Bones are composed of a complex arrangement of several tissues. A typical bone has two types of osseous tissue: compact and spongy. In addition, bones are composed of connective tissue forming membranes, marrow, cartilage, adipose tissue, nerves, and blood vessels. The study of body structure and disorders is called osteology.

**A. Classification of Bones**

The bones of the human body have different shapes and distinct gross anatomical features. Bones are placed in five classifications according to their shapes: long, short, flat, irregular, and sesamoid. Long bones are longer than they are wide, short bones are almost equal in length and width, flat bones are thin and relatively flat but may be curved, irregular bones are self-explanatory and do not fit into any of these categories, and sesamoid bones are small bones that develop in tendons for protection against wear and tear (ex: patella).

**ACTIVITY 1 CLASSIFICATION OF BONES ACCORDING TO SHAPE**

1. Identify the types of bones (long, short, flat, irregular, and sesamoid) labeled a-e on ‘Isaac’ according to shape.
   a. ______________________
   b. ______________________
   c. ______________________
   d. ______________________
   e. ______________________

**B. Gross Features of Long Bones**

The enlarged proximal and distal ends of long bones are called epiphyses, and the middle shaft area composed of compact bone is called the diaphysis. The area of the epiphysis where the bone grows in length is called the epiphyseal plate in a growing bone and the epiphyseal line in a bone that is adult size. The cavities within the spongy bone of the epiphyses contain red bone marrow, a tissue producing blood cells. Articular cartilage, composed of hyaline cartilage, covers both epiphyses, and the rest of the bone exterior is covered with a tough, connective tissue membrane, the periosteum. The hollow center of the bony diaphysis is called the medullary cavity, and a small amount of spongy bone is found in this cavity. The medullary cavity is lined with a connective tissue membrane called endosteum, and is filled with a fatty substance called yellow bone marrow. The endosteum also lines the cavities within the spongy bone of the epiphyses. Both the periosteum and endosteum contain osteoblasts and osteoclasts for bone formation, as well as bone tissue repair.

**ACTIVITY 2 GROSS FEATURES OF A LONG BONE**

1. Label Figure 6.1 on the next page.
C. Structure of Compact and Spongy Bone Tissue

Compact bone is composed of repeating units of osteons, with each unit having a central canal running longitudinally. The central canal contains blood vessels, lymphatic vessels, and nerves that serve compact bone tissue. The blood vessels, lymphatic vessels, and nerves travel from the periosteum, dense regular connective tissue covering the bone surface, to the central canal through the perforating canals. These canals run horizontally in compact bone and connect with the central canal. The main feature of each osteon is the concentric rings, or concentric lamellae, that look similar to the rings of a tree trunk cut in cross-section. When viewed on a stained slide of compact bone, there are dark areas with thin lines extending between the lamellae. The dark areas are lacunae, that are found between concentric lamellae, and the thin lines are canaliculi connecting the lacunae. Osteocytes are the bone cells that reside in the lacunae, and canaliculi allow nutrients from the blood vessels in the central canal to diffuse to the ostecytes embedded in the solid bone material. The canaliculi are also the route by which

- Articular cartilage
- Compact bone
- Diaphysis
- Distal epiphysis
- Endosteum
- Epiphyseal plate
- Medullary cavity
- Nutrient artery
- Periosteum
- Proximal epiphysis
- Spongy bone
- Yellow bone marrow
waste materials are removed from these cells. Interstitial lamellae fill in the spaces between the osteons.
Spongy bone does not have the concentric units of osteons and central canals, but instead has trabeculae, flat plates with latticework network of spiny projections. Spongy bone has many spaces filled with red bone marrow that provide the osteocytes with nutrients. Because this bone is not dense, spongy bone needs the protection of a thin, outer layer of compact bone. Spongy bone is found mostly in the epiphyses of long bones and in the middle of flat bones.

**ACTIVITY 3 STRUCTURE OF GROUND COMPACT BONE AND SPONGY BONE**

1. Label the structures on Figure 6.2a, Figure 6.2b, Figure 6.3a, and Figure 6.4b.

![Combined cross-section and longitudinal section of bone.](image)

<table>
<thead>
<tr>
<th>Structure</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood vessels</td>
<td>1.</td>
</tr>
<tr>
<td>Canaliculi</td>
<td>2.</td>
</tr>
<tr>
<td>Central canal</td>
<td>3.</td>
</tr>
<tr>
<td>Compact bone</td>
<td>4.</td>
</tr>
<tr>
<td>Concentric lamellae</td>
<td>5.</td>
</tr>
<tr>
<td>Lacunae</td>
<td>6.</td>
</tr>
<tr>
<td>Osteocyte</td>
<td>7.</td>
</tr>
<tr>
<td>Osteon</td>
<td>8.</td>
</tr>
<tr>
<td>Perforating canal</td>
<td>9.</td>
</tr>
<tr>
<td>Periosteum</td>
<td>10.</td>
</tr>
<tr>
<td>Spongy bone</td>
<td>11.</td>
</tr>
<tr>
<td>Trabeculae of spongy bone</td>
<td>12.</td>
</tr>
</tbody>
</table>
D. Chemical Composition of Osseous Tissue

The properties of osseous tissue are determined by its extracellular matrix which contains approximately 25% water, 25% protein fibers, and 50% mineral salts. Collagen fibers provide tensile strength and flexibility so bone does not break with normal stress. The mineral salts consist mainly of phosphate and calcium carbonate salts, giving the “backbone” or hardness to bone. As we age, the collagen content of osseous tissue decreases, causing bones to become brittle and break more easily. Decreased mineral content of bone, as occurs with rickets, causes bone to be soft and to bend due to body weight.

ACTIVITY 4 CHEMICAL COMPOSITION OF BONE

1. With your group, examine a long chicken bone baked at 250° for a minimum of two hours or until brittle. Compare what happens when you try to bend a treated and untreated bone.
   - What has happened to the flexibility of the bone?
   - What substance from this bone has been effected?
• What clinical disorder with bone brittleness is this activity simulating?

2. Examine a long chicken bone that has been soaked in an acidic solution. Try bending the bone and compare this with an untreated bone and the baked bone.
   • What has happened to the hardness of this bone?
   • What substance has been leached from this bone?
   • What clinical disorder with bone softness is this activity simulating?

E. Three Types of Cartilage
Cartilage is distinctly different from bone tissue in that cartilage has no blood vessels or nerves and therefore takes longer to heal than bone. Similar to bone, cartilage has oval-shaped lacunae with cartilage cells or chondrocytes inside. The perichondrium, a connective tissue covering, surrounds cartilage similar to the periosteum of bone. Cartilage is composed of both living cells and nonliving matrix secreted by chondrocytes, and is composed of a gel-like ground substance, fibers, and water. The two fiber types, collagen and elastin, give the three types of cartilage their different microscopic appearances. Hyaline cartilage is the most prominent type of cartilage in the body and contains collagen fibers that are thin and not visible with a compound microscope. This cartilage type appears glassy to the eye, and under the compound microscope its matrix appears smooth and homogeneous. Hyaline cartilage is found at the end of bones (articular cartilage), attaching ribs to the sternum (costal cartilage), in the nose (nasal cartilage), and in the trachea and bronchi (tracheal and bronchial cartilages). The matrix of hyaline cartilage makes it resilient with good support. Elastic cartilage is similar to hyaline cartilage, except the matrix is packed with elastic fibers. The many elastic fibers allow this cartilage to be flexible. Fibrocartilage has fewer lacunae and chondrocytes and its extracellular is packed with thick collagen fibers that give it tensile strength similar to dense regular connective tissue. Under the microscope, collagen fibers are the most prevalent structures seen. This cartilage type is found in intervertebral discs and also in the knee menisci.

ACTIVITY 5 THE STRUCTURE, FUNCTION, AND LOCATION OF CARTILAGE
1. Label the three types of cartilage in Figure 6.4 on the next page.
2. Obtain a chicken leg and scapel, forceps, and dissecting pan. Dissect your chicken leg and obtain a small piece of cartilage. See pictures in Figure 6.5 to ascertain where the cartilage will be found. You will need to make a very thin razor cut into the cartilage to obtain a piece of it. Place the section in Lugol's iodine solution on a microscope slide and examine it under high power. If glycogen is present in the cartilage, it will stain a mahogany red color. The elastic fibers will stain a different shade of brown. Draw and label a few cells in the circle provided below.
A. Gross Features of Long Bones

Complete the sentences with the correct word or words.

1. What area of the long bone is covered with cartilage? ________________________

2. What type of cartilage is articular cartilage? ________________________

3. What area (epiphysis or diaphysis) is made up of a thin layer of compact bone and thick spongy bone? ________________________

4. What area (epiphysis or diaphysis) is made up of a thick layer of compact bone and a very thin layer of spongy bone? ________________________

5. The long bone in Figure 6.2 is from an adult. If this figure was from a child, what structure would be present instead of the epiphyseal plate? ________________________

B. Microscopic Features of Long Bones

Identify the term that describes the phrase about long bones.

1. The type of bone cell that is found in the osteons of compact bone

2. The space where the osteocytes are located

3. Small canal that takes oxygen and nutrients to the osteocytes

4. Bone shaft

5. Vertical canal in an osteon

6. Horizontal canal in an osteon

7. Cavity that contains yellow marrow in adults

8. Membrane lining medullary cavity

9. Membrane covering surface of bone

10. Spiny projections in spongy bone
C. Comparison of Compact and Spongy Bone

Identify whether the statements below describe compact bone, spongy bone, or both.

1. composed of osteons
2. contains osteocytes and lacunae
3. has lamellae
4. has trabeculae
5. has red marrow
6. located in the epiphyses
7. located in the diaphysis
8. has a central canal
9. spaces filled with red marrow
10. has canaliculi

D. Chemical Composition of Bone

1. The hardness of bone is due to _____.
2. The flexibility and tensile strength of bone are due to _____.
3. What type of a macromolecule (carbohydrate, lipid, protein) is collagen?
4. A bone that has the collagen removed is flexible or inflexible?
5. A bone that has calcium removed is flexible or inflexible?
E. Cartilage Locations

Match the cartilages with the correct location.

a. elastic cartilage
b. fibrocartilage
c. hyaline cartilage

___ 1. knee cartilage
___ 2. articular cartilage
___ 3. external ear
___ 4. epiglottis
___ 5. larynx
___ 6. intervertebral discs

F. Cartilage Functions

Match the description or function with the correct cartilage type.

a. elastic cartilage
b. fibrocartilage
c. hyaline cartilage

___ 1. Gives padding and strength
___ 2. Gives flexibility and capability to bend
___ 3. Has resilience and “give”
___ 4. Has mostly collagen fibers and some lacunae with chondrocytes
___ 5. Has many short, elastic fibers in the matrix
___ 6. Matrix is smooth and homogeneous looking
USING YOUR KNOWLEDGE

A. Bone Tissue

Fill in the blank with the correct term.

1. Two bone cells located in the periosteum and endosteum are ______________________ and ________________

2. Which type of bone tissue, compact bone or spongy bone, significantly degenerates first in osteoporosis? ______

3. As we age, the amount of collagen in the extracellular matrix of bone decreases and bones become more brittle.
   Identify the osseous tissue cell that secretes collagen. __________________________

4. Explain the importance of the integumentary system to bone formation.

B. Bone Images

Identify the structures indicated on Figure 6.7 and Figure 6.8.

**FIGURE 6.7** Longitudinal section of a long bone.

5. ______________________________________
6. ______________________________________

**FIGURE 6.8** X-ray of a child’s knee joint.

7. ______________________________________
8. ______________________________________