

# 33.1 Skeletal System

## VOCABULARY

skeletal system  
appendicular skeleton  
axial skeleton  
vertebrae  
cartilage  
joint  
ligament  
calcification

**KEY CONCEPT** The skeletal system includes bones and tissues that are important for supporting, protecting, and moving your body.

## MAIN IDEAS

- ▶ Your skeletal system is made up of the appendicular and axial skeletons.
- ▶ Bones connect to form joints.
- ▶ Bones are living tissue.

## Connect to Your World

Your bones and muscles must be strong enough to support more than your body's weight. Each time you move, whether walking or running, your bones and muscles must absorb the force of the ground pushing upward on your foot. How much force do your bones need to absorb? When you jog, your body absorbs a force of more than twice your body weight with each step. When you jump and land, this force is about 12 times your body weight.

## ▶ MAIN IDEA

### Your skeletal system is made up of the appendicular and axial skeletons.



**FIGURE 1.1** The skeletal system is composed of an appendicular skeleton (white) and an axial skeleton (red).

Imagine a tree. The wood fibers support the tree and protect the tree's internal tissues. As wood fibers support a tree, your skeletal system protects your organs and supports your body, allowing your body to keep its shape. Unlike the wood in a tree, however, your skeletal system allows you to move.

The **skeletal system**, shown in **FIGURE 1.1**, is an organ system that includes the bones and the connective tissues that hold the bones together. The human skeleton has 206 bones, which can be categorized as part of either the appendicular or axial skeletons.

### Appendicular Skeleton

Unlike the branches of a tree, which cannot move much, parts of your skeleton allow for wide ranges of movement. The **appendicular skeleton** is the part of your skeleton that is adapted to allow the body to move. It includes the bones in the limbs that extend from the trunk of your body—your legs, arms, feet, and hands.

The appendicular skeleton also includes two sets of bones, called girdles, that connect your limbs to your body. The girdles attach the bones of the arms and legs to the body loosely enough that these limbs have a wide range of motion. Your arm, for example, can rotate from the floor to the ceiling, as when a swimmer does the backstroke or a baseball pitcher “winds up” during a pitch. Your leg is connected loosely enough that your knee can be raised high in front of your body, as when you are running, or it can move away from your body, as when a basketball player shuffles sideways down a court.

## Axial Skeleton

The **axial skeleton** is made up of the bones found in the trunk and head of the body. The bones of the axial skeleton support the weight of the body and protect the internal tissues. The axial skeleton includes the 27 bones in the skull, the 33 bones that form the spine, the 12 pairs of ribs, and the breastbone, the flat bone in the front of the chest that connects the ribs.

The bones of the axial skeleton cover most of the body's vital organs. **Vertebrae** are the bones that surround the spinal cord. The bones of the skull protect the brain, and the ribs and breastbone protect the heart and lungs, as shown in **FIGURE 1.2**.

Although the main functions of the axial skeleton are protection and support, it also provides some limited movement. The ribs are connected with flexible tissue that allows the chest to expand while breathing. Flexible tissue in the spine allows people to bend or to turn and look behind them.

## Cartilage

Bones are very hard organs. If two bones in your finger fused into one, your muscles would not be able to move your finger. But if the two bones were in contact with one another, they would rub together every time you moved, and eventually, the ends of the bones would wear down. Fortunately, the ends of your bones are protected from wear by cartilage.

**Cartilage** is flexible connective tissue that is found between your bones. It cushions your bones and allows for smooth movements. Sometimes cartilage physically connects two bones. The cartilage found in your chest, for example, holds neighboring ribs together into one strong rib cage. Because the ribs are held together with cartilage and not bone, the rib cage is flexible too. Cartilage is also found between neighboring bones that move relative to one another.

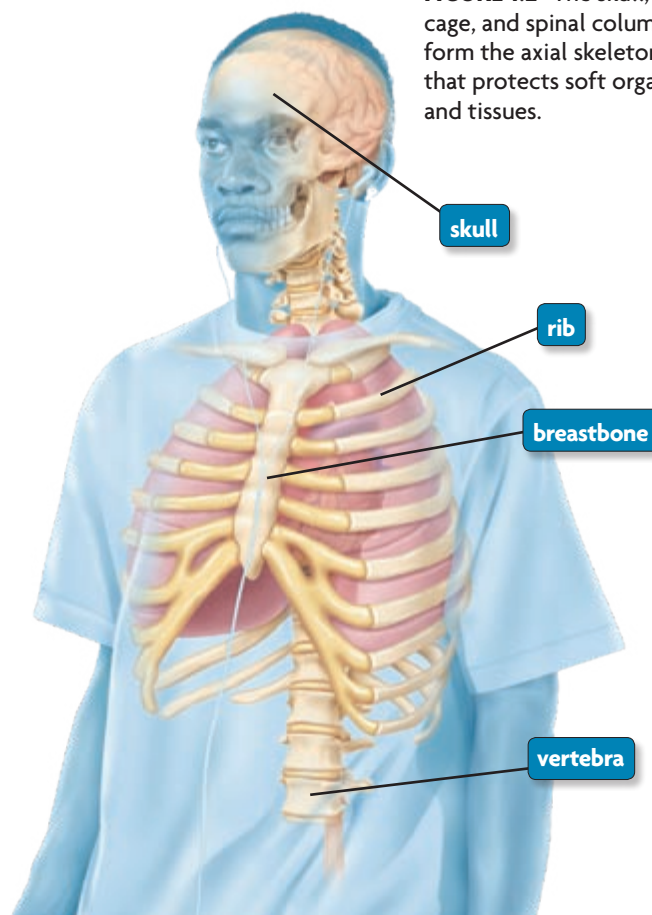
**Analyze** Why is it important that the ribs are connected by cartilage?

### ▶ MAIN IDEA

## Bones connect to form joints.

A **joint** is the place where two bones meet. Joints allow for different amounts of movement. Some joints are made of very strong fibers that do not allow movement. These joints, called fibrous joints, are made of the same dense material that bone is made of, and they act like a tough glue that connects the bones and holds them in place. Fibrous joints in your jawbone hold your teeth in your mouth. Fibrous joints also connect the plates of your skull into one large structure that surrounds your brain.

**FIGURE 1.2** The skull, rib cage, and spinal column form the axial skeleton that protects soft organs and tissues.



### READING TOOLBOX

#### TAKING NOTES

Use a main idea diagram to organize your notes about joints.

Joints are places where two bones meet.

- Fibrous joints occur in places such as the skull, where bones are fused together so they cannot move.
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## CONNECT TO

### LEVERS

Recall from your physical science courses that a lever is like a door that moves by pivoting at the hinges. Joints are similar to levers in that the bone is the rigid object, and the ligaments and joints allow the bone to pivot.

Cartilaginous (KAHR-tuhl-AJ-uh-nuhs) joints allow partial movement. In these joints, cartilage physically holds bones together. Discs of cartilage between the vertebrae keep the bones stacked on top of one another and give the spine some flexibility. A person can bend slightly to one side at the waist. However, a person cannot fold in half by bending to the right or left.

Cartilaginous joints are also found where the breastbone and ribs meet. Because of cartilage's flexibility, these joints allow the chest to expand and contract while you breathe. But there is a limit to how far your chest can expand. Taking in a deep breath will cause the circumference of your chest to expand by only about 7 cm (3 in.).

Other joints, called synovial joints, are cushioned with cartilage and held together by ligaments. A **ligament** is a long, flexible band of connective tissue that connects two bones across a joint. Ligaments keep bones physically connected while remaining loose enough that the bones can move. There are several different types of synovial joints, which are listed below and shown in **FIGURE 1.3**.

### VISUAL VOCAB

A **ligament** is a long band of connective tissue that connects two bones across a joint.



- 1 Gliding joints** allow the flat surfaces of bones to slide over each other. These joints give flexibility to the ankle and wrist. These joints give you the ability to walk on uneven surfaces and move your hand to the right and left.
- 2 Pivot joints** are found where two bones turn on each other and allow rotation. The top two vertebrae that support the skull form a pivot joint that allows the head to turn to the right and left.
- 3 Ball-and-socket joints** are found in the hip and shoulder. In these joints, the knoblike end of an arm or thigh bone fits into a bony cup in the shoulder blade or hip bone. Ball-and-socket joints allow the arm or leg to move in almost any direction.
- 4 Saddle joints** allow a bone to move front to back and left to right. Your thumbs are connected to your hands by saddle joints. The saddle joint in your thumb is what gives your thumb the ability to reach across the palm of your hand and touch your other fingers.
- 5 Hinge joints** allow bones to move in one direction, like a swinging door. These joints are found in the knees, fingers, and toes.

Some bones in the body are connected by more than one type of synovial joint. These are called compound joints. In your elbow, for example, a hinge joint connects your forearm to your upper arm and allows you to extend and retract your forearm. Your elbow also has a pivot joint that allows the arm to rotate so that your hand can face up or down.

**Infer** Why do you think that ligaments are found in the appendicular skeleton but not the axial skeleton?

**Animated**  
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PREMIUM CONTENT

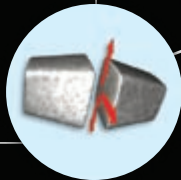
What Kind of Joint Is It?

## FIGURE 1.3 Joints

Some joints allow for movement.

### 1 GLIDING JOINT

Gives flexibility to the wrist and ankle



### 2 PIVOT JOINT

Allows the bones in the neck to move a short distance to the left or right



### 3 BALL-AND-SOCKET JOINT

Holds the upper arm and leg to the trunk of the body and allows these bones to move in almost any direction



### 4 SADDLE JOINT

Gives bones in the fingers the ability to move in all directions but in a much more limited way than a ball-and-socket joint



### 5 HINGE JOINT

Lets many different bones in the body move toward or away from one another



**CRITICAL VIEWING** How does the range of motion of a saddle joint in the thumb differ from the hinge joint in the finger?

**▶ MAIN IDEA**

## Bones are living tissue.

In addition to their role in providing support, allowing movement, and protecting internal organs, bones are living tissue that produce blood cells and act as a storage bank for minerals. Bones are covered by a layer of connective tissue called periosteum (PEHR-ee-AHS-tee-uhm), which holds and protects blood vessels that run alongside of the bone tissue. Just like any other tissue in the body, bones rely on blood vessels to bring nutrients and remove wastes.

### Bone Structure

There are two types of bone tissue: compact and spongy. Compact bone is the hard, dense layer that protects against jolts and bumps. It is found inside the periosteum but on the outside of the spongy bone. Compact bone is made up of several calcium-rich rings. These rings are maintained by bone cells called osteocytes, which are scattered in small spaces throughout the rings. At the center of the rings are channels called Haversian canals, each of which contains a small blood vessel.

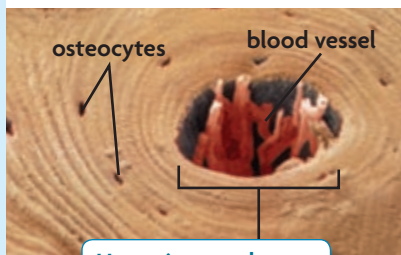
Spongy bone is the less dense bone that is surrounded by compact bone. Spongy bone is a porous tissue that holds and protects red or yellow bone marrow, as shown in **FIGURE 1.4**. When a person is young, most of the spongy bone is filled with red bone marrow. Red marrow is a part of the circulatory system. It produces blood cells. As a person matures and grows, some of the red bone marrow in their bones is replaced with yellow bone marrow.

**FIGURE 1.4 Bone Structure**

**Bones have many layers for protection and transport.**

#### Compact bone

Protects the inner layers and supports the body's weight

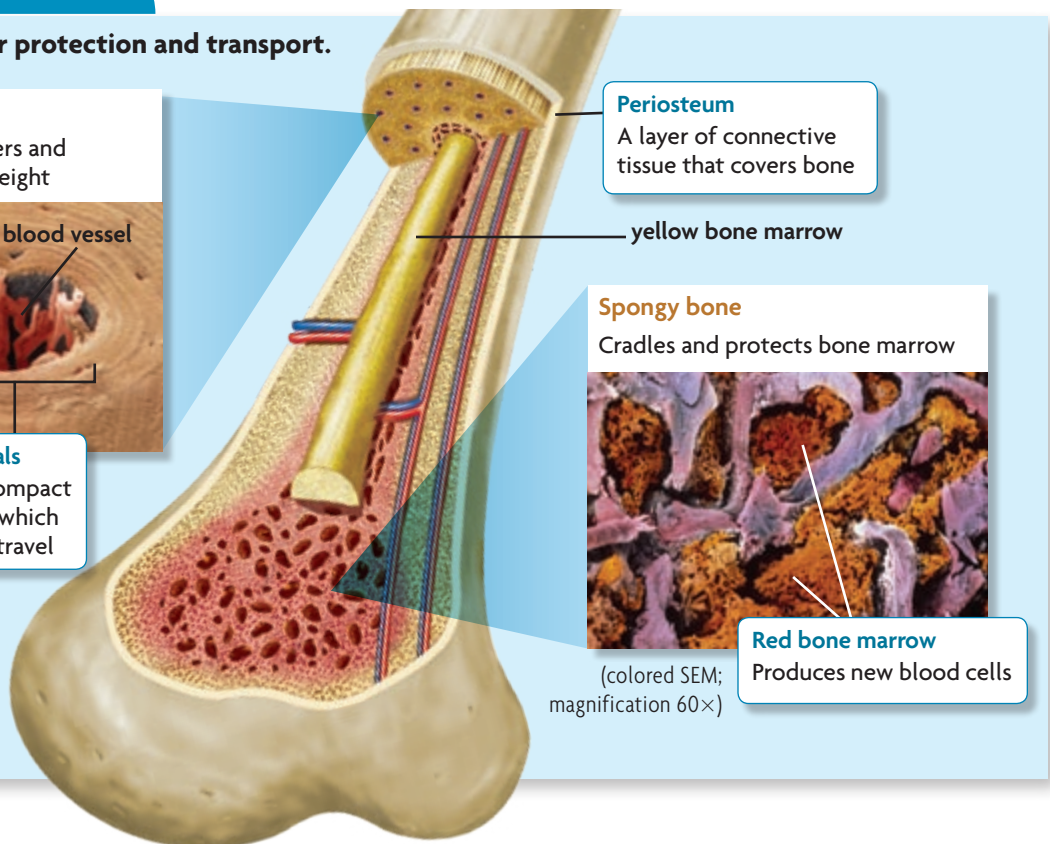


#### Haversian canals

Holes in the compact bone through which blood vessels travel

(colored SEM; magnification 250×)

**Analyze** How do both compact bone and spongy bone protect parts of the circulatory system?



#### Periosteum

A layer of connective tissue that covers bone

yellow bone marrow

#### Spongy bone

Cradles and protects bone marrow



#### Red bone marrow

Produces new blood cells

(colored SEM; magnification 60×)

Yellow marrow is mostly fat, but it can change back into red marrow and produce blood cells if the body suddenly loses blood.

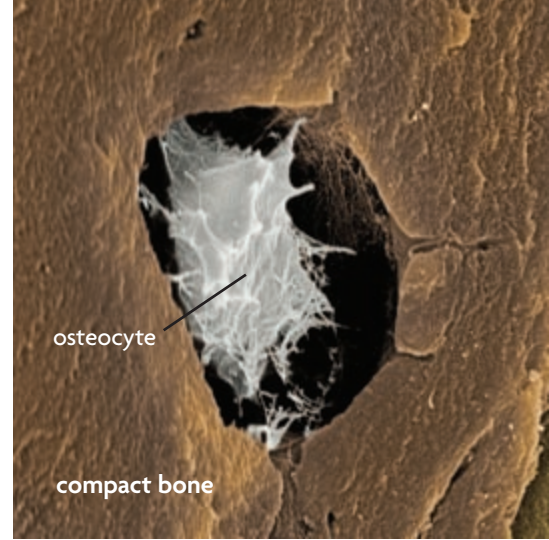
## Bone Growth

Human embryos do not have bones at first. Instead, when they are developing, their skeletal system is made mostly of cartilage. Over time, the flexible cartilage becomes hardened bone.

Bones form when cells called osteoblasts secrete chemicals that cause cartilage to harden. Osteoblasts release a mixture of collagen, a strong fibrous connective tissue, and calcium phosphate, a mineral that hardens the collagen. The process of creating hard bone by combining collagen and calcium phosphate is called **calcification**. Once bone calcifies, the trapped osteoblast is called an osteocyte, shown in **FIGURE 1.5**.

Bones grow from their ends, where the cartilage is located. After birth, two bands of cartilage remain at either end of the bone. Until puberty, children's bones grow longer, wider, and thicker. In adolescence, sex hormones stimulate bones to become more dense. Bones are strongest when a person is between 18 and 30 years old. After that, bones lose density because calcium is taken from the bones and used elsewhere in the body.

Depositing and removing calcium from bones is a continual process that reshapes bones and helps maintain chemical homeostasis in the body. New bone can be created by osteoblasts to heal fractures even after a person matures and the bones stop growing. Bones also serve as storage areas for calcium that the body uses in many metabolic activities such as muscle movement, which you will read about in Section 2. Calcium removal from and deposit into bones is regulated by calcitonin, a hormone produced by the thyroid gland, and parathyroid hormone (PTH), which is produced by the parathyroid gland. Calcitonin stimulates osteoblasts to remove calcium from the blood and deposit it in bone. PTH stimulates other bone cells called osteoclasts to remove calcium from bone and make it available for use in the body.



**FIGURE 1.5** Osteocytes are specialized bone cells that have produced compact bone. (colored SEM; magnification 4500×)

**Infer** How are Haversian canals important to the function of spongy bone?

## 33.1 Formative Assessment

### REVIEWING MAIN IDEAS

1. What are the differences between the **axial skeleton** and the **appendicular skeleton**?
2. How are **ligaments** and **cartilage** functionally similar in **joints**?
3. How is **calcification** important for growth and protection?

### CRITICAL THINKING

4. **Analyze** Some scientists say that a person's bones will never contain more calcium than they had when the person was 18 years old. How might they explain this hypothesis?
5. **Compare and Contrast** How are the joints of the axial skeleton similar to and different from the joints of the appendicular skeleton?



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PREMIUM CONTENT



### CONNECT TO

#### NERVOUS SYSTEM

6. **Vertebrae** protect the spinal cord, the organ that sends messages to and gets messages from the brain. Why do you think it is beneficial for vertebrae to have cartilaginous joints that limit movement?