CHAPTER 7: THE SKELETAL SYSTEM

OBJECTIVES:

1. List and discuss the 6 functions of bone tissue.

2. Name the four classifications of bones by shape, and give an example of each.

3. Define the terms *sesamoid bone* and *Wormian bone* and give an example of each.

4. Illustrate the major features of a long bong including the following: diaphysis, epiphyses, epiphyseal line, periosteum, endosteum, medullary cavity, nutrient foramen and note the locations of spongy bone, compact bone, yellow marrow, red marrow and articular cartilage.

5. List the functions of the periosteum.

6. Compare and contrast the organic and inorganic components of bone matrix, in terms of structure and function.

7. List the terms that are synonymous with inorganic bone matrix.

8. Discuss the different types of bone cells in terms of origin, location and function.

9. Distinguish between compact bone and spongy bone, in terms of structure and function.

10. Discuss the Haversian System as the structural unit of compact bone using the following terms: osteocytes, lacunae, lamellae, Haversian canal, blood vessels, bone matrix, and canaliculi.

11. Explain how adjacent Haversian Systems communicate with one another (i.e. exchange nutrients, gases and wastes).

12. Discuss the significance of the spongy bone within a flat bone.

13. Define the term *hematopoiesis* and name the major skeletal locations where it occurs.

14. Name the important function that the trabeculae in spongy or cancellous bones allows for.

CHAPTER 7: THE SKELETAL SYSTEM

15. Define the term *ossification*.

16. Distinguish between intramembranous and endochondral ossification, and denote which parts of the skeleton are formed by each.

17. Discuss the structure (zones of) the epiphyseal plate, explain its significance, and discuss its fate.

18. Compare and contrast appositional bone growth and growth in the length in long bones.

19. Explain why ossification is a lifelong event.

20. List the vitamins and minerals involved in bone remodeling and discuss the action (and any resulting deficiency) of each.

21. List the major hormones involved in bone development and remodeling.

22. Compare and contrast the functions of osteoblasts and osteoclasts in bone remodeling.

23. Fully discuss the negative feedback mechanisms involved in blood calcium (Ca^{++}) homeostasis, and explain how this is related to bone remodeling.

24. Distinguish between the axial and appendicular skeleton.

25. Define the term *suture* and designate the major sutures on a diagram of the skull.

26. Name the eight bones that protect the brain (i.e. cranium).

27. Identify the 4 skull bones that contain paranasal sinuses and give two possible functions for sinuses.

28. Illustrate the location of the following structures, name the bone that each is part of, and name the significance of each: foramen magnum, sella turcica, crista galli, occipital condyles, external auditory meatus, mastoid process, nasal conchae, zygomatic process, cribriform (horizontal) plate, styloid process, and perpendicular plate.

29. Name the major bones that shape the face.

30. Name the facial bone that contains the temporal process and name the "arch" formed when this process articulates with the zygomatic arch of the temporal bone.

CHAPTER 7: THE SKELETAL SYSTEM

31. Name the seven bones that compose the orbit of the eye.

32. Explain how the nasal septum is actually composed of two different bones.

33. Identify the only skull bone which is not fused or locked in place, and name the joint at which it moves.

34. Describe the structure, location and function of the hyoid bone.

35. List the 5 major curvatures of the vertebral column and identify the number of vertebrae in each.

36. Name the substance that acts as a "shock absorber" between individual vertebra.

37. Denote the following structures on a diagram of a vertebra: body, spinous process, anterior, posterior, transverse processes, vertebral foramen, and vertebral arch.

38. List the components of the thoracic cage.

39. Distinguish between true, false, and floating ribs.

40. Distinguish between the manubrium, body and xiphoid process of sternum.

41. Name the bones that compose the pectoral (shoulder) girdle, and denote medial and lateral portions, glenoid cavity (fossa), coracoid process, acromion, spine, body, and inferior angle.

42. Name the bones in the upper limbs and denote them on a skeleton.

43. Distinguish between capitulum and trochlea, name the bone they are part of, and discuss their significance.

44. Given a humerus, denote the location of the proximal head, distal capitulum and trochlea, neck, greater and lesser tubercles, deltoid tuberosity, body, lateral and medial condyles, and olecranon fossa.

45. Note the relative positions of the radius and ulna, and name the significance of the olecranon (process).

46. Given a radius, denote the location of the head, neck, radial tuberosity, ulnar notch, and styloid process.

47. Given an ulna, denote the location of the olecranon process, trochlear notch, coronoid process, radial notch, head, and styloid process.

48. Identify the number of bones that make up the wrist, palm region of hand, and fingers, and give the scientific name for each.

49. Name the bones that compose the pelvic girdle, and denote the following features on each: ilium, ischium, pubis, iliac crest, aceulum, obturator foramen, and ischial spine.

50. Explain how the bones named above articulate anteriorly and posteriorly.

51. Name the tissue that composes the anterior articulation of the coxal bones.

52. Distinguish between a male and female pelvis, in terms of differences in the greater (false) pelvis, the pelvic brim (inlet), the pubic arch (angle), the acetabulum**.**

53. Name the longest, strongest, and largest bone in the body.

54. Given a femur, denote the location of the head, neck, greater and lesser trochanters, linea aspera, lateral and medial condyles, epicondyles, and patellar surface.

55. Identify the significance of trochanters.

56. Explain why the patella is unique.

57. Compare and contrast the structure, location and function of the tibia and fibula, and denote the location of the lateral and medial malleolus.

58. Identify how many bones compose the ankle, foot and toes, and give the scientific name for each.

59. Distinguish between the talus and calcaneus.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

I. INTRODUCTION

The organs of the skeletal system include the bones and the structures that connect bones to other structures, including ligaments, tendons, and cartilages.

II. FUNCTIONS OF BONE TISSUE (Discussed in more detail on pages 193-199)

A. **Support**

1. The bones in legs and pelvis support the trunk,
2. The atlas (1st vertebra) supports the skull, etc.,

B. **Protection** of underlying organs

1. The skull protects the brain,
2. The rib cage protects the heart and lungs, etc.,

C. **Movement**

1. Skeletal muscles attached to bones by tendons.
    a. serve as levers to move bones.

D. **Mineral Homeostasis**

1. Bone stores many minerals

    a. calcium,
    b. phosphorus
    c. others.

E. **Hematopoiesis**

1. Definition = Blood Cell Formation

    a. All blood cells are formed in the red marrow of certain bones.

F. **Energy Storage**

1. Yellow marrow in the shaft of long bones
2. serves as an important chemical energy reserve.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

III. CLASSIFICATION OF BONES: See Figure 7.1, page 186.

Bones are classified according to their **shape**:

A. **Long bones** consist of a shaft with two ends.

1. Examples include:

a. thigh bone = femur,
b. upper arm bone = humerus.

B. **Short bones** are cube-like.

1. Examples include:

a. wrist bones = carpals,
b. ankle bones = tarsals.

C. **Flat bones** are thin and usually curved.

1. Examples include:

a. most skull bones,
b. breast bone = sternum,
c. shoulder blades = scapulae,
d. ribs.

D. **Irregular bones** are not long, short, or flat.

1. Examples include:

a. vertebrae,
b. auditory ossicles.

Two other subcategories are also used to classify bones:

E. **Sesamoid bones** develop within a tendon.
1. The patella is the only human sesamoid bone.

F. **Wormian bones** (or sutural bones) are tiny bones within the skull that lie between major skull bones.
See Fig 7.16, page 199.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

IV. BONE STRUCTURE

A. Gross Anatomy = **typical long bone** (i.e. humerus):

See Figure 7.2, page 186 and Figure 7.3, page 187.

1. **Diaphysis** = shaft.

   a. consists of a central medullary cavity (filled with yellow marrow)
   b. surrounded by a thick collar of compact bone.

2. **Epiphyses** (pl) = expanded ends.

   a. consist mainly of spongy bone
   b. surrounded by a thin layer of compact bone.

3. **Epiphyseal line** = remnant of epiphyseal plate.

   a. cartilage at the junction of the diaphysis and epiphyses (growth plate).

4. **Periosteum** = outer, fibrous, protective covering of diaphysis.

   a. richly supplied with blood & lymph vessels, nerves (nutrition):

      m **Nutrient Foramen** = perforating canal.

   b. Osteogenic layer contains osteoblasts (bone-forming cells) and osteoclasts (bone-destroying cells);

   c. serves as insertion for tendons and ligaments.

5. **Endosteum** = inner lining of medullary cavity.

   a. contains layer of osteoblasts & osteoclasts.

6. **Articular cartilage** = pad of hyaline cartilage on the epiphyses where long bones articulate or join.

   a. "shock absorber".

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*
LONG BONE STRUCTURE SUMMARY (Keyed on page 145 of this outline)

LONG BONE PART	DESCRIPTION	FUNCTION

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

IV. Gross Structure of Bone (continued)

B. **Flat bones (See Fig 7.3c, page 187)**

1. covered by periosteum-covered compact bone;
2. surrounding endosteum-covered spongy bone.
3. In a flat bone, the arrangement looks like a sandwich:
   - spongy bone (meat), sandwiched between
   - two layers of compact bone (bread).

* **Hematopoietic tissue** (red marrow) is located in the spongy bone within the epiphyses of long bones and flat bones.

V. **HISTOLOGY OF BONE**

A. Chemical Composition of Bone (both organic and inorganic)

1. **Organic** components (35%):

a. **Cells**:

- **osteoprogenitor cells**
  1. derived from mesenchyme,
  2. can undergo mitosis and become osteoblasts.
- **osteoblasts**
  1. form bone matrix by secreting collagen,
  2. cannot undergo mitosis.
- **osteocytes (See Fig 7.7, page 189)**
  1. mature bone cells derived from osteoblasts;
  2. principle bone cell,
  3. cannot undergo mitosis,
  4. maintain daily cellular activities (i.e. exchange of nutrients & wastes with blood).
- **osteoclasts (See Fig 7.10, page 191)**
  1. function in bone resorption (i.e. destruction of bone matrix),
  2. important in development, growth, maintenance & repair of bone.

b. **Osteoid**

- primarily **collagen** which
- gives bone its high tensile strength.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

V. A. Histology: Chemical Composition of Bone (continued)

2. **Inorganic** component (65%):

a. Hydroxyapatite (mineral salts) which is primarily

- o **calcium phosphate** [$Ca_3(PO_4)_2 \cdot (OH)_2$]which
- o gives bone its hardness or rigidity.

B. **Microscopic Structure of Compact Bone**

Compact Bone is solid, dense, and smooth.

1. Structural unit = **Haversian System** or Osteon.

See Fig 7.4, page 187 and Fig 7.5, page 188.

a. elongated cylinders cemented together to form the long axis of a bone;
b. Components of Haversian System:

- o **osteocytes** (spider-shaped bone cells that lie in "**lacunae**") that have laid down a
- o matrix of collagen and calcium salts in
- o concentric **lamellae** (layers) around a
- o central **Haversian Canal** containing
- o blood vessels and nerves.

c. Communicating canals within compact bone:

- o **Canaliculi** connect the lacunae of osteocytes;
- o **Volkmann's canals** connect the blood & nerve supply of adjacent Haversian systems together.
  1. run at right angles to and connect adjacent Haversian canals.

C. **Microscopic Structure of Spongy (Cancellous) Bone**

1. consists of poorly organized **trabeculae** (small needle-like pieces of bone)
2. with a lot of open space between them.
3. nourished by diffusion from nearby Haversian canals.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

VI. **BONE DEVELOPMENT** (Osteogenesis/ossification)

A. Introduction

1. The "skeleton" of an embryo is composed of fibrous CT membranes (formed from mesenchyme and hyaline cartilage) that are loosely shaped like bones.

2. This "skeleton" provides supporting structures for ossification to begin.

3. At about 6-7 weeks gestation, ossification begins and continues throughout adulthood.

B. **Ossification follows one of two patterns**:

See Fig 7.6, page 189 & See Table 7.1, page 190 for a summary.

Both mechanisms involve the replacement of preexisting CT with bone.

1. **Intramembranous Ossification** is when a bone forms on or within a fibrous CT membrane.

   a. **Flat bones** are formed in this manner (i.e. skull bones, clavicles);

2. **Endochondral Ossification** occurs when a bone is formed from a hyaline cartilage model.

   a. **Most bones** of the skeleton are formed in this manner.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

VII. The Physiology of **Bone Growth**

A. Introduction

During infancy and childhood, long bones lengthen entirely by growth at the epiphyseal plates and all bones grow in thickness by a process called appositional growth.

B. **Growth in Length** of Long Bones (See Fig 7.9, page 191)

1. Structure of the Epiphyseal Plate or Disc (4 zones):

a. **Zone of resting cartilage**
- o near epiphysis,
- o small, scattered chondrocytes,
- o anchor plate to epiphysis.

b. **Zone of proliferating cartilage**
- o larger chondrocytes that resemble a **stack of coins**,
- o Chondrocytes divide to replace those that die at the diaphyseal surface of the epiphysis.

c. **Zone of Hypertrophic cartilage**
- o extremely large chrondrocytes that are arranged in columns,
- o maturing cells.

d. **Zone of calcified cartilage**
- o only a few cells thick,
- o consists of dead cells because the matrix around them became calcified,
- o This calcified matrix is destroyed by osteoclasts and is then invaded by osteoblasts and capillaries from the diaphysis.
- o The osteoblasts lay down bone on the calcified cartilage that persists.
- o As a result, the diaphyseal border of the plate is firmly cemented to the bone of the diaphysis.

e. (**Metaphysis) =** the region between the epi- and diaphysis where the calcified matrix is replaced by bone.

VII. B. Growth in Long Bones (continued)

2. The **epiphyseal plate allows for bone lengthening** until adulthood. As a child grows, (See Fig 7.11, page 192)

   a. Cartilage cells are produced by mitosis on the epiphyseal side of the plate,
   b. They are then destroyed and replaced by bone on the diaphyseal side of the plate.

   * Therefore, the thickness of the plate remains almost constant, while the bone on the diaphyseal side increases in length.

3. The **rate of bone growth** is controlled by:

   a. **human Growth Hormone** (hGH) from the pituitary
   b. **sex hormones** from the gonads (see below)

4. Ossification of most bones is **completed by age 25**.
   See Ossification Timetable 7.2, page 192.

   The cartilage of the epiphyseal plate is replaced by bone forming the **epiphyseal line.**

C. **Appositional Growth**

Along with increasing in length, bones increase in thickness or diameter.

1. occurs in osteogenic layer of periosteum;
2. Osteoblasts lay down matrix (compact bone) on outer surface.
3. This is accompanied by osteoclasts destroying the bone matrix at the endosteal surface.

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

VIII. Bone Remodeling and Repair

Once a bone has been formed, it is continuously being remodeled throughout life. This process involves the action of osteoblasts and osteoclasts, two hormones (calcitonin & parathyroid hormone) and in turn affects blood calcium homeostasis.

A. Rate of Remodeling Varies:

1. Distal femur is replaced every four months.
2. Diaphysis may not be fully replaced during one's lifetime.

B. **Osteoclasts** are large multinucleated cells responsible for bone resorption;

1. secrete lysosomal enzymes that digest the organic matrix;
2. secrete acids that solubilize calcium salts into Ca^{++} and PO_4^{-} ions which can then enter blood.

C. **Control of Bone Remodeling/ Calcium Homeostasis**

1. involves 2 hormones (negative feedback):

a. **Parathyroid hormone (PTH)** which is secreted by the parathyroid glands when blood calcium levels are low:

- stimulates osteoclast activity which releases Ca^{++} into the blood;
- causes kidneys to reabsorb Ca^{++} back into the blood and therefore,
- causes an increase in blood calcium levels (back to normal).

B. **Calcitonin** which is secreted by the thyroid gland when blood calcium levels are high:

- inhibits bone resorption and causes a deposition of bone matrix;
- causes the kidneys to secrete excess Ca^{++} into the urine and therefore,
- results in a decrease in blood calcium levels (back to normal).

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

VIII. **Bone Remodeling and Repair**

C. **Control of Bone Remodeling/ Calcium Homeostasis (Also see Fig 7.15, p. 199)**

2. Negative Feedback Loop

Thyroid Gland Hormone: Calcitonin

1. Osteoblasts use excess Ca^{++} to lay down bone matrix;
2. Kidney tubules secrete excess Ca^{++} into urine.

Stress: - blood Ca^{++}

$^{-}$ blood Ca^{++}

Normal Blood Ca^{++}

- blood Ca^{++}

Stress: $^{-}$ blood Ca^{++}

1. Osteoclasts resorb bone matrix;
2. Kidney tubules reabsorb Ca^{++} back into bloodstream

Parathyroid Hormone Parathyroid Glands

CHAPTER 7: THE SKELETAL SYSTEM: *OVERVIEW*

VIII. Bone Remodeling and Repair (continued)

D. **Minerals** needed for bone remodeling:

1. Calcium (component of hydroxyapatite matrix);
2. Phosphorus (component of hydroxyapatite);
3. Magnesium (needed for normal osteoblast activity);
4. Boron (?inhibits calcium loss?);
5. Manganese (?needed for new matrix?).

E. **Vitamins** needed for bone growth, remodeling, repair

1. **Vitamin D** greatly increases intestinal absorption of dietary calcium & retards its urine loss,

2. **Vitamin C** helps maintain bone matrix

3. **Vitamin A controls** the activity, distribution and coordination of **osteoblasts & osteoclasts** during development.

4. **Vitamin B_{12}** may play a role in osteoblast activity.

F. **Hormones** needed for bone growth & remodeling

1. **Human Growth Hormone** (hGH):
   a. secreted by pituitary;
   b. responsible for the general growth of all tissues;

2. **Sex hormones**
   a. estrogens & testosterones;
      - aid osteoblast activity (i.e. promote new bone growth);
      - also degenerate cartilage cells in epiphyseal plate (i.e. close epiphyseal plate).

3. **Thyroid hormones (T_3 and T_4)**

   a. T_3 = Triiodothreonine
   b. T_4 = Thyroxine
      - needed for normal bone growth & maturity.

4. **PTH & Calcitonin (discussed previously)**

CHAPTER 7: THE SKELETAL SYSTEM: *AXIAL SKELET0N*

I. **Introduction** (Skeletal Organization)

The skeletal system consists of bones and joints that allow for the many functions discussed above in the overview. In the next sections we will not only name and locate the bones of the skeleton, but we will study the structure of each. That is that many bones contain holes that allow blood vessels and/or nerves to pass through (i.e foramina), and many bones have distinct markings that allow for attachment of muscles and therefore movement.

The skeleton is divided into two major divisions, an **axial and appendicular** portion. See Figure 7.17, page 201.

The **AXIAL skeleton** includes the bones of the skull, hyoid bone, vertebral column and thoracic cage:

A. The **SKULL** = cranium (brain case) and facial bones:

In addition to the figures presented in this chapter, please refer to Skull Plates One through Thirty-Three on pages 241-255 in text.

All the bones of the skull (except the mandible) are firmly interlocked along structures called **sutures**.

*A suture is the area where skull bones fuse together or articulate (join).

1. **Cranium** =brain case or helmet.

The cranium is composed of eight bones including the frontal, occipital, sphenoid, and ethmoid bones, along with a pair of parietal and temporal bones.

a. **Frontal bone** = forehead.

- articulates with parietal bones along **coronal suture**; See Fig 7.21, page 204.
- forms superior portion of orbit; See Fig 7.20, page 203.
- contains 2 **frontal (paranasal) sinuses** See Fig 7.27, page 209.

CHAPTER 7: THE SKELETAL SYSTEM: *AXIAL SKELET0N*

I. A. The Skull (continued)

1. Cranium (continued)

b. **Parietal bones** =behind frontal bone;
bulging sides of skull.

o Articulations: See Fig 7.21, page 204.

1. anteriorly with frontal bones at **coronal suture**;
2. posteriorly with occipital bone at **lambdoidal suture**;
3. laterally with temporal bones at **squamous suture**;
4. between bones at **sagittal suture**

c. **Occipital bone** = base of skull.

See Fig. 7.21 and Fig 7.22, pg. 204.

o articulates with paired parietal bones along the lambdoidal suture;

o **Foramen magnum** ("large hole") = opening in occipital bone where nerve fibers pass from brain into spinal cord;

o **Occipital condyles** = rounded processes on either side of foramen magnum which articulate with the first vertebra (atlas).

d. **Temporal bones** lie inferior to parietal bones at squamous suture.

See Fig 7.21, page 204.

o **Zygomatic process** = bar-like extension that meets the zygomatic bone;
o **External auditory meatus** = opening in tympanic region which opens to the inner portions of the ear;
o **Styloid process** = needle-like extension (attachment for some neck muscles);
o **Mastoid process** = a rounded process that extends down from mastoid region of temporal bone (attachment for neck muscles).

CHAPTER 7: THE SKELETAL SYSTEM: *AXIAL SKELET0N*

I. A. The Skull (continued)

1. Cranium (continued)

e. **Sphenoid bone** = butterfly shaped bone that spans the length of the cranial floor.

- lateral portions are wedged between many other skull bones = "keystone"; Fig. 7.21, pg. 204;
- contains two **sphenoid (paranasal) sinuses** See Fig. 7.27, pg. 209;
- **Sella turcica** (Fig. 7.23, pg. 206 & Fig 7.26, page 208) = portion of sphenoid bone which rises up and form a saddle-shaped mass that houses the **pituitary gland**.

f. **Ethmoid bone** = complex shaped bone composed of two masses on either side of the nasal cavity; See Fig. 7.24, page 207;

- contains two **ethmoid (paranasal) sinuses**; See Fig. 7.27, page 209;
- Cribriform or **horizontal plate** connects two masses of ethmoid bone horizontally; See Fig 7.24, page 207.
- **Perpendicular plate** projects downward from cribriform plate to form superior portion of **nasal septum**; See Fig 7.24, page 207 and Fig 7.19, page 203.
- **Nasal concha** = delicate scroll-shaped plates that project into nasal cavity; See Fig 7.19, page 203 & Fig 7.25, page 207;
- **Crista galli** = process that extends from horizontal plate that serves as the **attachment for meninges** (membranes) that surround the brain. See Fig 7.24, page 207 & Fig 7.26, page 208.

CHAPTER 7: THE SKELETAL SYSTEM: *AXIAL SKELET0N*

I. A. The Skull (continued)

2. The **facial skeleton** shapes the face and provides attachment for various muscles that move the jaw and control facial expressions.

See Fig 7.19, page 203 and Fig 7.21, page 204.

a. **Maxillary bones (maxillae)** = upper jaw.
- o contains two **maxillary (paranasal) sinuses;** See Fig 7.27, page 209.

b. **Zygomatic bones** = cheek bones.
- o **temporal process** projects posteriorly and articulates with the zygomatic process of temporal bone.
- * These two processes compose the **zygomatic arch;** See Fig 7.22, pg 204.

c. **Nasal bones** = bridge of nose.

d. **Lacrimal bones** = median walls of orbit.
- o See Fig 7.20, page 203 for details of orbit; composed of seven bones.

e. **Palatine bones** = complete posterior portion of hard palate;
See Fig 7.28 and Fig 7.29, pg 210.
See box on page 209: Cleft palate.

f. **Vomer** = inferior portion of nasal septum.
- o Superior portion of nasal septum is formed by the perpendicular plate of the ethmoid bone; See Fig 7.30, p 211.

g. **Mandible** = lower jaw.
- o largest, strongest bone in the face;
- o See Fig 7.31, page 211;
- o mandibular condyle articulates with the mandibular fossa of the temporal bone at **temporomandibular joint (TMJ)**.
- o only movable bone in the skull.

B. **Hyoid Bone** (See Fig 7.18, page 202).
1. Location: in neck, between lower jaw and larynx; held in place by muscles and ligaments.
2. Function: supports tongue.

CHAPTER 7: THE SKELETAL SYSTEM: *AXIAL SKELET0N*

I. C. **Vertebral Column**: See Fig. 7.34, page 215.

1. 26 irregular bones are divided into **5 curvatures**:

   a. **Cervical** curvature = 7 vertebrae (bones) in neck;
      - m atlas
      - m axis

   b. **Thoracic** curvature = 12 vertebrae in thoracic cavity.
   c. **Lumbar** curvature = 5 large vertebrae in abdominal cavity.
   d. **Sacrum** = 5 fused vertebrae that articulate with coxal bones of pelvis; See Fig 7.39, page 219.
   e. **Coccyx** = 3-5 vertebrae which makeup the tailbone; See Fig 7.39, page 219.

2. **Intervertebral disk** = protective pad of fibrocartilage between individual vertebra; slightly movable joint.

3. **General Structure of Vertebrae**

   See Fig 7.35, page 216.

   a. **body** = discoid shaped anterior region;
   b. **vertebral arch** = posterior region;
      - o pedicle = short bony posterior projection;
      - o lamina = flattened plates that articulate posteriorly into spinous process;

   c. **vertebral foramen** = opening between body and vertebral arch through which the spinal cord passes;
   d. **spinous process** = midline posterior projection;
   e. **transverse processes** = laterally from pedicle.

4. **Specific Structure of Vertebrae**:

   See Figures 7.36, page 217 and Fig 7.368, page 218.

   In lab, you will be able to compare and contrast the structure of vertebra from different regions of the spine.

   See Table 7.9, page 219 to summarize the bones of the vertebral column.

I. D. **The Thoracic Cage** includes the ribs, sternum, thoracic vertebrae, and costal cartilages.

See Fig 7.40, page 221.

1. **Sternum**

a. Three parts:
- **manubrium** = upper portion.
  1. resembles handle;
  2. articulates with clavicle.

- **body** = middle vertical portion;
  1. site where most ribs articulate anteriorly.

- **xiphoid process** = lower extension from body.

2. **Ribs**:

a. 12 pairs
- articulate anteriorly with sternum through **costal (hyaline) cartilage**;
- articulate posteriorly with thoracic vertebrae;
- Three types:
  1. **True ribs** = upper 7 pairs that articulate directly with sternum;
  2. **False ribs** = remaining 5 pairs of ribs;
  3. **Floating ribs** = 11th and 12th pair;
     These ribs do **not** articulate anteriorly.

- Typical Rib Structure: Fig 7.41, pg 222.
  1. Head
     a. superior facet
     b. inferior facet
  2. Neck
  3. Tubercle
     a. articular
     b. non-articular
  4. Costal Angle
  5. Costal groove
  6. Body

CHAPTER 7: THE SKELETAL SYSTEM: *APPENDICULAR SKELETON*

The appendicular skeleton includes the **limbs** of the upper and lower extremities, **and** the bones that attach those limbs to the trunk (**pectoral and pelvic girdle**s):

I. The **pectoral (shoulder) girdle** connects the upper limbs to the rib cage and consists of two pairs of bones.

See Fig 7.42, page 223.

A. anterior **clavicles** (2) = collar bones:

1. medial sternal ends;
2. lateral acromial end;
3. provide attachments for many muscles.

B. posterior **scapulae** (2) = shoulder blades: See Fig 7.43, page 224.

1. flattened, triangular bones;
2. Glenoid cavity (fossa) = small fossa that articulates with the head of the humerus;
3. Coracoid process = anterior projection of superior portion (looks like a bent finger); attachment for biceps muscle;
4. Acromion = uppermost point of shoulder;
5. Spine = diagonal posterior surface;
6. Body = flattened triangular region;
7. medial & Lateral Border
8. inferior Angle.

II. **Upper limbs**: See Figure 7.44, page 225.

A. **humerus** = upper arm bone: See Fig 7.45, page 226.

1. typical long bone;
2. note location of:
   - proximal head;
   - distal capitulum and trochlea (articulate with radius and ulna, respectively);
   - greater/lesser tubercles;
   - deltoid tuberosity;
   - body;
   - medial/lateral epicondyles;
   - olecranon fossa.

CHAPTER 7: THE SKELETAL SYSTEM: *APPENDICULAR SKELETON*

II. Upper Limbs (continued)

B. **Radius** = forearm bone on same side as **thumb**;

See Fig 7.46, page 227.

1. Note location of

a. head;
b. neck;
c. radial tuberosity;
d. ulnar notch (distal);
e. styloid process (lateral prominence).

C. **Ulna** = forearm bone on same side as **pinky**;

See Fig 7.46, page 227.

1. Note location of

a. olecranon (process)= prominence of elbow;
b. trochlear notch = receives trochlea of humerus;
c. Coronoid process (Fig 7.46b);
d. head (inferior)
e. styloid process (medial prominence).

D. **Carpus** = 8 carpals (wrist; short) bones.

See Fig 7.47, page 228.

E. **Metacarpus** = 5 metacarpals (hand; long) bones.

F. **Phalanges** (plural); phalanx (singular) = finger bone or digit.

1. Thumb (pollex) = 2 digits;
2. Fingers = 3 digits;
3. Total per limb = 14 digits or phalanges.

III. **Pelvic (hip) Girdle** = connects lower limbs to the vertebral column

See Fig 7.49, page 229.

A. Composed of a pair of **coxal bones**:

1. which articulate:

a. anteriorly at the symphysis pubis, oposteriorly with the sacrum.

2. Each coxal bone consist of 3 separate bones during childhood, but these bones are securely fused in adults:

See Fig 7.50, page 230.

a. **ilium** = largest uppermost flaring portion of coxal bone.

iliac crest = prominence of the hip (i.e. hands on hips.
- The socket which articulates with head of femur is called the **acetabulum.**
- The hole in each coxal bone is called the **obturator foramen.**

b. **ischium** = lowest L-shaped portion of coxal bone (i.e. area we sit on).

- Note ischial spine

c. **pubis** = anterior portion of coxal bone; bladder rests upon it.

* The pubis (coxal) bones articulate anteriorly at the **symphysis pubis** (fibrocartilage disc).

See Fig 7.49a, page 229.

* **Female vs. Male pelvis**:

See Fig 7.51, page 230 and Table 7.11, page 231.

IV. **Lower Limbs**: See Fig 7.52, page 232.

A. **Femur** = thigh bone: See Fig 7.53, page 233.
1. largest, longest, strongest bone in skeleton;
2. note the location of:
   a. head,
   b. neck,
   c. greater & lesser trochanters,
      (attachment for thigh and buttock muscle),
   d. linea aspera,
   e. lateral & medial condyles (tibia),
   f. epicondyles,
   g. patellar surface (patella).

B. **Patella** = knee cap; sesamoid bone.

C. **Tibia** = shin bone: See Fig 7.54, page 233.
1. very strong;
2. note location of:
   a. medial/lateral condyles;
   b. tibial tuberosity;
   c. medial malleolus (bulge of ankle).

D. **Fibula** = thin bone lateral to tibia: See Fig 7.54, page 233.

1. Note the location of:
   a. head,
   b. lateral malleolus (lateral ankle bulge).

E. **Tarsus** = 7 tarsal (ankle) bones.
See Fig 7.55 and Fig 7.56, page 234.

1. Body weight is carried on 2 largest tarsals:
   a. **Talus** = uppermost tarsal which articulates with the tibia and fibula;
   b. **Calcaneus** = heel bone.

F. **Metatarsus** = 5 metatarsal (foot) bones.

G. **Phalanges** = toe bones or digits (14 total).

CHAPTER 7: THE SKELETAL SYSTEM: *SUMMARY TABLE*

NAME OF BONE: **SCIENTIFIC** **COMMON**			
AXIAL OR APPENDICULAR SKELETON?			
CLASSIFICA-TION BY SHAPE			
HOW MANY IN SKELETON?			
SPECIAL FEATURES OR MARKINGS			
SPECIFIC ARTICULA-TION(S)			
SPECIAL FUNCTIONS			

CHAPTER 7: THE SKELETAL SYSTEM: *SUMMARY TABLE* *(Key of page 146 outline)*

NAME OF BONE: **SCIENTIFIC** **COMMON**			
AXIAL OR APPENDICULAR SKELETON?			
CLASSIFICA-TION BY SHAPE			
HOW MANY IN SKELETON?			
SPECIAL FEATURES OR MARKINGS			
SPECIFIC ARTICULA-TION(S)			
SPECIAL FUNCTIONS			

CHAPTER 7: THE SKELETAL SYSTEM: ***HOMEOSTATIC DISORDERS***

A. Pituitary dwarfism (page 193)

B. Fractures (See CA 7.1, pages 194-195)

C. Osteoporosis (See CA 7.2, page 198)

D. Mastoiditis (page 205)

E. Cleft palate (page 209)

F. Vertebral Disorders (See CA 7.3, page 220)

G. Polydactyly (See Fig 7.48, page 228 and page 226)

H. Others (page 235)

INNERCONNECTIONS of the skeletal system with other organ systems: See page 236.

CHAPTER 7: THE SKELETAL SYSTEM
OVERVIEW OF LONG BONE STRUCTURE (outline page 123)

LONG BONE PART	DESCRIPTION	FUNCTION
Diaphysis	long shaft of bone; collar of compact bone surrounding medullary cavity filled with yellow marrow (fat storage)	rigidity
Epiphyses	expanded ends of long bone; spongy bone filled with red bone marrow	hematopoeisis; form synovial joints
Periosteum	dense fibrous CT that surrounds outer surface of the bone; inner layer is osteogenic layer composed of osteoblasts & osteoclasts; A nutrient foramen serves as passageway for nutrient artery to penetrate bone.	protection, attachment site for muscles, bone remodeling
Endosteum	inner lining of medullary cavity with osteogenic layer	lining, bone remodeling
Articular cartilage	covers epiphysis	shock absorber, forms synovial joint
Epiphyseal Line	at junction of epiphysis and diaphysis	remnant of growth plate

CHAPTER 7: THE SKELETAL SYSTEM
SAMPLE OF BONE SUMMARY TABLES *(*outline pages 142-143)

NAME of bone: SCIENTIFIC **COMMON**	***SCAPULA*** ***SHOULDER BLADE***	***TEMPORAL***	***PHALANX*** ***DIGIT (FINGER)***
AXIAL OR APPENDICULAR SKELETON?	***APPENDICULAR***	***AXIAL***	***APPENDICULAR***
CLASSIFICA-TION BY SHAPE	***FLAT***	***FLAT***	***LONG***
HOW MANY IN SKELETON?	***2***	***2***	***56***
SPECIAL FEATURES OR MARKINGS	***ACROMION ARTICULATES WITH CLAVICLE; GLENOID FOSSA ARTICULATES WITH HEAD OF HUMERUS; CORACOID PROCESS SERVES AS ORIGIN FOR BICEPS BRACHII; TRIANGULAR; POSTERIOR SPINE;***	***EXT.AUD.MEATUS FOR EAR CANAL; MASTOID & STYLOID PROCESSES SERVE AS ATTACHMENT FOR NECK MUSCLES, ZYGOMATIC PROCESS ARTICULATES WITH TEMPORAL PROCESS OF ZYGOMATIC TO FORM ARCH***	
ARTICULA-TION(S)	***SEE ABOVE***	***SEE ABOVE***	***WITH ONE ANOTHER TO FORM FINGERS***
SPECIAL FUNCTIONS	***ATTACHMENT SITE OF UPPER LIMBS; HEMATOPOIESIS***	***PROVIDES INLET FOR SOUND WAVES, PROTECTION OF SKULL***	***MANIPULATION***