Bone and cartilage are the principal tissues that provide support for the body; together they make up the skeletal system. The early skeleton is formed largely from cartilage. Later, the cartilage is replaced almost entirely by bone. Bones provide attachments for muscles and act as levers for the movements of body parts. Bones perform additional essential functions. They are the sites for blood cell formation and are storage depots for many substances, such as fat, calcium, and phosphorus.

Bone tissue has an intricate architecture that is both stable and dynamic. Although it has great strength and rigidity, bone tissue is able to change structurally in response to a variety of chemical and mechanical factors.

Chapter 6 topics for student review include an overview of skeletal cartilages, the structures of long and flat bones, the remodeling and repair of bone, and bone development and growth.

**Building the Framework**

**Skeletal Cartilages**

1. Use the key choices to identify the type of cartilage tissue found in the following body locations:

   - **Key Choices**
   - A. Elastic cartilage  
   - B. Fibrocartilage  
   - C. Hyaline cartilage

1. At the junction of a rib and the sternum

2. The skeleton of the external ear

3. Supporting the trachea walls

4. Forming the intervertebral discs

5. Forming the epiglottis

6. At the ends of long bones

7. Most of the fetal skeleton

8. Knee menisci
2. In comparing bone and cartilage tissue, indicate whether each of the following statements is true (T) or false (F).

   T  1. Cartilage is more resilient than bone. (176 - High water content accounts for resilience - ability to spring back to original shape after being compressed)

   F  2. Cartilage is especially strong in resisting shear (bending and twisting) forces.

   T  3. Cartilage can grow faster than bone in the growing skeleton.

   F  4. In the adult skeleton, cartilage regenerates faster than bone when damaged.

   T  5. Neither bone nor cartilage contains capillaries.

   F  6. Bone tissue contains relatively little water compared to cartilage tissue, which contains a large amount of water.

   F  7. Nutrients diffuse quickly through cartilage matrix but very poorly through solid bone matrix.

3. What single structural characteristic accounts for the resilience of cartilage and its ability to grow rapidly in the developing skeleton?

   Cartilage contains a large amount of water and can accommodate mitosis (184)

Functions of the Bones

1. List and explain five important functions of bones. Write your answers in the answer blanks below.

   1. Support - provides framework to cradle soft organs

   2. Protection - skull: brain, vertebra: spinal cord, ribs: organs

   3. Movement - act as levers for muscles to pull


   5. Blood cell formation: occurs in marrow cavities

Classification of Bones

1. Identify each of the following bones as a member of one of the four major bone categories. Use L for long bone, S for short bone, F for flat bone, and I for irregular bone. Enter the appropriate letters in the answer blanks.

   S  1. Calcaneus (A45)

   F  2. Frontal (A05)

   L  3. Femur (A41)

   L  4. Humerus (A31)

   L  5. Mandible (A06)

   L  6. Metacarpal (A35)

   7. Radius (A23)

   8. Sternum (A06)

   9. Vertebra (A01, A20)
Bone Structure

1. Figure 6.1A is a drawing of a sagittal section of the femur. Do not color the articular cartilage. Leave it white. Select different colors for the bone regions listed at the coding circles below. Color the coding circles and the corresponding regions on the drawing. Complete Figure 6.1A by labeling compact bone and spongy bone.

Figure 6.1B is a mid-level, cross-sectional view of the diaphysis of the femur. As in A, identify by color the area where yellow marrow is found. Label the membrane that lines the cavity and the membrane that covers the outside surface. Indicate by an asterisk (*) the membrane that contains both osteoblasts and osteoclasts.

- Diaphysis
- Area where red marrow is found
- Epiphyseal plate
- Area where yellow marrow is found

Figure 6.1
* contains both osteoblasts and osteoclasts
2. Using the key choices, characterize the following statements relating to the structure of a long bone. Enter the appropriate answers in the answer blanks.

**Key Choices**

A. Diaphysis  
B. Epiphyseal plate  
C. Epiphysis  
D. Red marrow  
E. Yellow marrow cavity

1. Location of spongy bone in an adult's bone  
2. Location of compact bone in an adult's bone  
3. Site of hematopoiesis in an adult's bone  
4. Scientific name for bone shaft  
5. Site of fat storage  
6. Region of longitudinal growth in a child  
7. Composed of hyaline cartilage until the end of adolescence

3. Figure 6.2 is a sectional diagram showing the five-layered structure of a typical flat bone. Select different colors for the layers below. Add labels and leaders to identify Sharpey’s fibers and trabeculae. Then answer the questions that follow, referring to Figure 6.2 and inserting your answers in the answer blanks.

![Figure 6.2](image-url)
1. Which layer is called the diploe? **The spongy bone**

2. Name the membrane that lines internal bone cavities. **Endosteum**

3. Five descriptions of bone structure are provided in Column A.

   First, identify the structure by choosing the appropriate term from Column B and placing the corresponding answer in the answer blank.

   Second, consider Figure 6.3A, a diagrammatic view of a cross section of bone, and Figure 6.3B, a higher-magnification view of compact bone tissue. Select different colors for the structures and bone areas in Column B and use them to color the coding circles and corresponding structures on the diagrams. Since concentric lamellae would be difficult to color without confusing other elements, identify one lamella by using a bracket and label.

   **Column A**

   1. Layers of calcified matrix
   2. "Residues" of osteocytes
      
   3. Longitudinal canal, carrying blood vessels and nerves
   4. Nonliving, structural part of bone
   5. Tiny canals connecting lacunae

   **Column B**

   A. Central [Haversian] canal
   B. Concentric lamellae
   C. Lacunae
   D. Canaliculi
   E. Bone matrix
   F. Osteocyte

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**Figure 6.3**
5. Classify each of the following terms as a projection (P), a depression (D), or an opening (O). Enter the appropriate letter in the answer blanks.


6. Circle the term that does not belong in each of the following groupings.
   1. Ridity  Calcium salts  Hydroxyapatites  Collagen  Hardness
   2. Hematopoiesis  Red marrow  Yellow marrow  Spongy bone  Diploë
   3. Lamellae  Cellular extensions  Canaliculi  Circulation  Osteoclasts
   4. Osteon  Marrow cavity  Volkmann’s canals  Haversian canal  Canaliculi
   5. Epiphysis  Articular cartilage  Periosteum  Hyaline cartilage
   6. Perichondrium  Periosteum  Appositional growth  Osteoblasts
   7. Spongy  Cancellous  Woven  Lamellar  Trabecular

1. Using the key choices, insert the correct answers in the answer blanks below.

**Key Choices**

A. Atrophy  C. Gravity  E. Osteoclasts  G. Parathyroid hormone
B. Calcitonin  D. Osteoblasts  F. Osteocytes  H. Stress and/or tension

- **G. Parathyroid hormone** 1. When blood calcium levels begin to drop below homeostatic levels, [1] is released, causing calcium to be released from bones. (188)
- **F. Osteocytes** 2. Mature bone cells, called [2], maintain bone in a viable state.
- **A. Atrophy** 3. Disuse such as that caused by paralysis or severe lack of exercise results in muscle and bone [3].
- **H. Stress and/or tension** 4. Large tubercles and/or increased deposit of bony matrix occur at sites of [4].
- **D. Osteoblasts** 5. Immature, or matrix-depositing, bone cells are referred to as [5].
- **B. calcitonin** 6. [6] causes blood calcium to be deposited in bones as calcium salts.
- **E. Osteoclasts** 7. Bone cells that liquefy bone matrix and release calcium to the blood are called [7].
- **C. Gravity** 8. Astronauts must perform isometric exercises when in outer space because bones atrophy under conditions of weightlessness or lack of [8].
3. According to Wolff's law, bones form according to the stresses placed upon them. Figure 6.5 is a simple diagram of the proximal end of a femur (thighbone). There are two sets of double arrows and two single arrows. Your job is to decide which of the single or paired arrows represents each of the following conditions and indicate those conditions on the diagram. Color the arrows to agree with your coding circles.

- Orange: Site of maximal compression
- Blue: Load (body weight) exertion site
- Green: Site of maximal tension
- Purple: Point of no stress

Explain why long bones can “hollow out” without jeopardy to their integrity (soundness of structure).

A bone is loaded (stressed) whenever weight bears down on it or muscles pull on it. This loading is usually off center, however, and tends to bend the bone. Both the compression and stretching forces are minimal toward the center of the bone (they cancel each other out), so a bone can “hollow out” for lightness — use spongy bone instead of compact bone.

Also

1. Long bones thickest midway along diaphysis (where stresses greatest)
2. Curved bones thickest where most likely to buckle
3. Trabeculae of spongy bone form trusses, or struts, along lines of compression
4. Large, bony projections occur where heavy, active muscles attach

Figure 6.5
4. Figure 6.4 is a diagram representing the histological changes in the epiphyseal plate of a growing long bone.

First, select different colors for the types of cells named below. Color the coding circles and the corresponding cells in the diagram.

- Region of ossification
- Dividing cartilage cells
- Older, enlarging, vesiculating cells

Second, identify bracketed zones A–D on the diagram as: growth, ossification, hypertrophic, or calcification.

Third, complete the statements on page 129, referring to Figure 6.4 and the labeled regions on the diagram. Insert the correct words in the spaces provided.

![Diagram of epiphyseal plate](image-url)
4. Use the key choices to identify the fracture (fx) types shown in Figure 6.6 and the fracture types and treatments described below. Enter the appropriate answer in each answer blank.

**Key Choices**

A. Closed reduction  
B. Comminuted fracture  
C. Compression fracture  
D. Compound fracture  
E. Depressed fracture  
F. Greenstick fracture  
G. Open reduction  
H. Simple fracture

1. Bone is broken cleanly; the ends do not penetrate the skin
2. Nonsurgical realignment of broken bone ends and splinting of bone
3. Bone breaks from twisting forces
4. A break common in children; bone splinters, but break is incomplete
5. A fracture in which the bone is crushed; common in the vertebral column
6. A fracture in which the bone ends penetrate through the skin surface
7. Surgical realignment of broken bone ends
8. A common type of skull fracture
9. Also called a closed fracture
10. A common sports fracture
11. Often seen in the brittle bones of the elderly
5. For each of the following statements about bone breakage and the repair process that is true, insert T in the answer blank. For false statements, correct the underlined words by inserting the correct words in the answer blanks.

1. A **hematoma** usually forms at a fracture site.  
   - **T**

2. Deprived of nutrition, **osteocytes** at the fracture site die.  
   - **T**

3. Nonbony debris at the fracture site is removed by **fibroblasts**.

4. Osteocytes produce collagen fibers that span the break.

5. Osteoblasts from the **medullary cavity** migrate to the fracture site.

6. The **fibrocartilaginous callus** is the first repair mass to splint the broken bone.

7. The bony callus is composed of **compact** bone.