

LECTURE TOPICS OUTLINE

SKELETAL SYSTEM I

NOTE:

LAB ASSIGNMENTS for this topic will run over 3 Weeks.
A SEPARATE WORKSHEET WILL BE PROVIDED.

I. TISSUES AND ORGANS OF THE SKELETAL SYSTEM

A. Functions of the Skeleton

The skeleton functions in support, protection, movement, blood formation, electrolyte balance, acid-base balance, and detoxification of the body.

B. Bones and Osseous Tissue

1. The study of bones is osteology.
2. Osseous, or bony tissue, is predominant in bones, but also present are blood, marrow, cartilage, adipose tissue, nerves, and fibrocartilage.

C. Bones of the Skeletal System

1. There are 206 bones in the adult; 270 in a newborn. Many fuse during growth and development.
2. The skeleton is divided into **axial** and **appendicular** portions.
3. **Axial** skeleton: the skull, middle-ear bones, the hyoid bone, rib cage, vertebral column, and sternum.
4. **Appendicular** skeleton: the upper and lower extremities, and the pectoral and pelvic girdles.

II. GROSS ANATOMY OF BONES

A. The Shapes of Bones

1. **Long bones** include those in the appendages that produce body movement.
2. **Short bones** are equal in length and width, such as those of the wrist and ankle.
3. **Flat bones**, such as in the skull, protect soft tissues.
4. **Irregular bones** include the vertebrae and others.

B. General Features of Bones

1. The features of a **long bone** include its outer layer of **compact** bone, a **medullary cavity** containing bone marrow, and **spongy bone** at its ends.
2. The shaft of a long bone is referred to as the **diaphysis**; the expanded ends are the **epiphyses**.
3. The epiphyses are covered with **articular cartilage**, and the outer bone is covered by **periosteum**. The inside is lined with **endosteum**.
4. During growth, an **epiphyseal plate of hyaline cartilage** forms a model for bone to replace.

III. HISTOLOGY OF OSSEOUS TISSUE

A. The Cells of Osseous Tissue

1. **Osteogenic cells** develop from mesenchyme and occur in the endosteum, the inner periosteum, and in the Haversian canals. They are the only source of new cells of **osteoblasts** and **osteocytes**.
2. **Osteoblasts** are bone-forming cells, and build new bone matrix.
3. **Osteocytes** are **osteoblasts** trapped in bone matrix. They remain active in maintenance of bone.
4. **Osteoclasts** are bone-dissolving cells that **form by fusion of monocytes**.
They break down bone and release its minerals to the blood.

B. The Matrix of Osseous Tissue

1. The **organic** matter in bone (one-third of the dry weight) is **collagen, GAGs, proteoglycans, and glycoproteins**.
2. The remainder is **mineral components**, especially **hydroxyapatite** and **calcium carbonate**.
Other minerals are present in minute quantities.

C. Histology of Compact Bone (HOLE text; 8th edition: p. 188, 9th edition: p. 199)

1. **Lamellae** are arranged mostly in concentric circles around Haversian canals.
This is the basic structural unit of **compact** bone, collectively called an **osteon**.
2. Within the lamellae lie the **lacunae** with osteocytes. **Canaliculi** extend between adjacent lamellae.
3. **Perforating (Volkmann's) canals** enter the bone from the outside and inside, and feed into the **Haversian systems**, carrying nerves and blood vessels.

D. Histology of Spongy

1. **Spongy** bone consists of slender plates, called **trabeculae**.
2. Bone marrow occupies the spaces within the trabeculae.

E. Bone Marrow

1. In children, **red marrow** (myeloid tissue) is **hemopoietic** and fills the medullary cavity.
2. In adults (age 30), most of the marrow in the medullary cavity is **yellow marrow** that stores fat.
3. In older adults (age 70), most of the yellow marrow is replaced by gelatinous marrow.

IV. BONE DEVELOPMENT

A. Intramembranous Ossification

1. **Intramembranous ossification** occurs **within a membrane of soft tissue** that represents the location of a future flat bone.
Its cells differentiate into **osteogenic cells** and **osteoblasts**, and **trabeculae** are formed.
2. **Osteoblasts** form on the trabeculae and lay down an **organic matrix** and deposit **calcium phosphate** within it. When trapped, they become **osteocytes**.

B. Endochondral

1. **Endochondral ossification** is bone formation using a **cartilage model**.
In the center of the model is the **primary ossification center** where lacunae enlarge and minerals are deposited around them.
2. **The Primary Ossification Center**
 - a. Cells of the **periochondrium** become osteogenic cells and osteoblasts and produce bone on the outside of the model.
 - b. In the center of the model, a primary marrow space is formed.
3. **The Metaphysis**
 - a. The transition between the head of hyaline cartilage and the primary marrow space is the **metaphysis**.
 - b. It exhibits five zones representing stages of ossification: the zone of reserve cartilage; the zone of cell proliferation; the zone of cell hypertrophy; the zone of calcification; and the zone of bone deposition.
4. **The Secondary Ossification Center**
 - a. At birth, secondary ossification centers form in the epiphyses of long bones.
The epiphysis is hollowed out from the center outward and is replaced by bone.
 - b. Cartilage remains until adulthood at the **epiphyseal plates**.

C. Bone Growth and Remodeling

1. Each year, bone exchanges 18% of its calcium.
Usually about 5% of the adult skeleton undergoes remodeling at any one time.
2. Physical activity enlarges bony prominences.
3. **Cartilage** can grow two ways: by **interstitial growth** and by **appositional growth**.
4. In **achondroplastic dwarfism**, chondrocytes fail to multiply in long bones.

V. PHYSIOLOGY OF OSSEOUS TISSUE

A. Mineral Deposition

1. Mineralization (deposition): process whereby calcium and phosphate are deposited in blood tissue.
2. Mineralization of bone is based on the action of seed crystals on an unstable solution of calcium and phosphate salts, in the presence of collagen fibers.

B. Mineral Resorption

1. **Resorption** is the process of dissolving bone to release its minerals to the bloodstream.
2. **Osteoclasts** dissolve bone using an acid and **acid phosphatase**.

C. Calcium and Phosphorus Homeostasis

1. The skeleton serves as a **reservoir** for calcium, phosphorus, and other minerals that play important roles in physiology.
2. Excessively low calcium concentration is called **hypocalcemia**, causing the nervous system to become **hyperexcitable**. Muscle tetany can result
3. Excessive calcium is **hypercalcemia**, which can cause nervous system depression and sometimes cardiac arrest.
4. The balance between calcium storage and resorption is controlled by two hormones: **calcitonin** that acts to lower blood levels of calcium by stimulating osteoblasts and inhibiting osteoclasts; and **parathyroid hormone (PTH)** that raises blood calcium when it drops too low. PTH stimulates osteoclasts, lessens urinary excretion of calcium, and stimulates the synthesis of vitamin D.

D. Vitamin D

1. Vitamin D is a hormone that is produced in concert by the skin, liver, and kidney.
2. The most active form is **calcitrol**, produced together by the skin (with UV light), liver, and kidney. Calcitrol promotes **intestinal absorption of calcium and phosphate** while reducing urinary elimination of these minerals.
3. Insufficient vitamin D can cause **rickets** in children and **osteomalacia** in adults.

VI. BONE DISORDERS

A. Fractures and Their Repair

1. The Healing of Fractures

- a. A bone fracture results in a **hematoma** from torn blood vessels.
- b. Next, **soft granulation tissue** forms as blood vessels grow into the hematoma. **Macrophages** remove debris as osteoclasts, osteogenic cells; **fibroblasts** migrate to the area.
- c. **Fibroblasts** deposit **collagen**, and a **fibrocartilage callus** is formed by chondroblasts. The callus is first soft, then becomes hard as it is replaced with bony tissue.
- d. The area of the fracture is remodeled for 3-4 months until broken bone fragments are resorbed.

2. The Treatment of Fractures

1. Fractures may be set by **closed reduction** (no surgery) or by **open reduction** (surgical placement of bones, using pins and plates).
2. **Orthopedics**: branch of medicine dealing with injuries/disorders of bones, joints, and muscles.

OSTEOPOROSIS

- i. The most common bone disease is **osteoporosis** in which bones lose mass and become brittle.
- ii. The group most prone to this disease are elderly, postmenopausal white women; black women are rarely afflicted.
- iii. The spine commonly becomes compressed, a condition leading to **kyphosis**.
- iv. Disuse osteoporosis occurs at any age due to immobilization or inadequate weight-bearing exercise.