongy bone is surrounded by compact bone and does not contain Haversian systems.

There are two types of bone marrow—red and yellow. Red and white blood cells and platelets are produced in **red bone marrow**. Red bone marrow is found in the humerus bone of the arm, the femur bone of the leg, the sternum and ribs, the vertebrae, and the pelvis. The cavities of an infant's bones are composed of red marrow. Children's bones have more red marrow than adult bones. **Yellow bone marrow**, found in many other bones, consists of stored fat. The body can convert yellow bone marrow to red bone marrow in cases of extreme blood loss or anemia.

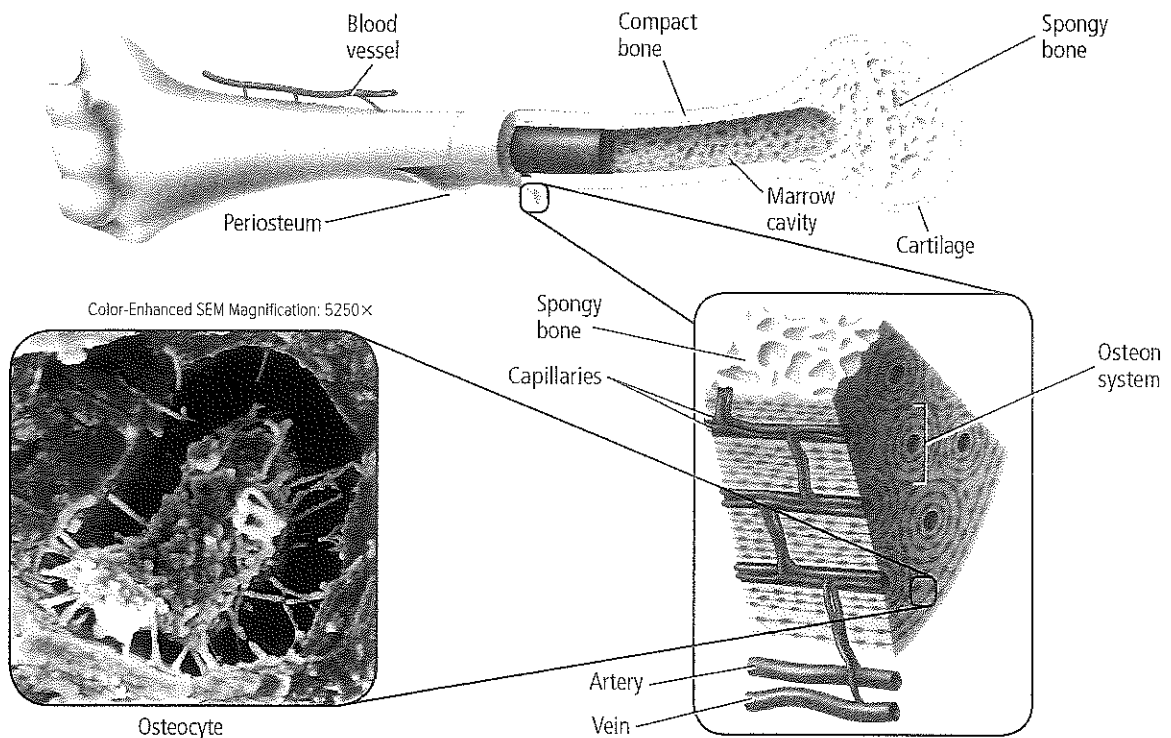
Formation of bone The skeletons of embryos are composed of cartilage. During fetal development, cells in fetal cartilage develop into bone-forming cells called **osteoblasts**. The formation of bone from osteoblasts is called **ossification**. Except for the tip of the nose, outer ears, discs between vertebrae, and the lining of movable joints, the human adult skeleton is all bone. Osteoblasts also are the cells responsible for the growth and repair of bones.




BrainPOP

* **Figure 7** Bone is either compact bone or spongy bone.

Classify how spongy bone and compact bone differ in location and function.



Remodeling of bone Bones constantly are being remodeled, which involves replacing old cells with new cells. This process is continual throughout life and is important in the growth of an individual. Cells called **osteoclasts** break down bone cells, which are then replaced by new bone tissue. Bone growth involves several factors, including nutrition and physical exercise. For example, a person with insufficient calcium can develop a condition known as osteoporosis that results in weak, fragile bones that break easily.

 **Reading Check** Compare the roles of osteoblasts and osteoclasts.

Repair of bone Fractures are very common bone injuries. When a bone breaks but does not come through the skin, it is a simple fracture. A compound fracture is one in which the bone protrudes through the skin. A stress fracture is a thin crack in the bone. When a bone is fractured, repair begins immediately. Refer to **Figure 8**, which illustrates the steps in the repair of a broken bone.

Fracture Upon injury, endorphins, chemicals produced in the brain and sometimes called “the body’s natural painkillers,” flood the area of the injury to reduce the amount of pain temporarily. The injured area quickly becomes inflamed, or swollen. The swelling can last for two or three weeks.

Within about eight hours, a blood clot forms between the broken ends of the bone and new bone begins to form. First, a soft callus, or mass, of cartilage forms at the location of the break. This tissue is weak, so the broken bone must remain in place.

Callus formation About three weeks later, osteoblasts form a callus made of spongy bone that surrounds the fracture. The spongy bone is then replaced by compact bone. Osteoclasts remove the spongy bone while osteoblasts produce stronger, compact bone.

Splints, casts, and sometimes traction can ensure that the broken bone remains in place until new bone tissue has formed. Broken fingers often are kept in place by being taped to an adjacent finger.

Remodeling Bones require different amounts of time to heal. Age, nutrition, location, and severity of the break are all factors. A lack of calcium in a person’s diet will slow down bone repair. Bones of younger people usually heal more quickly than bones of older people. For example, a fracture might take only four to six weeks to be repaired in a toddler, but it might take six months in an adult.

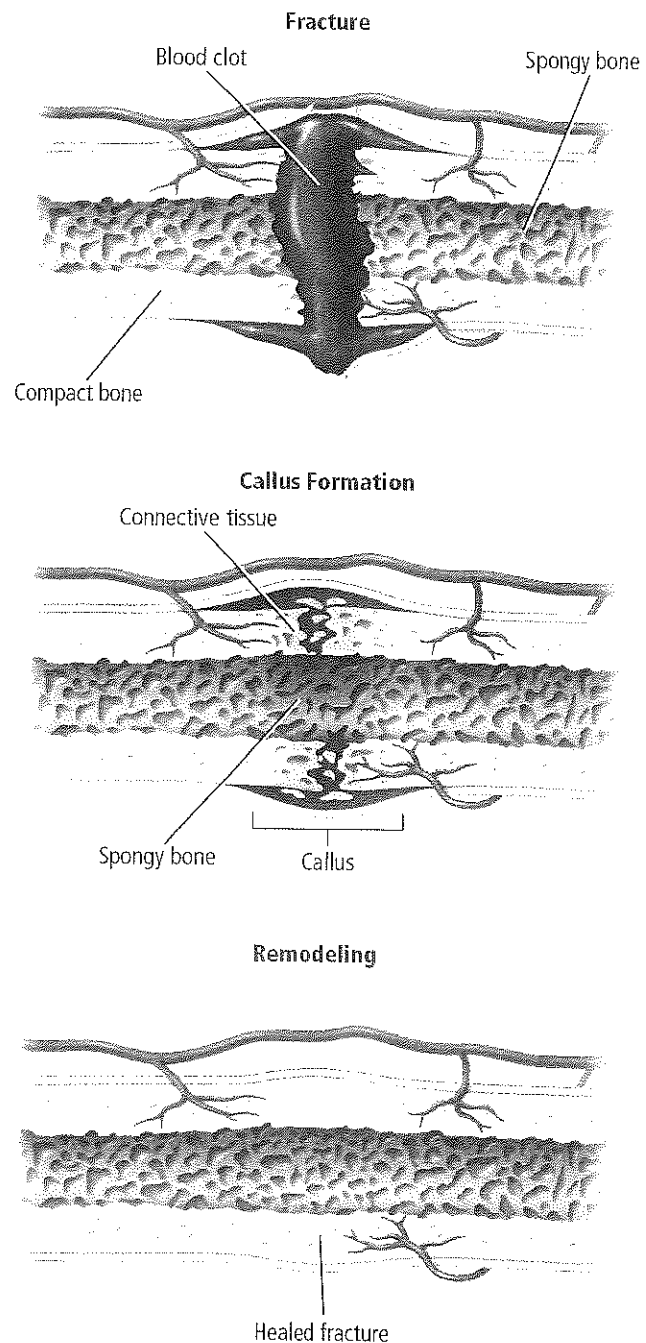


What’s BIOLOGY Got To Do With It?



Animation

Figure 8 Bone repair requires several steps. First, a mass of clotted blood forms in the space between the broken bones. Then connective tissue fills the space of the broken bone. Eventually, osteoblasts produce new bone tissue.





Launch Lab

Review Based on what you have read about joints, how would you now answer the analysis questions?



BrainPOP

Joints

Joints occur where two or more bones meet. Except for the joints in the skull, they can be classified according to the movement they allow and the shapes of their parts. **Table 2** identifies five kinds of joints—ball-and-socket, pivot, hinge, gliding, and sutures. Study **Table 2** to identify the type of movement that each kind of joint allows and also the bones involved in each example.

Not all joints are movable. The joints between some skull bones are fixed. At birth, however, skull bones are not all fused together. They become fused by the time a baby is about three months old. Gliding joints, like those found in the hand, have limited movement. Other joints, such as the hinge joint of the elbow and the pivot joint in the lower arm, allow back-and-forth movement and twisting. The ball-and-socket joints of the hips and shoulders have the widest range of motion.

The bones of joints are held together by ligaments. **Ligaments** are tough bands of connective tissue that attach one bone to another. You will learn more about ligaments and tendons, which attach muscle to bone, in the following section.



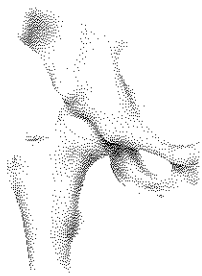

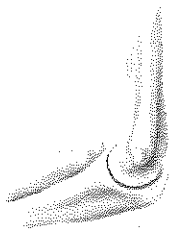

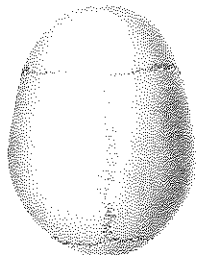
Reading Check Review the types of joints and how joints are classified.

Table 2

Some Joints of the Skeletal System



Interactive Table

| Name of Joint | Ball-and-Socket | Pivot | Hinge | Gliding | Sutures |
|---------------|--|--|--|---|--|
| Example |  |  |  |  |  |
| Description | In a ball-and-socket joint, the ball-like surface of one bone fits into a cuplike depression of another bone and allows the widest range of motion of any kind of joint. The joints of the hips and shoulders are ball-and-socket joints. They allow a person to swing his or her arms and legs. | The primary movement at a pivot joint is rotation. One example of a pivot joint is the elbow joint where two bones of the lower arm, the radius, and the ulna meet. This joint allows a person to twist the lower arm. | In a hinge joint, the convex surface of one bone fits into the concave surface of another bone. Elbows and knees are hinge joints. They allow back-and-forth movement like that of a door hinge. | Gliding joints allow side-to-side and back-and-forth movement. The joints in wrists and ankles are gliding joints. The joints of vertebrae also are gliding joints. | Sutures are joints in the skull that are not movable. There are 22 bones in an adult skull. All skull bones except the lower jaw bone are joined at sutures. |



Osteoarthritis (ahs tee oh ar THRI tus) The ends of bones in movable joints, such as the knee, are covered by cartilage, which serves as a cushion and allows smooth movement of the joint. Osteoarthritis is a painful condition that affects joints and results from the deterioration of the cartilage. It is a very common condition in knees and hips and also affects the neck and back. Osteoarthritis affects about ten percent of Americans and the frequency increases with age. A young person who has a joint injury is at risk to develop osteoarthritis later in life.

Rheumatoid arthritis Rheumatoid (roo MAH toyd) arthritis is another form of arthritis that affects joints. Rheumatoid arthritis is not the result of cartilage deterioration or of wear and tear on the joint. Affected joints lose strength and function and are inflamed, swollen, and painful. Fingers can look deformed, as illustrated in **Figure 9**.

Bursitis Shoulders and knees also have fluid-filled sacs called bursae that surround these joints. Bursae decrease friction and act as a cushion between bones and tendons. Bursitis is an inflammation of the bursae and can reduce joint movement and cause pain and swelling. Perhaps you have heard of “tennis elbow” which is a form of bursitis. Treatment usually involves resting the joint involved.

Sprains A sprain involves damage to the ligaments that hold joints together. It is caused when a joint is twisted or overstretched and usually causes the joint to swell and be tender and painful.



Figure 9 Rheumatoid arthritis can cause loss of strength and function and involves severe pain.

Compare *how rheumatoid arthritis differs from the more common osteoarthritis*.

Mini Lab 2

Examine Bone Attachments

How are bones attached to muscles and other bones? Tendons attach muscle to bone, and ligaments attach bone to bone. You will examine these attachments using a skinned chicken wing.

Procedure 

1. Read and complete the lab safety form.
2. Wear disposable **lab gloves**. Put the **skinned chicken wing** in a **dissection pan**.
3. Choose one muscle and use a pair of **dissection scissors** to cut the muscle away from the bone, leaving each end intact. Look for the long, white, tough tendons that connect the muscle to the bone.
4. Move the bones at the joint and notice how the tendon moves as the bones are pulled.
5. Carefully cut away all the muscles from the bones. The bones will still be attached to each other. Look for the white ligaments that hold them together. Examine the ends of each bone.
6. Draw a diagram of the wing without the muscles showing how the bones are attached to each other. Compare this drawing to the one you made in the Launch Lab.

Analysis

1. **Explain** how the drawing that you made in the Launch Lab is different from the drawing that you made of the wing in this lab.
2. **Observe and Infer** Did you notice how a muscle is attached at one end to a bone and then how the ligament at the other end runs across a joint to attach that end of the muscle to the next bone? Use a diagram to explain why this is important.
3. **Think critically** about the color of the ends of the bones at moveable joints. What do you think this material is?



**Table 3****Functions of the Skeletal System**

| Function | Description |
|--------------------------|---|
| Support | <ul style="list-style-type: none"> Legs, pelvis, and vertebral column hold up the body Mandible supports the teeth Almost all bones support muscles |
| Protection | <ul style="list-style-type: none"> Skull protects the brain Vertebrae protect the spinal column Rib cage protects the heart, lungs, and other organs |
| Formation of blood cells | <ul style="list-style-type: none"> Red bone marrow produces red blood cells, white blood cells, and platelets |
| Reservoir | <ul style="list-style-type: none"> Stores calcium and phosphorus |
| Movement | <ul style="list-style-type: none"> Attached muscles pull on bones of arms and legs Diaphragm allows normal breathing |

Functions of the Skeletal System

You might think that the only purpose of a skeleton is to serve as a framework to support the body. The bones of the legs, pelvis, and the vertebral column hold up the body. The mandible supports the teeth, and almost all bones support muscles. Many soft organs are directly or indirectly supported by nearby bones.

The skeletal system serves other functions besides support, as shown in **Table 3**. The skull protects the brain, vertebrae protect the spinal cord, and the rib cage protects the heart, lungs, and other organs.

The outer layers of bone tissue also protect the bone marrow found inside bones. In addition to forming red blood cells and white blood cells, red bone marrow forms platelets, which are involved in blood clotting. Red blood cells are produced at the rate of more than two million per second.

Until a person reaches about seven years of age, all bone marrow is red bone marrow. Then, fat tissue replaces some red marrow and gives the marrow a yellowish appearance, which gives it its name. Fat is an important source of energy.

Bones are reservoirs for the storage of minerals such as calcium and phosphorus. When blood calcium levels are too low, calcium is released from bones. When blood calcium levels are high, excess calcium is stored in bone tissue. In this way, the skeletal system helps to maintain homeostasis.

Bones that have muscles attached to them allow movement of the body. For example, as muscles pull on the bones of the arms and legs, they cause movement. Muscles that are attached to your ribs allow you to breathe normally.

Section 2 Assessment

Section Summary

- The human skeleton consists of two divisions.
- Most bones are composed of two different types of tissue.
- Bones are being remodeled constantly.
- Bones work in conjunction with muscles.
- The skeleton has several important functions.

Understand Main Ideas

1. **Identify** and describe the functions of the axial skeleton and the appendicular skeleton.
2. **Compare** the compositions of red bone marrow and yellow bone marrow.
3. **Compare** the body's mechanism for repairing a fractured bone with the original development of bone.
4. **Construct** a classification scheme for all of the bones shown in **Figure 6**.

Think Critically

5. **Consider** what the result might be if osteoblast and osteoclast cells did not function properly both in a developing fetus and in an adult.
6. **Distinguish** between compact and spongy bone based on appearance, location, and function.



Section 3

Reading Preview

Essential Questions

- What are the three types of muscle tissue?
- What are the events involved in muscle contraction at the cellular and molecular levels?
- What are the differences between slow-twitch and fast-twitch muscle fibers?

Review Vocabulary


anaerobic: chemical reactions that do not require the presence of oxygen

New Vocabulary

smooth muscle
involuntary muscle
cardiac muscle
skeletal muscle
voluntary muscle
tendon
myofibril
myosin
actin
sarcomere

Multilingual eGlossary

The Muscular System

 **The three major types of muscle tissue differ in structure and function.**

Real-World Reading Link Leonardo da Vinci contributed a great amount of knowledge to the scientific community. He studied the human body by examining cadavers. Da Vinci replaced muscles with string and learned that muscles shorten and pull on bones to make them move.

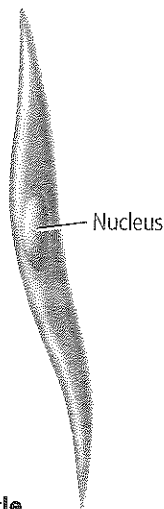
Three Types of Muscle

A muscle consists of groups of fibers or muscle cells that are bound together. When the word muscle is used, many people immediately think of skeletal muscle. Examine **Figure 10** to see that there are three types of muscle: smooth muscle, cardiac muscle and skeletal muscle. Muscles are classified according to their structure and function.

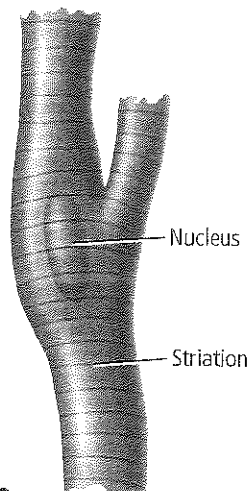
Smooth muscle Many hollow internal organs such as the stomach, intestines, bladder, and uterus are lined with **smooth muscle**. Smooth muscle is called **involuntary muscle** because it cannot be controlled consciously. For example, food moves through the digestive tract because of the action of smooth muscles that line the esophagus, stomach, and small and large intestines. Under a microscope, smooth muscle does not appear striated, or striped, and each cell has one nucleus.

Cardiac muscle The involuntary muscle present only in the heart is called **cardiac muscle**. Cardiac muscle cells are arranged in a network, or web, that allows the heart muscle to contract efficiently and rhythmically. This arrangement gives strength to the heart. Cardiac muscle is striped, or striated, with light and dark bands of cells with many nuclei. Cells usually have one nucleus and are connected by gap junctions.

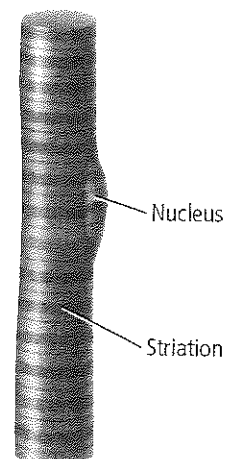
Figure 10 When magnified, differences in muscle shape and appearance can be seen. Smooth muscle fibers appear spindle-shaped; cardiac muscle appears striated or striped; skeletal muscle also appears striated. Explain *how muscles are classified, in addition to their appearance.*



Smooth muscle



Cardiac muscle



Skeletal muscle



VOCABULARY

SCIENCE WORDS & DEFINITIONS

Contract

Science usage: to tighten or to shorten

Muscles contract and cause movement.

Common usage: to become affected with

If you are exposed to the flu, you may contract the illness.

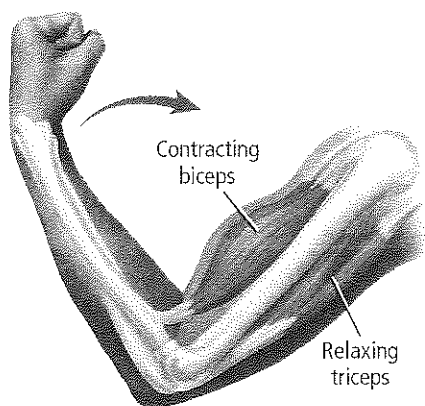


Virtual Lab

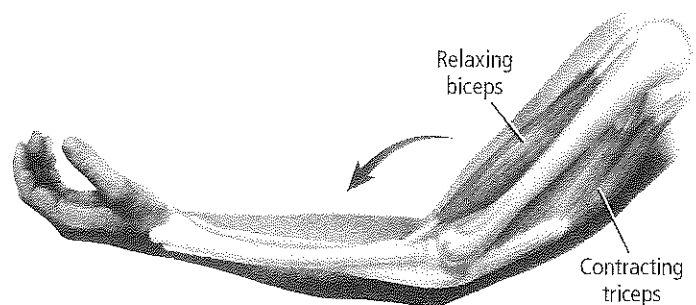
◀ **Figure 11** Skeletal muscles are arranged in antagonistic pairs.



Animation



When the biceps muscle contracts, the lower arm is moved upward.



When the triceps muscle on the back of the upper arm contracts, the lower arm moves downward.

Skeletal muscle Most of the muscles in the body are skeletal muscles. **Skeletal muscles** are muscles attached to bones by tendons and when tightened, or contracted, cause movement. Skeletal muscles are **voluntary muscles** that are consciously controlled to move bones. **Tendons**, which are tough bands of connective tissue, connect muscles to bones. Under a microscope, skeletal muscles also appear striated.

✔ **Reading Check** Compare and contrast the three types of muscles.

Skeletal Muscle Contraction

Most skeletal muscles are arranged in opposing, or antagonistic pairs. **Figure 11** illustrates muscles that you use to raise your arm and opposing muscles that you use to lower your arm. Skeletal muscle is arranged into fibers, which are fused muscle cells. Muscle fibers consist of many smaller units called **myofibrils**. Myofibrils consist of even smaller units, **myosin** and **actin**, which are protein filaments. Myofibrils are arranged in sections called sarcomeres. A **sarcomere** is the functional unit of a muscle and the part of the muscle that contracts as illustrated in **Figure 12**. The striations of skeletal muscles are a result of the sarcomeres, which run Z line to Z line. Z lines are where actin filaments attach within a myofibril. The overlap of actin and myosin filaments results in a dark band called the A band. The M line consists of only myosin filaments. The arrangement of the components of a sarcomere causes a muscle to shorten and then relax.

Sliding filament theory The sliding filament theory is also illustrated in **Figure 12**. This theory states that once a nerve signal reaches a muscle, the actin filaments slide toward one another, causing the muscle to contract. Notice that the myosin filaments do not move. There are many skeletal muscles involved in a simple motion.

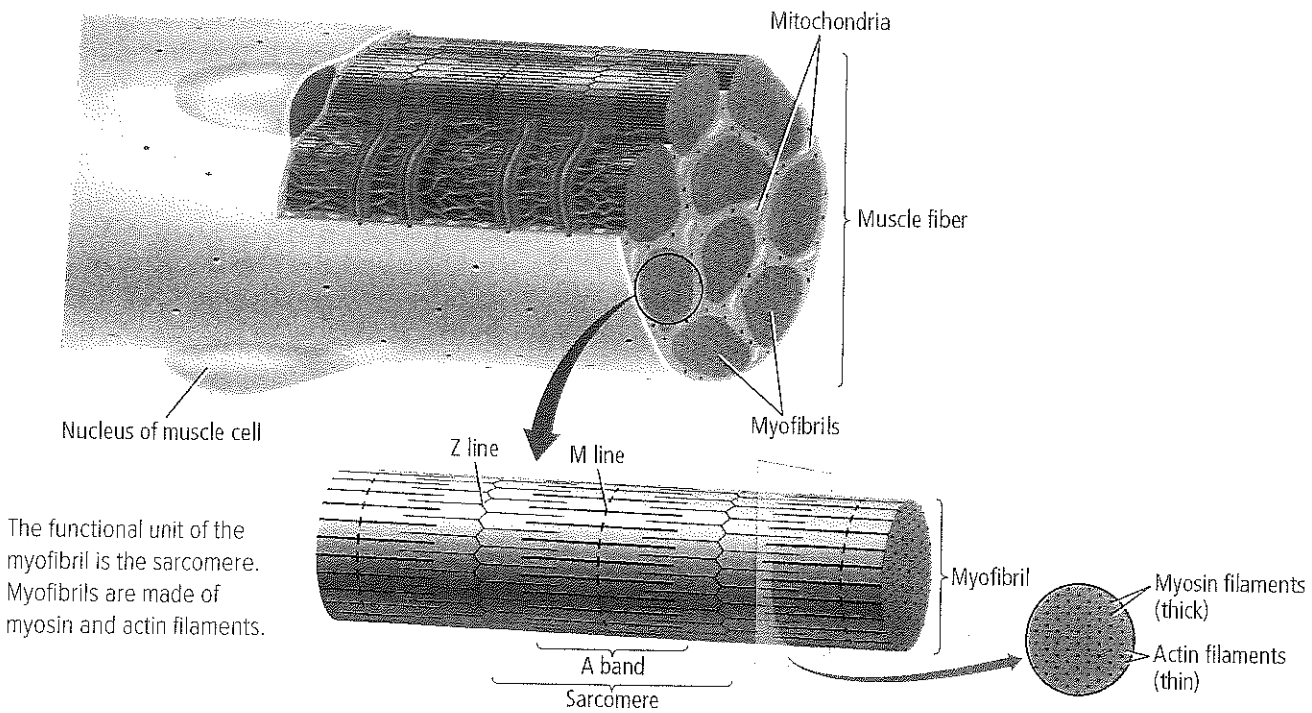
Connection to Chemistry When the nerve impulse reaches the muscle, calcium is released into the myofibrils causing the myosin and actin to attach to each other. The actin filaments are pulled toward the center of the sarcomere, resulting in muscle contraction. ATP is necessary for this step of muscle contraction. As the muscle relaxes, the filaments return into their original positions.



Visualizing Muscle Contraction

Figure 12

A muscle fiber is made of myofibrils. The protein filaments actin and myosin form myofibrils.



The functional unit of the myofibril is the sarcomere. Myofibrils are made of myosin and actin filaments.

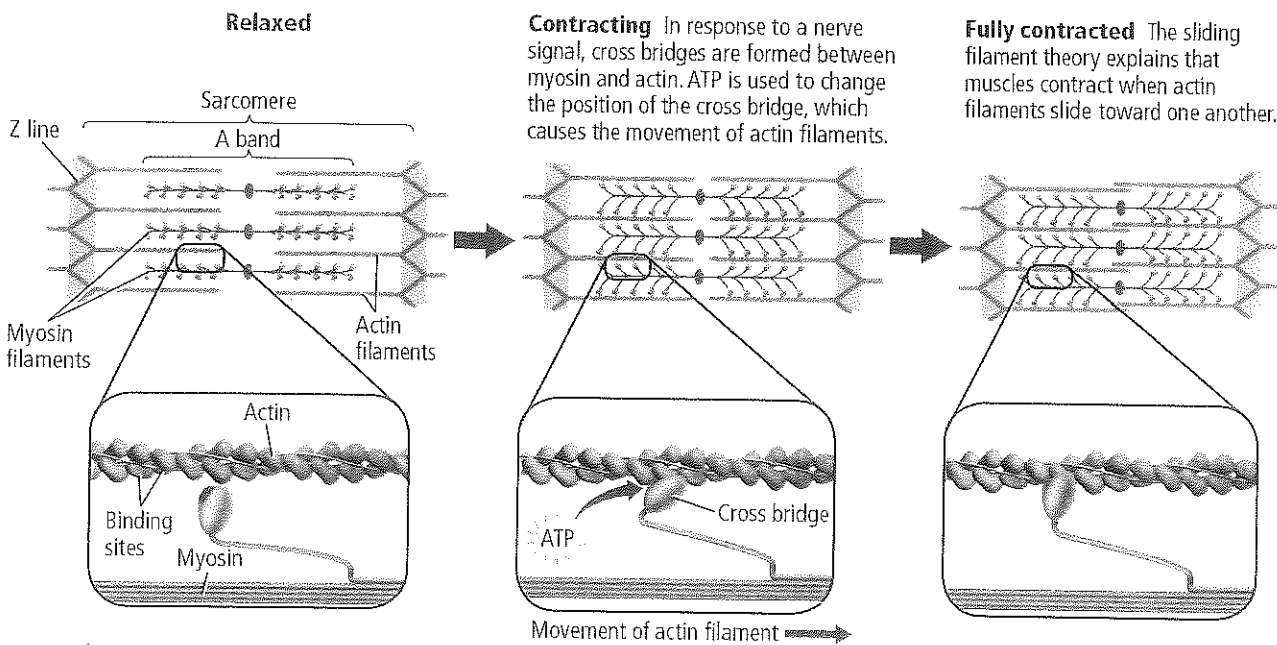




Figure 13 Crossing the finish line is a moment of intense energy. Explain why normal breathing is important after intense exercise.

Energy for muscle contraction All muscle cells metabolize aerobically and anaerobically. When sufficient oxygen is available, aerobic cellular respiration occurs in muscle cells.

Recall that cellular respiration process provides ATP for energy. After a period of intense exercise, muscles might not get enough oxygen to sustain cellular respiration, limiting the amount of ATP that is available. Muscles, like those of the athlete in **Figure 13**, then must rely on the anaerobic process of lactic acid fermentation for energy.

During exercise, lactic acid builds up in muscle cells, causing fatigue. Excess lactic acid enters the bloodstream and this stimulates rapid breathing. After resting for a short time, adequate amounts of oxygen are restored and lactic acid is broken down.

You probably have seen a dead animal along the side of the road. When an animal dies, rigor mortis sets in. Rigor mortis is a state of prolonged muscular contraction. ATP is required to pump the calcium back out of the myofibrils, which causes the muscles to relax. In rigor mortis, the dead animal cannot produce ATP, so the calcium remains in the myofibrils and the muscle remains contracted. After 24 hours, cells and tissues begin degrading and the muscle fibers cannot remain contracted.

Skeletal Muscle Strength

Many people do not develop the physiques of champion body-builders, no matter how often they work out in the weight room. A person might be the fastest sprinter on the track team, but quickly becomes fatigued in a long-distance race. What might be the reason for these differences? The reason in both cases is the ratio of slow-twitch muscle fibers to fast-twitch muscle fibers. Both slow-twitch and fast-twitch fibers are present in every person's muscles.

DATA ANALYSIS LAB 1

Based on Real Data*

Interpret the Data

How is the percentage of slow-twitch muscle related to action of a muscle? The proportion of slow-twitch to fast-twitch muscle fibers can be determined by removing a small piece of a muscle and staining the cells with a dye called *ATPase stain*. Fast-twitch muscle fibers with a high amount of ATP activity stain dark brown.

Think Critically

- Hypothesize** why a muscle such as the soleus has more slow-twitch muscle fibers than a muscle such as the orbicularis oculi.
- Classify** muscles by giving examples of muscles that have a high proportion of fast-twitch muscle fibers.

Data and Observations

| Muscle | Action | Percent Slow Twitch |
|------------------------------|-------------------|---------------------|
| Soleus (leg) | Elevates the foot | 87 |
| Biceps femoris (leg) | Flexes the leg | 67 |
| Deltoid (shoulder) | Lifts the arm | 52 |
| Sternocleidomastoides (neck) | Moves the head | 35 |
| Orbicularis oculi (face) | Closes the eyelid | 15 |

*Data adapted from: Lamb, D.R. 1984. *Physiology of Exercise* New York: Macmillan Co.

Slow-twitch muscles Muscles vary in the speeds at which they contract. Slow-twitch muscles contract more slowly than fast-twitch muscle fibers. Slow-twitch muscle fibers have more endurance than fast-twitch muscle fibers. The body of the triathlete in **Figure 14** has many slow-twitch fibers. These kinds of muscle fibers function well in long-distance running or swimming because they resist fatigue more than fast-twitch muscle fibers.

Slow-twitch muscle fibers have many mitochondria needed for cellular respiration. They also contain myoglobin, a respiratory molecule that stores oxygen and serves as an oxygen reserve. Myoglobin causes the muscles to have a dark appearance. Exercise increases the number of mitochondria in these fibers, but the overall increase in the size of the muscle is minimal.

Fast-twitch muscles Fast-twitch muscle fibers fatigue easily but provide great strength for rapid, short movements. Fast-twitch muscle fibers are adapted for strength. They function well in exercises requiring short bursts of energy such as sprinting or weightlifting, as illustrated in **Figure 14**.

Fast-twitch fibers are lighter in color because they lack myoglobin. Because they have fewer mitochondria, they rely on anaerobic metabolism, which causes a buildup of lactic acid. This causes these muscles to fatigue easily. Exercise increases the number of myofibrils in a muscle, thereby increasing the diameter of the entire muscle.

Most skeletal muscles contain a mixture of slow-twitch and fast-twitch muscle fibers. The ratio of these fibers is determined genetically. If there is a very high ratio of slow-twitch to fast-twitch, a person might be a champion cross-country runner. Champion sprinters have a high proportion of fast-twitch muscle fibers. Most people are somewhere in between.

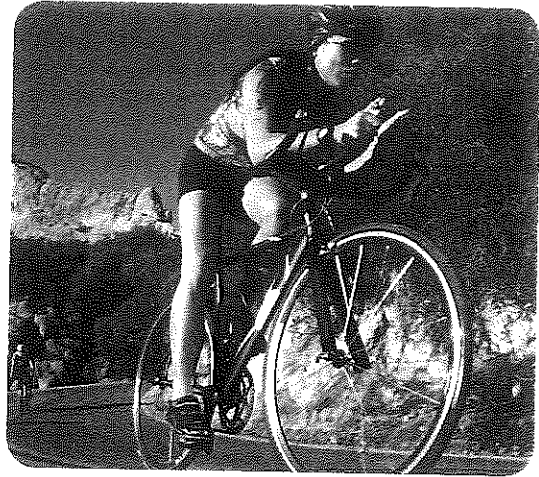


Figure 14 Triathletes have a high proportion of slow-twitch muscle fibers. Weight lifters have a high proportion of fast-twitch muscle fibers.

Section 3 Assessment

Section Summary

- There are three types of muscle tissue.
- Skeletal muscles are arranged in antagonistic pairs that work opposite to each other.
- Smooth muscles line many internal organs.
- Cardiac muscle is present only in the heart.
- All muscle cells metabolize both aerobically and anaerobically.

Understand Main Ideas

1. **Construct** a chart that lists similarities and differences among the three types of muscles.
2. **Identify** which type of muscles are voluntary and which are involuntary.
3. **Explain** why aerobic respiration occurs before lactic acid fermentation in most muscles.
4. **Compare** the role of mitochondria in slow-twitch and fast-twitch muscle fibers.

Think Critically

5. **Infer** Wild turkeys have a higher ratio of dark meat (muscle) to white meat than farm-raised turkeys. Why does this allow wild turkeys to fly longer distances than domesticated turkeys?

WRITING IN Biology

6. Write a short story that describes the sequence of events involved in skeletal muscle contraction. Tell your story from the point of view of a calcium ion.



Biology & Society

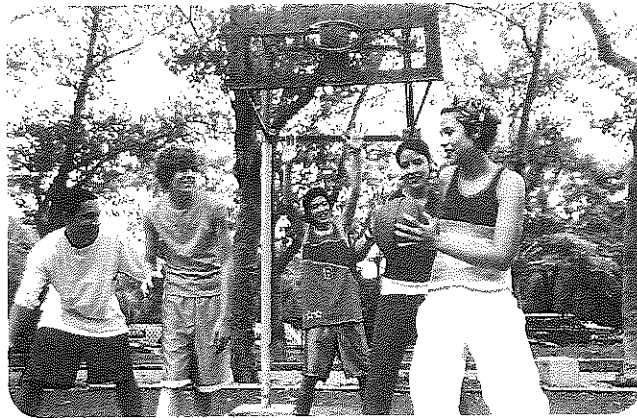
SPFs and Sunscreens

When you are outside playing sports or hanging out with your friends, the Sun is a welcome companion. Its warm rays are a staple of summertime fun. But are you adequately protecting yourself from the potentially harmful effects of the Sun? Retailers display many shelves of sun-protection products, but how much protection do these products provide?

Damaged skin It is important to understand that tanned skin is damaged skin. Skin cells that have been exposed to and injured by the Sun's ultraviolet (UV) rays produce melanin in order to absorb the rays. The melanin causes the "tanned" look. There are two kinds of UV rays that can reach Earth. UVB rays cause sunburns. UVA rays, which penetrate skin more deeply than UVB rays, cause other kinds of skin damage, such as wrinkles and sunspots. The same problems can result from using tanning beds or sunlamps, both of which emit UV rays. Even if you do not become sunburned, exposure to both kinds of UV rays can increase your risk of skin cancers—especially melanoma, the most serious kind of skin cancer.

To protect skin from the Sun's rays, people can wear sunscreen. Many sunscreens are labeled with a number marked "SPF," which stands for "Sun Protection Factor." However, SPF only measures protection from UVB rays. Sunscreens that are labeled "broad-spectrum" offer some protection from UVA rays, but scientists have not yet developed a system of measuring how well a sunscreen protects from UVA rays.

Understanding SPF Using the best product may be difficult because SPF numbers can be misleading. For example, one might think that a sunscreen with an SPF of 30 would have twice the protection against UVB rays than a sunscreen with an SPF of 15. However, that is not the case. A sunscreen with an SPF of 15 protects against 93



These students should all be wearing sunscreen with at least SPF 15 on all skin surfaces exposed to the Sun's rays.

percent of UVB rays, while a sunscreen with an SPF of 30 protects against 97 percent of UVB rays.

The American Cancer Society recommends that when outdoors, people of all ethnicities should wear a water-resistant sunscreen with an SPF of at least 15. About one ounce of sunscreen should be applied 15 to 30 minutes before going outside, even on cloudy days. Sunscreen should be reapplied every two hours. This simple habit goes a long way to protect skin from the Sun's rays. And for people who miss having that golden glow, there are always self-tanning products.

WRITING in Biology

Create a skit Write a skit that explains SPF ratings and why wearing sunscreen is important to one's health. Research other steps that people can take to protect themselves from the Sun, and include those steps in the skit. If time allows, perform your skit for other classes.

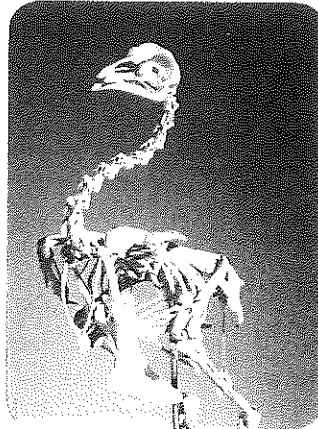


BIOLAB

FORENSICS: HOW CAN SKELETONS HELP YOU SOLVE A "CRIME"?

Background: Imagine there is a National Museum of Domestic Chickens and it has been robbed. Several bones from the first chicken eaten in America are missing. Three dogs are suspects. Your job is to examine impressions of bones that were found in mud near the doghouse of each dog and to determine if any of the bones came from a chicken. You will be given a clue for each unknown bone.

Question: Can the structure and form of a bone tell you from which animal it came?



Materials

impressions of three unknown bones
set of clues
various animal skeletons
hand lens
metric ruler
string

Safety Precautions

Procedure

1. Read and complete the lab safety form.
2. Collect materials you will use to measure and examine the skeletons. Determine what types of measurements you will make.
3. Obtain impressions of three bones and a set of clues from your teacher. Do not open the clues until you are told to do so.
4. Design a data table to record your measurements.
5. Examine the skeletons. Compare them to the impressions.
6. Make measurements and record the data.
7. Open the clues you were given and reexamine your data and answers.
8. **Cleanup and Disposal** Return any reusable materials to their proper storage areas.

Analyze and Conclude

1. **Analyze Data** Based on your observations and measurements, determine which one of the impressions came from a chicken.
2. **Interpret Data** How did you use information concerning the size and shape of each impression to help you determine from which animal it came?
3. **Evaluate** Did your conclusions change after you opened the clues? Explain your reasoning if your conclusions changed.
4. **Compare and Contrast** What similarities did you notice between each impression and bones in the human skeleton? What differences did you notice?
5. **Relate** Which skeletons seem to share the most characteristics with a human skeleton?
6. **Draw Conclusions** Which dog stole the chicken bones?

SHARE YOUR DATA

Poster Session Paleontologists are scientists who study fossils. Through their studies of fossil bones they have found evidence that birds had a dinosaur ancestor. Research the evidence that has been found and create a poster that shows what you learned.



Chapter 32 Study Guide

THEME FOCUS Structure and Function Specialized functions of the integumentary, skeletal, and muscular systems maintain homeostasis within the human body.

Big Idea These systems work together to maintain homeostasis by protecting, supporting, and moving the body.

Section 1 The Integumentary System

epidermis (p. 936)
keratin (p. 936)
melanin (p. 937)
dermis (p. 937)
hair follicle (p. 937)
sebaceous gland (p. 937)

Big Idea Skin is a multilayered organ that covers and protects the body.

- The skin is the major organ of the integumentary system.
- Maintaining homeostasis is one function of the integumentary system.
- There are four types of tissues in the integumentary system.
- Hair, fingernails, and toenails develop from epithelial cells.
- Burns are classified according to the severity of the damage to skin tissues.

Section 2 The Skeletal System

axial skeleton (p. 941)
appendicular skeleton (p. 941)
compact bone (p. 942)
osteocyte (p. 942)
spongy bone (p. 942)
red bone marrow (p. 942)
yellow bone marrow (p. 942)
osteoblast (p. 942)
ossification (p. 942)
osteoclast (p. 943)
ligament (p. 944)

Big Idea The skeleton provides a structural framework for the body and protects internal organs such as the heart, lungs, and brain.

- The human skeleton consists of two divisions.
- Most bones are composed of two different types of tissue.
- Bones are being remodeled constantly.
- Bones work in conjunction with muscles.
- The skeleton has several important functions.

Section 3 The Muscular System

smooth muscle (p. 947)
involuntary muscle (p. 947)
cardiac muscle (p. 947)
skeletal muscle (p. 948)
voluntary muscle (p. 948)
tendon (p. 948)
myofibril (p. 948)
myosin (p. 948)
actin (p. 948)
sarcomere (p. 948)

Big Idea The three major types of muscle tissue differ in structure and function.

- There are three types of muscle tissue.
- Skeletal muscles are arranged in antagonistic pairs that work opposite to each other.
- Smooth muscles line many internal organs.
- Cardiac muscle is present only in the heart.
- All muscle cells metabolize both aerobically and anaerobically.

Section 1

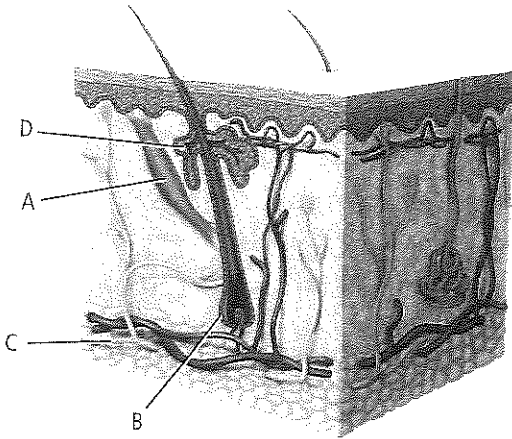
Vocabulary Review

Explain the difference between the terms in each set.

- epidermis, dermis
- melanin, keratin
- sebaceous glands, hair follicles

Understand Main Ideas

Use the diagram below to answer question 4.



- Which tissue type is responsible for "goose bump" formation?

| | |
|------|------|
| A. A | C. C |
| B. B | D. D |
- When are blackheads formed?
 - when sebaceous glands become clogged
 - when grooves in the epidermis gather dirt
 - when hair follicles grow inward rather than outward
 - when there is an excess of keratin produced
- How does the skin regulate body temperature?
 - by increasing sweat production
 - by retaining water
 - by producing vitamin D
 - by regulating fat content in the epidermis
- Which are not found in the dermis?
 - muscles
 - sweat and oil glands
 - fat cells
 - nerve cells

- What could be inferred from suntans?
 - Sunning for the purpose of tanning produces healthier skin.
 - A tan might indicate sun damage to the skin.
 - Tanning strengthens the elastic in the skin making the skin feel tight.
 - Tanning promotes skin that has a more youthful appearance.

Constructed Response

- Write an Idea** What possible effects on the body might there be if the epidermis was absent?
- Open Ended** What possible effects on the body might there be if the dermis was absent?
- THEME FOCUS Structure and Function** How does the integumentary system help maintain homeostasis?

Think Critically

- Explain** why it does not hurt when you get a haircut.
- Assess** the reason why people with third degree burns do not feel pain at the site of the burn.

Section 2

Vocabulary Review

Explain the difference between the terms in each set.

- spongy bone, compact bone
- tendons, ligaments
- osteoblasts, osteoclasts

Understand Main Ideas

Use the figure below to answer question 17.



- Where would you find the type of joint shown above?

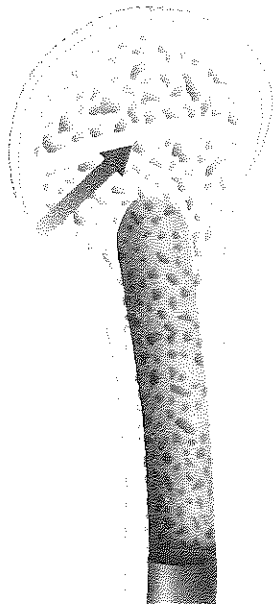
| | |
|--------------|----------|
| A. hip | C. elbow |
| B. vertebrae | D. skull |



Chapter 32 Assessment

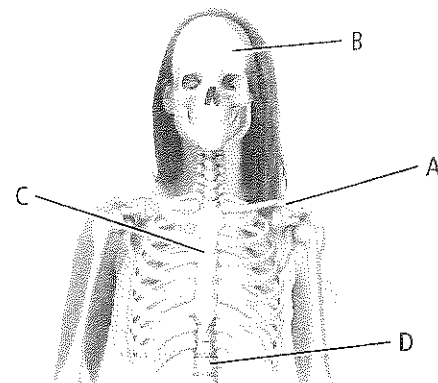
18. Which is not a function of bone?
- A. production of vitamin D
 - B. internal support
 - C. protection of internal organs
 - D. storage of calcium

Use the diagram below to answer question 19.



19. What is a characteristic of the portion of the bone indicated by the arrow?
- A. It contains no living cells.
 - B. It contains bone marrow.
 - C. It is the only type of bone tissue in long bones.
 - D. It is made of overlapping osteon systems.
20. Which pair of terms is mismatched?
- A. cranium, sutures
 - B. wrist, pivot joint
 - C. shoulder, ball-and-socket joint
 - D. knee, hinge joint
21. What are the cells that remove old bone tissue called?
- A. osteoblasts
 - B. osteocytes
 - C. osteoclasts
 - D. osteozymes
22. Which is not part of the axial skeleton?
- A. skull
 - B. ribs
 - C. hip bone
 - D. vertebral column

23. Which is part of the appendicular skeleton?



- A. A
- B. B
- C. C
- D. D

Constructed Response

24. **Write a Paragraph** Describe potential consequences if all bone tissue in humans was comprised of spongy bone and there was no compact bone.
25. **Open Ended** Describe potential consequences if all bone tissue in humans was comprised of compact bone and there was no spongy bone.
26. **Short Answer** Compare the function of osteoclasts and osteoblasts.

Think Critically

27. **Analyze** the following scenario. A person enters the emergency room with an ankle injury. What structures of the patient's ankle need to be examined to determine the proper treatment?
28. **Hypothesize** what might happen to a woman's bones if she did not increase her intake of calcium during pregnancy?

Section 3

Vocabulary Review

For each set of terms below, choose the one term that does not belong and explain why it does not belong.

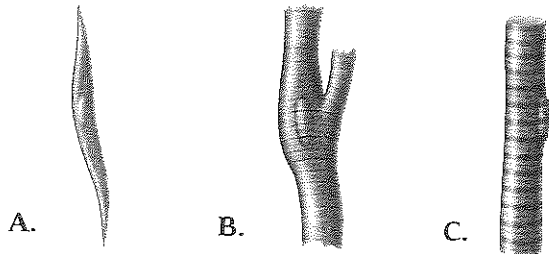
29. actin, melanin, myosin
30. cardiac muscle, smooth muscle, fast-twitch muscle
31. sarcomere, myofibril, myoglobin



Understand Main Ideas

32. Which requires ATP?
- muscle contraction
 - muscle relaxation
 - both muscle contraction and relaxation
 - neither muscle contraction nor relaxation

Use the diagram below to answer question 33.



33. What muscles shown above are classified as voluntary muscles?
- the muscle type shown in A
 - the muscle type shown in B
 - the muscle type shown in C
 - all muscles
34. Which is a characteristic of fast-twitch muscle fibers?
- They contain more myoglobin than slow-twitch fibers.
 - They are resistant to fatigue.
 - They have fewer mitochondria than slow-twitch fibers.
 - They require high amounts of oxygen in order to function.

Constructed Response

35. **Compare/Contrast** Compare and contrast the structure of skeletal, smooth, and cardiac muscle.
36. **Short Answer** Explain, based on the structure of the muscle fibers, why skeletal muscles can contract but not lengthen.

Think Critically

37. **Predict** any possible consequences if cardiac and smooth muscle had the same structure as skeletal muscle.
38. **Infer** why it is important that no muscle contains solely slow-twitch or fast-twitch fibers.

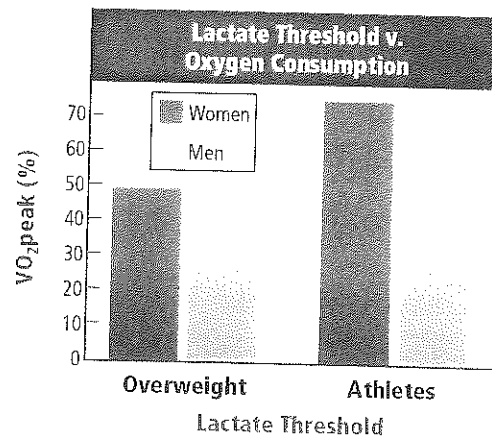
Summative Assessment

39. **Big Idea** Explain how the loss of the integumentary body system would cause a breakdown of homeostasis.
40. **Writing** **Biology** Imagine you are a writer for a health and fitness magazine. Write a brief article about the need for calcium in order for the skeletal and muscular systems to function correctly.

Document-Based Questions

Athletes burn fat at a maximum rate when they exercise at an intensity near the lactate threshold—the point at which lactic acid starts to build up in the muscles. In addition, athletes who consume the greatest amounts of oxygen during intense exercise [VO_{2peak}] burn the most fat. Researchers compared the lactate threshold and oxygen consumption of overweight subjects who did not exercise to those of highly-trained athletes.

Data obtained from: Bircher, S. and Knechtle, B. 2004. Relationship between fat oxidation and lactate threshold in athletes and obese women and men. *Journal of Sports Science and Medicine* 3:174–181.



41. At what percent of VO_{2peak} was the lactate threshold reached in overweight subjects?
42. How might an overweight person who does not exercise increase his or her VO_{2peak} and, therefore, his or her lactate threshold?



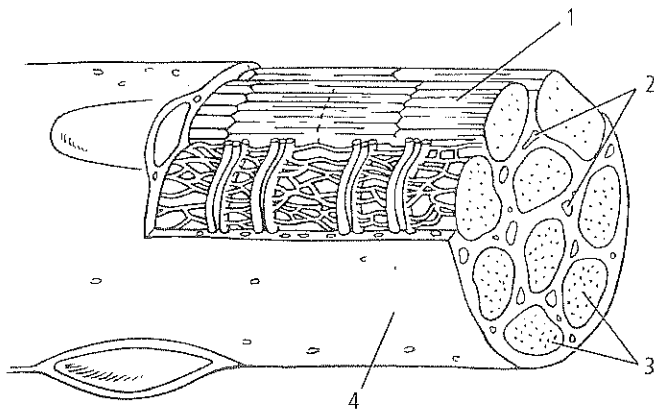
Standardized Test Practice

Cumulative

Multiple Choice

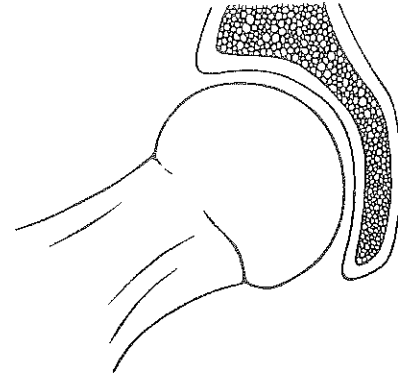
1. Which describes the circulatory system of most reptiles?
- A. double loop, four-chambered heart
 - B. double loop, three-chambered heart
 - C. single loop, three-chambered heart
 - D. single loop, two-chambered heart

Use the figure below to answer question 2.



2. Which part of a muscle is used for cellular respiration?
- A. 1
 - B. 2
 - C. 3
 - D. 4
3. Which characteristic makes bats unique among mammals?
- A. eyesight
 - B. feathers
 - C. flight
 - D. teeth
4. Which learned behavior occurs only at a certain critical time in an animal's life?
- A. classical conditioning
 - B. fixed action pattern
 - C. habituation
 - D. imprinting

Use the figure of the joint below to answer question 5.

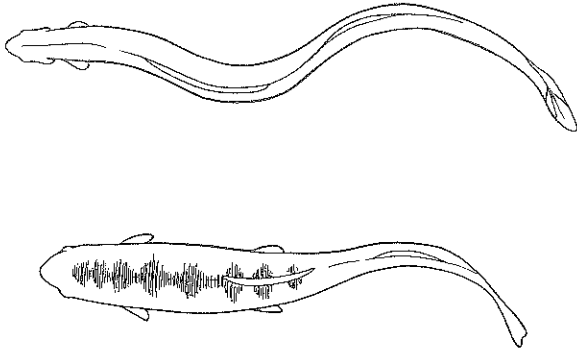


5. Where is the type of joint shown in the figure found?
- A. elbows and knees
 - B. fingers and toes
 - C. hips and shoulders
 - D. wrists and ankles
6. Which describes the characteristics of a bird's brain?
- A. Birds have a large medulla to process their vision.
 - B. Birds have a large cerebellum to control respiration and digestion.
 - C. Birds have a large cerebrum to coordinate movement and balance.
 - D. Birds have a large cerebral cortex to control flight.
7. Which type of bone is classified as irregular?
- A. leg bones
 - B. skull
 - C. vertebrae
 - D. wrist bones
8. Which adaptation helps stop fishes from rolling side to side in the water?
- A. ctenoid scales
 - B. paired fins
 - C. placoid scales
 - D. swim bladders



Short Answer

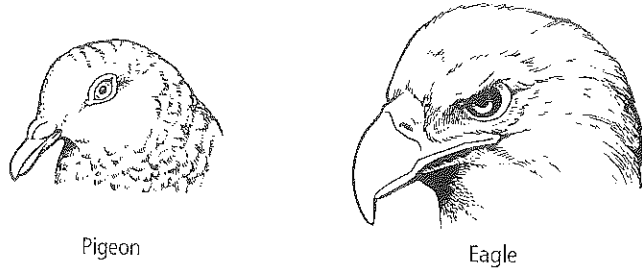
Use the diagram below to answer questions 9 and 10.



- Describe the difference between how a fish with an S-shaped pattern swims and a fish that moves its tail only.
- Decide where a fish with an S-shaped pattern would be likely found swimming.
- Relate the key events in the life cycle of a butterfly to the key events in the life cycle of a grasshopper.
- Howler monkeys are the loudest land animals. Their calls are heard for miles across the jungle. They use their calls to mark their territory. Assess this type of behavior.
- Describe how fetal cartilage becomes bone.
- A chimpanzee picks up a blade of grass and sticks it in an anthole. When it pulls the blade of grass out, it has ants on it. The chimpanzee eats the ants. The chimpanzee continues doing this because it is an easy way to get ants. Assess this activity as it relates to animal behaviors.
- Describe two types of joint conditions.

Extended Response

Use the diagram to answer questions 16 and 17.



- Evaluate what the location of the eyes on these two birds reveals about their behavior.
- Explain how the beaks of these two birds give evidence of what they eat.

Essay Question

Whooping cranes are an endangered species. One of the reasons for this is that they hatch in nesting areas and then migrate south for the winter. Humans can raise chicks, but teaching them to migrate is a different problem. Operation Migration solved this problem in 2001. Operation Migration used ultralight aircraft to lead a migration of human-raised whooping cranes on a 2000-km migration from Wisconsin to Florida. The whooping cranes followed the ultralight aircraft that used recorded calls to learn the migration route.

Using the information in the paragraph above, answer the following question in essay format.

- Migratory behavior has been shown to be an innate behavior. Evaluate why it is necessary to use ultralight aircraft to guide the birds so they can learn the migration route.

NEED EXTRA HELP?

| If You Missed Question . . . | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Review Section . . . | 29.1 | 32.3 | 30.1 | 31.1 | 32.2 | 29.2 | 32.2 | 28.1 | 28.1 | 28.1 | 26.3 | 31.2 | 32.2 | 31.1 | 32.2 | 29.2 | 29.2 | 31.2 |

