Lecture Outline: The Skeletal System

I. **Functions of the Skeletal System**

A. **Support**: Provides the framework for the body

B. **Protection**: Encloses important organs, like the brain (cranium) and heart/lungs (rib cage)

C. **Movement**: Provides stiff bones for muscles to pull on, enabling body movement

D. **Breathing**: Muscles pull on ribs to change lung volume, facilitating air intake and exhalation

E. **Mineral Storage**: Serves as a large reservoir of **calcium and phosphate** in the form of hydroxyapatite (calcium phosphate)

1. Regulates blood calcium levels as part of homeostasis
2. Calcium ions are crucial for heart beating and skeletal muscle movement
3. Phosphate is essential for many reasons, including being a component of plasma membranes

F. **Hemopoiesis**: Production of **blood cells** (red and white) occurs in the marrow within bones

II. **Bone Tissue and Structure**

A. **Bone Composition**

1. Mainly **hydroxyapatite** (calcium phosphate), which makes bones hard
2. Hardest part of the body, second only to teeth enamel

B. **Types of Bone Tissue**

1. **Compact Bone**
    a. Much less space, therefore denser and stronger
    b. Forms the **superficial layer** on any bone
    c. Composed of cylindrical structures called **osteons**
2. **Spongy Bone**
    a. Located **deep to compact bone**
    b. Has many pores/holes, giving it a sponge-like appearance, but it is still hard and strong
    c. Makes bones lighter while retaining strength
    d. Spaces contain **marrow** (red and yellow)
    e. Composed of tiny beam-like structures called **trabeculae**

C. **Bone Cells**

1. **Osteoblasts**: Cells that **create** the extracellular matrix material
2. **Osteocytes**: Mature bone cells that **maintain** the extracellular matrix; locked in lacunae (little lagoons)
3. **Osteoclasts**: Cells that **degrade** the extracellular matrix, breaking down hydroxyapatite to release calcium when needed

D. **Osteons (in Compact Bone)**

1. **Central Canal**: Passageway for blood vessels and nerves
2. **Lamellae**: Several concentric layers of hard material surrounding the central canal

III. **Bone Development and Dynamics**

A. **Bone Shapes**

1. **Long bones**: Longer than they are wide (e.g., humerus, femur)

2. **Flat bones**: Thin and flattened (e.g., sternum)
3. **Short bones**: Cube-shaped, not particularly long in any dimension (e.g., ankle/tarsal bones, wrist/carpal bones)
4. **Irregular bones**: Complex, irregular shapes (e.g., vertebrae)

B. **Long Bone Anatomy**

1. **Diaphysis**: The long, central shaft of the bone
2. **Epiphysis**: The two tips at either end of the long bone
3. **Medullary Cavity**: An open, deep internal area within thicker bones, which contains marrow

C. **Ossification (Bone Hardening)**

1. Initial skeleton (pre-birth) is primarily made of pliable **cartilage** (mostly hyaline cartilage) or connective tissue membranes (skull)
2. **Epiphyseal Plate**: A cartilage plate between the diaphysis and epiphysis in growing bones, where new material is added to make the bone longer
3. **Epiphyseal Line**: Formed when the epiphyseal plate ossifies (turns into bone) around age 20, indicating that longitudinal growth has stopped

D. **Bone Remodeling**

1. Bones are **dynamic** and continuously being partially destroyed and rebuilt throughout life
2. Involves both **osteoclasts** (tearing down old material) and **osteoblasts** (building new material)
3. Bones adapt to stress; for example, trabeculae can be added and rearranged to withstand greater force

E. **Fracture Healing (Four Stages)**

1. **Hematoma Formation**: A large blood clot (hematoma) forms

at the fracture site due to severed blood vessels, providing immediate but weak support

2. **Fibrocartilage Formation**: The hematoma is gradually replaced by fibrocartilage, which is stronger than a blood clot
3. **Ossification of Fibrocartilage**: The fibrocartilage turns into bony material (a bony callus), making the bone strong enough for use
4. **Remodeling**: The bony callus is gradually broken down and reshaped to restore the bone to its original form, often resulting in a site stronger than it was originally

F. **Fetal Skeleton Development**

1. In a fetus, dark areas on X-rays indicate bony material, while lighter areas are still cartilage
2. **Fontanelles**: Soft spots in a baby's skull, consisting of dense connective tissue membranes, which eventually ossify to form skull sutures

IV. **Divisions of the Skeleton**

A. **Overall Bone Count in Adulthood**: **206 bones**

1. Humans are born with more bones that fuse over time (e.g., mandible, frontal bone)
2. Over half (106) of the bones are in the feet and hands
3. 56 bones (over a quarter) are in the fingers and toes (phalanges), allowing for dexterity

B. **Axial Skeleton**: Forms the central long axis of the body

1. **Skull**
    a. Total: **22 bones**
    b. **Cranium (Brain Case)**: 8 bones that are in direct contact with the brain, forming the protective brain case

c. **Facial Bones**: 14 bones that attach to the front of the cranium

d. Examples of skull bones to know:

(1) Parietal bone (forms side walls of cranium, "parietal" means wall)

(2) Temporal bone (orange, near temples, often first place for graying hair, indicating time)

(3) Occipital bone (unpaired, at the back, may have a larger protuberance in males)

(4) Frontal bone (unpaired, forms forehead, starts as two halves in fetus)

(5) Zygomatic bone (blue, cheekbone, forms part of the zygomatic arch, which is like a yoke)

(6) Maxillae (2, upper jawbones, stay separate)

(7) Mandible (lower jawbone, starts as two halves, fuses into one)

2. **Vertebral Column (Spine)**

a. Encloses and protects the **spinal cord** (part of the central nervous system)

b. Made of many individual bones (vertebrae) whose slightly movable joints allow overall flexibility

c. **Categories of Vertebrae**:

(1) **Cervical Vertebrae (C1-C7)**: **7** bones in the neck ("cervix" means neck/narrowing)

(2) **Thoracic Vertebrae (T1-T12)**: **12** bones in the chest ("thorax" means chest), which articulate with the ribs

(3) **Lumbar Vertebrae (L1-L5)**: **5** bones in the lower back, typically have the largest bodies due to weight-

bearing

(4) **Sacrum**: A single bone fused from **5 sacral vertebrae**, part of the pelvic girdle

(5) **Coccyx**: A single bone fused from **2-4 coccygeal bones**, also known as the tailbone

i. **Normal Curvatures**: The vertebral column is not straight but has natural curves in the cervical, thoracic, and lumbar regions

j. **Curvature Disorders**:

(1) **Scoliosis**: Abnormal sideways curvature

(2) **Kyphosis**: Exaggerated thoracic curvature (hunchback)

(3) **Lordosis**: Exaggerated lumbar curvature

n. **Vertebra Structure**:

(1) **Vertebral Foramen**: The central hole in each vertebra, which collectively forms a tunnel for the spinal cord; the hole gets smaller inferiorly

(2) **Body**: The main weight-bearing part of the vertebra; gets larger inferiorly

(3) **Intervertebral Discs**: Tough pads of fibrocartilage located between vertebral bodies, allowing slight movement

(4) **Herniated Disc**: Occurs when part of an intervertebral disc bulges out and presses on spinal nerves, causing pain (discs do not "slip")

s. **Special Cervical Vertebrae**:

(1) **C1 (Atlas)**: The superior-most vertebra, named after Atlas from mythology as it holds up the skull; has no body, allows nodding ("yes" movement)

(2) **C2 (Axis)**: Has a pivot point (dens) that articulates with the atlas, allowing for twisting/rotation of the head ("no" movement)

v. **Distinguishing Vertebrae Types**:

(1) Cervical vertebrae are the only ones with three holes (one vertebral foramen and two additional holes for blood vessels)

(2) Thoracic vertebrae (side view) resemble giraffe heads

(3) Lumbar vertebrae (side view) resemble moose heads, and have very large bodies

3. **Ribs**: **12 pairs** (24 total) associated with thoracic vertebrae
   a. **True Ribs (Pairs 1-7)**: Connect directly to the sternum via their own band of hyaline cartilage
   b. **False Ribs (Pairs 8-12)**: Do not connect directly to the sternum

(1) Pairs 8-10: Have cartilage that connects to the cartilage of other ribs

(2) Pairs 11-12 (Floating Ribs): Connect only to the vertebrae and have no anterior connection

4. **Sternum**: Breastbone, central bone in the chest to which true ribs and some false ribs indirectly attach

C. **Appendicular Skeleton**: Consists of limbs and the structures that attach them to the axial skeleton

1. **Pectoral Girdle**: Forms a ring (though not complete) around the neck/shoulders
   a. **Clavicles** (2): Collar bones
   b. **Scapulae** (2): Shoulder blades
2. **Upper Limbs**

a. **Humerus**: The single bone of the arm (brachium), from shoulder to elbow

b. **Antibrachium (Forearm) Bones** (2):

(1) **Radius**: Runs parallel to the ulna in anatomical position; rotates for pronation (palm down) and supination (palm up)

(2) **Ulna**: Forms the hinge joint at the elbow with the humerus

e. **Manus (Hand) Bones**:

(1) **Carpus (Wrist)**: The proximal part of the hand, made of **8 carpal bones** arranged in two rows

(2) **Metacarpals**: The 5 bones of the palm, beyond the carpals

(3) **Phalanges (Fingers/Digits)**: The 14 bones of the fingers (2 in the thumb, 3 in each of the other four fingers)

3. **Pelvic Girdle**: Forms a complete ring, attaching the lower limbs to the axial skeleton

a. Composed of **two Ossa Coxae** (pelvic bones) and the **sacrum** (part of the axial skeleton)

b. **Ossa Coxae**: Each pelvic bone fuses from three parts in adulthood:

(1) **Ilium**: The superior and largest part

(2) **Ischium**: The posterior, rounded part that one sits on ("sitting bones")

(3) **Pubis**: The anterior part, where the two pubes meet in the front

f. **Sexing a Skeleton using the Pelvic Girdle**:

(1) Female pelvis has a more **U-shaped angle** where

the pubes meet, creating a wider birth canal

(2) Male pelvis has a more **V-shaped angle** where the pubes meet

4. **Lower Limbs**

a. **Femur**: The single bone of the thigh (proximal part of lower limb), and the **largest bone** in the skeleton

b. **Leg Bones** (from knee to foot):

(1) **Tibia**: The larger of the two leg bones, bears all the weight from above and connects to the femur

(2) **Fibula**: The smaller bone, situated lateral to the tibia; does not bear weight but supports when shifting to the side, connecting only to the tibia and tarsal bones

e. **Pedis (Foot) Bones**:

(1) **Tarsus (Ankle)**: The proximal part of the foot, made of **7 tarsal bones** (one fewer than carpal bones)

(2) **Metatarsals**: The 5 bones that make up the arch of the foot, beyond the tarsals

(3) **Phalanges (Toes/Digits)**: The 14 bones of the toes (2 in the great/big toe, 3 in each of the other four toes)