*COLORING EXERCISE*

Using colored pens or pencils, shade in the figure and accompanying labels in contrasting colors of your choice as indicated by the red numerals.

## Long Bone

### GROSS STRUCTURE

EPIPHYSIS 1
EPIPHYSEAL PLATE 2
DIAPHYSIS 3
PERIOSTEUM 4
ARTICULAR CARTILAGE 5
MEDULLARY CAVITY 6
ENDOSTEUM 7
CANCELLOUS BONE 8
COMPACT BONE 9
BLOOD VESSEL 10

**Fill-in** (complete each item with the correct term)

1. Tiny round specks of bone found in a tendon are often called __?__ bones.
2. The fibrous covering of a long bone is called the __?__.
3. The shaft portion of a long bone is termed the __?__ of the bone.
4. The head region on the end of a long bone shaft is the __?__.
5. The __?__ on the outside of the long bone is made of hyaline cartilage.
6. Yellow bone marrow is made of __?__ tissue.
7. A bone that is as long as it is wide is classified as a __?__ bone.
8. When classified according to shape, the pelvic bone is considered to be __?__.
9. A human skeleton that is taken apart is called a(n) __?__ skeleton.
10. There are __?__ bones in a *standard* human skeleton.
11. The bones of the upper and lower extremities compose the __?__ skeleton.
12. Red bone marrow is associated with __?__ bone tissue.
13. The __?__ cartilage articulates with another bone or bone process.
14. When classified according to shape, the femur is a(n) __?__ bone.
15. The __?__ is the central space of the long bone.

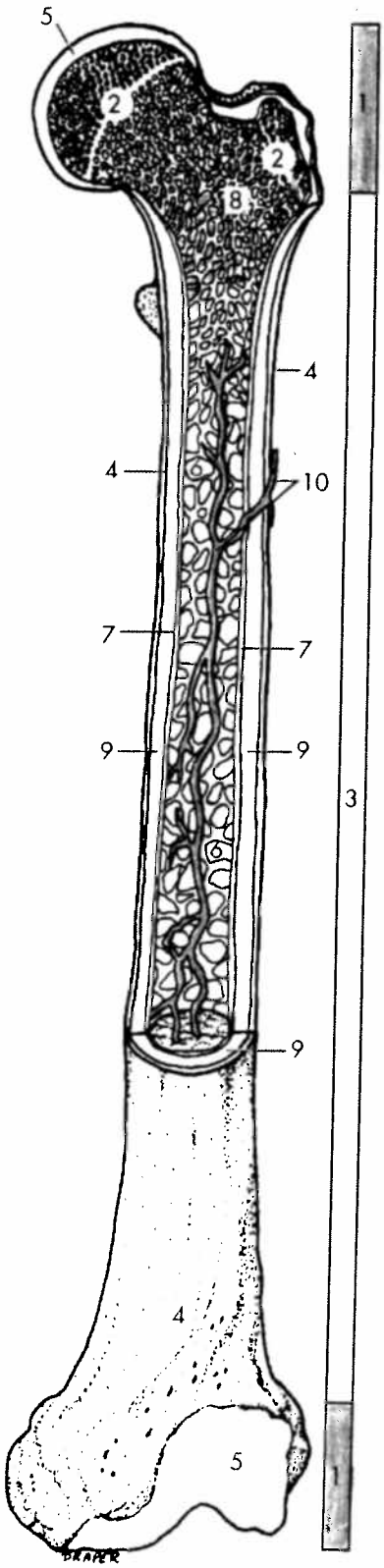


Figure 11-3 Structures of the long bone.

Name: _____ Date: _____ Section: ____

LAB REPORT 11

# Overview of the Skeleton

Multiple Choice

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Figure 11-5

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____

## Multiple Choice (only one response is correct)

1. The inner lining of the medullary cavity is
   a. made of compact bone
   b. called the *endosteum*
   c. called the *periosteum*
   d. a and c are correct

2. Which of these tissues is present in a typical long bone?
   a. blood tissue
   b. cancellous bone
   c. compact bone
   d. dense fibrous tissue
   e. hyaline cartilage
   f. all of the above

3. In the coloring figure of the long bone, the epiphyseal plate is shown. What the reason for its presence?
   a. it is scar tissue from a previous fracture
   b. it is an area of growth between the epiphysis and diaphysis during bone development
   c. it is callous tissue from overuse of the bone
   d. it is the site of a current fracture

4. The human skeleton functions to
   a. produce blood tissue
   b. store fat and minerals
   c. protect vital organs
   d. allow movement of the body
   e. provide a supporting framework
   f. all of the above

5. Your physician has just informed you that you have 40 bones in your skull. This means
   a. you have the standard number of skull bones
   b. you have some sesamoid bones in your skull
   c. you have some sutural bones in your skull
   d. you are missing some skull bones

6. The same physician tells you that all of your knee ligaments have been sever This means that
   a. your leg bones are not being held together very well
   b. your leg muscles have become separated from the bone
   c. your patella (kneecap) is fractured
   d. your femur (thigh bone) is fractured

LAB EXERCISE 11

# Overview of the Skeleton

This exercise is the first of several concerning the *skeletal system.* The skeletal system's major organs are the **bones** and **ligaments.** Ligaments are simply cords of regular dense fibrous tissue that bind the bones to one another. Bones are more complex in their structure, so we will spend some time investigating the nature of a typical bone. Before we move on to a detailed study of all the bones of the skeleton, we will survey the basic plan of the skeleton.

Investigation of the gross and microscopic structure of the typical bone and of the basic skeletal plan will be sound preparation for the exercises that follow.

## Before you begin

- ❑ Read the appropriate sections in Chapters 7 and 8 in your textbook.

- ❑ Set your learning goals. When you finish this exercise, you should be able to
  - ❑ describe the organs of the skeletal system
  - ❑ describe the gross and microscopic structure of bone tissue
  - ❑ list the primary functions of the skeletal system
  - ❑ outline the organization of the skeletal system

- ❑ Prepare your materials:
  - ❑ microscope
  - ❑ prepared microslides:
    Compact bone (ground bone) c.s.
    Cancellous bone
    Epiphyseal plate c.s.
  - ❑ human skeleton (disarticulated)
  - ❑ human skeleton (articulated)
  - ❑ long bone (fresh, whole)
  - ❑ whole long bone (fresh, l.s.)

- ❑ Read the directions and safety tips for this exercise **carefully** before starting any procedure.

**HINT**

The concepts of this exercise will be easier to understand if you briefly review the microscopic organization of bone tissue presented in Exercise 8.

## A. Bone types

The 206 bones in the standard human skeleton can be cl fied by their shapes. The best way to learn this classifica scheme is by trying to classify the bones yourself, as out lined in the following steps.

- ❑ **1** Unpack the bones of a disarticulated (taken apa human skeleton and spread the bones over your work place.

- ❑ **2** Divide the group of bones into four piles, accord to the categories given here. Do not use books o other aids to help you.
  - ❑ **Long bones** are cylindrical bones that are lor than they are wide.
  - ❑ **Short bones** are as long as they are wide, sor times having an almost cuboidal shape.
  - ❑ **Flat bones** arise when bone tissue invades ar hardens fibrous membranes, so they are sheetlik shape. They are usually curved, rather than ab- solutely flat.
  - ❑ **Irregular bones** don't quite fit any of the oth categories because of the complexity of their sha

- ❑ **3** Compare your results to the results of others in lab section. Does everyone agree?

## B. Gross structure of a bone

All bones have the same general structural pattern. Som bones have more "optional features" than other bones, s less. The long bone is often used as a general specimen study because it has all the features that any bone can h

**SAFETY FIRST!**

Because fresh animal tissues at room temperature harbor dangerous bacterial colonies, specimens sho only be handled when wearing disposable, nonpor gloves.

- ❑ **1** Obtain fresh long bone specimens from a large animal. One should be whole (uncut), and the o cut along its long axis (longitudinal section, l.s.).

- ❑ **2** Examine the external aspect of a whole bone. Fi the features described.

❑ **Ligament**—Although actually a separate organ, some bits of these fibrous straps that hold bones together may still be attached to your specimen.
❑ **Periosteum**—The periosteum is a sheet of irregular dense fibrous connective tissue continuous with the ligaments. It covers the shaft and part of the heads of a long bone. Try to scrape some of the periosteum away from the underlying bone. How strongly is it attached?
❑ **Articular cartilage**—The articular cartilage is a smooth cap of hyaline cartilage found where the bone *articulates* (forms a joint) with another bone. Joints, or connections between bones, are often movable. Which function of the skeletal system benefits by the presence of movable joints?
❑ **Diaphysis**—The diaphysis is the whole central shaft of the long bone. Only the external part of the shaft, made of solid bone tissue, is visible from the external aspect. For what skeletal functions is the hard shell of the diaphysis specialized?
❑ **Epiphysis**—The epiphyses are the "heads" of a long bone, one proximal to the diaphysis, one distal. Only the external portions are visible in a whole specimen.

❑ 3 Use the sectioned bone specimen to identify the structures listed.
❑ **Medullary cavity**—The medullary cavity, as its name implies, is a space within the center of the diaphysis. The walls surrounding the space are made of both cancellous and compact bone. In the adult, the cavity generally contains *yellow bone marrow,* which is a mass of fatty tissue. What is the purpose of yellow marrow?
❑ **Endosteum**—The endosteum is a thin epithelial membrane that lines the medullary cavity.
❑ **Cancellous bone**—The epiphyses, like diaphyses, have a compact bone cortex, but the medulla is often different. The inside of each epiphysis has cancellous, or spongy, bone. The soft tissue in the spaces of the cancellous bone is often *red bone marrow,* which produces blood cells.

## C. Microscopic structure of a bone

The microscopic structure of the long bone reflects the general nature of any type of bone. As you learned in Exercise 8, there are two basic types of bone tissue within a bone organ: **compact bone** and **cancellous bone.** In this exercise, you will build on what you learned about these bone tissue types. Then you will be able to integrate this information with what you already know about the gross structure of bone so that you can see "the big picture" of bone structure and function.

**SAFETY FIRST!**
Avoid electrical hazards while using the microscope. Be sure to exercise care in dealing with broken glass slides. Do not reach for slides or other objects while you are looking into the ocular, or you may knock over something (or someone).

❑ 1 **Compact bone**—Compact bone is found mainly in the hard, outer shell of a bone organ. Compact bone tissue is formed by solid, cylindrical units called **osteons** packed tightly together. The osteon, or **Haversian system,** consists of multiple concentric layers of hard bone matrix, with cells sandwiched between each layer. This bone matrix is made up of collagen fibers encrusted with crystals of a calcium-containing mineral called *apatite.* Each layer of bone matrix is a **lamella** (plural *lamellae*). **Osteocytes** are literally trapped within lacunae between the lamellae. The osteocytes were once active **osteoblasts** but have trapped themselves in the solid matrix they formed. Notice in Figure 11-1 that the **periosteum** that surrounds each bone is made up of an inner layer that contains active osteoblasts and an outer layer of dense fibrous connective tissue. The lamellae are centered around the **central (Haversian) canal**'s blood vessels. There are also transverse canals connecting the central canals of adjacent osteons. These transverse canals are called **transverse** or **Volkmann's canals.** They are also sometimes called **perforating canals.** The osteocytes trapped within lacunae transport materials to and from the canal by way of tiny **canaliculi** ("small canals") that connect the osteo-

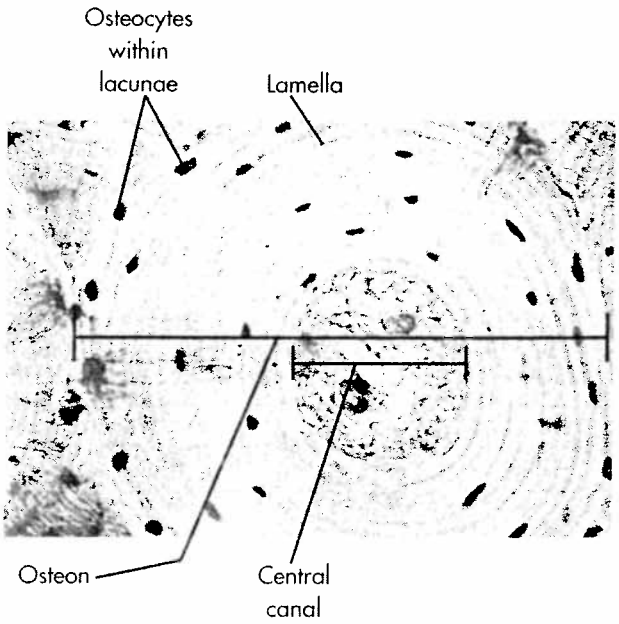


**Figure 11-1** Compact bone (ground bone) in cross section. High power.

cytes to each other and to the canal. Observe a prepared slide of ground bone (compact bone) and try to identify as many features as possible.

**LANDMARK CHARACTERISTICS**

A cross section of compact bone has rings of lamellae surrounding several adjacent Haversian, or *central,* canals. The lamellae resemble rings in an onion slice. The central canals are either clear or nearly black, the lamellae buff to orange, and the osteocytes brown or black. The canaliculi often appear as wavy hairlines radiating from the lacunae. See LABORATORY REFERENCE, Plate 22.

❑ 2 **Cancellous bone and hematopoietic tissue**—*Cancellous bone* is found in the inner portions of a bone organ. Cancellous bone is easily identified by its open, latticelike structure. Thin plates of bone matrix, with a scattering of osteocytes trapped within lacunae, form structural beams that have great strength despite the open spaces. These branching beams of hard bone are called **trabeculae.** Because cancellous bone has open spaces, it is sometimes called **spongy bone.** This name can be misleading because one might think spongy bone is as soft as a bath sponge; it is not soft at all because it has hard trabeculae. The spaces are filled with *hematopoietic* or *myeloid tissue,* a special type of blood tissue that produces new blood cells. Hematopoietic tissue is also called *red bone marrow.*

**LANDMARK CHARACTERISTICS**

Cancellous bone is distinguished by its rather disorganized array of trabecular beams of bone surrounded by myeloid tissue. The bone pieces may look like slivers of compact bone, with lamellae that often do not form complete circles. The myeloid tissue is a scattering of blood cells, which appear as tiny, dark circles. Myeloid (hematopoietic) tissue may also have a netlike formation of very thin collagen fibers called *reticular fibers.* In some preparations, the bone tissue is pink, and the myeloid cells are dark red. See LABORATORY REFERENCE, Plate 23.

❑ 3 **Epiphyseal plate**—Until a long bone has stopped growing in length, a layer of cartilage called the **epiphyseal plate** remains between each epiphysis and the diaphysis. During periods of growth, proliferation of epiphyseal cartilage cells brings about a thickening of this layer. **Ossification** (bone formation) of the additional cartilage nearest the diaphysis then follows; that is, osteoblasts make new bone matrix. As a result of this process, the bone becomes longer.

**LANDMARK CHARACTERISTICS**

The epiphyseal plate shown in Figure 11-2 is made up o four regions, each region in turn made of several layer of cells. The layer closest to the epiphysis (top of figur are not changing or growing, so are said to be at rest (r The letter p in the figure marks the *zone of proliferatio* which includes cells undergoing mitotic division. This where the plate becomes thicker. The letter h in the figu marks the *zone of hypertrophy,* where older, enlarged cel degenerate before calcification occurs in the *zone of calc fication* marked c in the figure. Below the zone of calcif cation, new cancellous bone can be seen. Typically, th epiphyseal plate is seen as a region of hyaline cartila separated from a region of cancellous bone by a region degenerating chondrocytes (cartilage cells) in lacun that seem to be "stacked" in roughly parallel colum (Figure 11-3).

## D. The plan of the skeleton

The usual number given for bones in the human skeleton 206. This is by no means the absolute normal number, ho ever. Most people have more bones, but each person has ferent types, locations, and numbers of "extra" bones. So people may be missing a bone or two. In this activity, you will examine both the standard 206 bones and the extra bones that may be present (Table 11-1, p.104).

❑ 1 Obtain an articulated (connected) human skeleton

❑ 2 The standard **axial skeleton** consists of 80 bones t form the central axis of the skeleton. These 80 bon

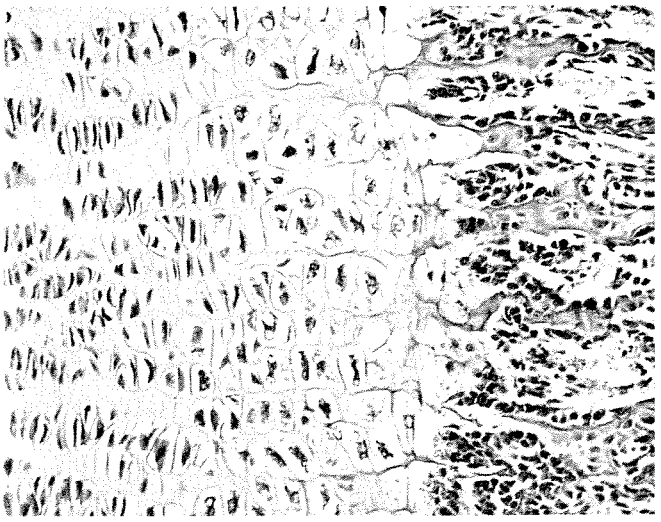

Figure 11-2 Detail of epiphyseal plate. Epiphyseal pl cartilage *at right* transforms into zones of proliferating ch drocytes with primary ossification occurring on their calcif remnants. Newly formed bone appears *at left* (50×).

include 28 skull bones, 1 unattached bone in the throat, 26 vertebrae, and 25 rib cage bones. Locate the bones of the axial skeleton in your specimen. Do not worry about learning the names of individual bones now. That will come later. For now, concentrate on "the big picture" of skeletal organization.

**SAFETY FIRST!**

Be cautious when handling the articulated skeleton. The bones or mounting hardware may become loose and fall from the support frame, injuring you or your lab mates.

❑ 3 Locate the bones of the **appendicular skeleton** in your specimen. The appendicular skeleton, comprising the 126 nonaxial bones, includes the bones of the appendages, or extremities (arms and legs). Sixty-four of these bones are in the *upper extremities* (shoulders and arms). Sixty-two bones are in the *lower extremities* (hips and legs).

❑ 4 Ask your lab instructor if there are any extra stan dard bones or any standard bones missing in yo specimen. What difficulties could such differenc have caused the individual during life?

❑ 5 Determine whether your specimen has any of th extra bone types typically found in skeletons (Figure 11-4):

❑ **Sesamoid bones** are so called because they resemble sesame seeds: tiny rounded specks. Sesamoid bones are often found within tendons of the hand and foot.

❑ **Wormian bones,** also called *sutural bones,* are bones that form in the sutures (joints) between th cranial bones of the skull.

## E. Bone markings and features

As you have already observed on your specimen, bones not generally have a smooth surface. There are many bumps, holes, and projections on the bones of the humar skeleton. These *bone markings* are named with terms that describe their shape and location. As a preview to the ne few exercises, review the terms used to name bone mark listed in Table 11-2.

**BONES OF SKELETON (206 TOTAL)*** Table 11-1

| Part of Body | Name of Bone |
|---|---|
| SKULL (28 BONES TOTAL) | |
| Cranium (8 bones) | Frontal (1)<br>Parietal (2)<br>Temporal (2)<br>Occipital (1)<br>Sphenoid (1)<br>Ethmoid (1) |
| Face (14 bones) | Nasal (2)<br>Maxillary (2)<br>Zygomatic (malar) (2)<br>Mandible (1)<br>Lacrimal (2)<br>Palatine (2)<br>Inferior conchae (turbinates) (2)<br>Vomer (1) |
| Ear bones (6 bones) | Malleus (hammer) (2)<br>Incus (anvil) (2)<br>Stapes (stirrup) (2) |
| HYOID BONE (1) | |
| SPINAL COLUMN (26 bones total) | Cervical vertebrae (7)<br>Thoracic vertebrae (12)<br>Lumbar vertebrae (5)<br>Sacrum (1)<br>Coccyx (1) |
| STERNUM AND RIBS (25 bones total) | Sternum (1)<br>True ribs (14)<br>False ribs (10) |
| UPPER EXTREMITIES (including shoulder girdle) (64 bones total) | Clavicle (2)<br>Scapula (2)<br>Humerus (2)<br>Radius (2)<br>Ulna (2)<br>Carpals (16)<br>Metacarpals (10)<br>Phalanges (28) |
| LOWER EXTREMITIES (62 bones total) | Coxal bones (2)<br>Femur (2)<br>Patella (2)<br>Tibia (2)<br>Fibula (2)<br>Tarsals (14)<br>Metatarsals (10)<br>Phalanges (28) |

*Excluding variable sesamoid and wormian bones.*

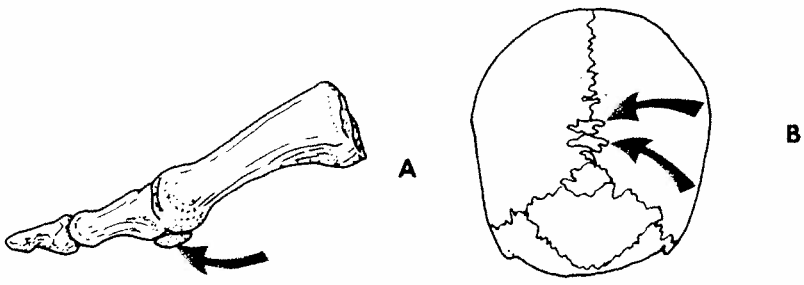


**Figure 11-4** **A,** Sesamoid bone at the base of the thumb. **B,** Wormian bones along a suture joint.

## BONE MARKINGS — Table 11

| Marking | Meaning |
|---|---|
| Angle | A corner |
| Body | The main portion of a bone |
| Condyle | Rounded bump; usually fits into a fossa on another bone, forming a joint |
| Crest | Moderately raised ridge; generally a site for muscle attachment |
| Epicondyle | Bump near a condyle; often gives the appearance of a "bump on a bump;" for a muscle attachment |
| Facet | Flat surface that forms a joint with another facet or flat bone |
| Fissure | Long, cracklike hole for blood vessels and nerves |
| Foramen | Round hole for vessels and nerves (pl. *foramina*) |
| Fossa | Depression; often receives an articulating bone (pl. *fossae*) |
| Head | Distinct epiphysis on a long bone, separated from the shaft by a narrowed portion (or neck) |
| Line | Similar to a crest but not raised as much (is often rather faint) |
| Margin | Edge of a flat bone or flat portion of an irregular bone |
| Meatus | Tubelike opening or channel (pl. *meati*) |
| Neck | A narrowed portion, usually at the base of a head |
| Notch | A V-like depression in the margin or edge of a flat area |
| Process | A raised area or projection |
| Ramus | Curved portion of a bone, like a ram's horn (pl. *rami*) |
| Sinus | Cavity within a bone |
| Spine | Similar to a crest but raised more; a sharp, pointed process; for muscle attachment |
| Sulcus | Groove or elongated depression (pl. *sulci*) |
| Trochanter | Large bump for muscle attachment (larger than tubercle or tuberosity) |
| Tubercle | Smaller version of a tuberosity |
| Tuberosity | Oblong, raised bump, usually for muscle attachment |