

The Skeletal System:

1. Overview & Functions of the Skeletal System

Components of the Skeletal System

- **Bones** (skeleton)
- **Joints**
- **Cartilages**
- **Ligaments**

Two Major Skeletal Divisions

1. **Axial Skeleton.** Skull, ribs, and vertebrae (forms the longitudinal axis).

2. **Appendicular Skeleton**
Pelvis and extremities (limbs and girdles).

Five Primary Functions of Bones

- **Support.** Provides structural framework for the whole body.
- **Protection** Protects underlying soft organs (e.g., skull protects brain, bony thorax protects heart/lungs).

- **Movement** Bones act as levers moved by attached skeletal muscles.

- **Storage** Stores minerals (calcium, magnesium, phosphorus) and fats (yellow marrow).

- **Blood Cell Formation (Hematopoiesis)** Occurs within red marrow.

2. Bone Anatomy & Histology

Bone Composition & Tissue Types

- **Adult Bone Count:** 206 bones.

- **Chemical Makeup:** Calcium, magnesium, phosphorus, and collagen fibers densely packed to form hard tissue.

- **Bone Tissue Types:**

- **Compact Bone:** Dense, homogeneous, smooth outer layer.

- **Spongy (Cancellous) Bone:** Composed of small, needle-like pieces of bone (trabeculae) with many open spaces.

Gross Anatomy of a Long Bone

- **Diaphysis** The central shaft; thick cylinder composed primarily of **compact bone**.
- **Epiphysis** The proximal and distal ends of the bone; composed mostly of **spongy bone** capped by a thin layer of compact bone.
- **Periosteum**: Fibrous connective tissue membrane covering the outside of the diaphysis.
- **Perforating** (Sharpey's) Fibers. Collagen fibers securing the periosteum to the underlying bone.
- **Arteries (Nutrient Arteries)**: Enter the shaft to supply bone cells with oxygen and nutrients.
- **Articular Cartilage**: Smooth hyaline cartilage covering external epiphysis surfaces to decrease friction at joints.
- **Medullary Cavity (Marrow Cavity)**:

- **Infants** Contains **red marrow** for blood cell formation.

- **Adults**. Contains ****yellow marrow** (mostly fat storage).

Microscopic Anatomy of Compact Bone

- **Osteon (Haversian System)** The basic functional/structural unit of compact bone.
- **Central (Haversian) Canal**: Runs longitudinally down the center of each osteon; carries blood vessels and nerves.
- **Perforating (Volkmann's) Canal**: Runs perpendicular (at right angles) to the central canals; connects nerves and blood vessels of the periosteum to the central canals and medullary cavity.
- **Lamellae**: Concentric rings of hard, calcified matrix around the central canal.
- **Lacunae**: Tiny cavities housing osteocytes (mature bone cells).
- **Canaliculi**: Hair-like canals radiating from lacunae, linking them together and to the central canal.

3. Classification of Bones by Shape

Category	Anatomical Characteristics	Key Examples
<u>Long Bones</u>	Typically longer than they are wide; have a shaft with heads at both ends; mostly compact bone	Femur, Humerus, Radius, Ulna
<u>Short Bones</u>	Generally cube-shaped; contain mostly spongy bone	Carpals (wrist), Tarsals (ankle)
<u>Flat Bones</u>	Thin, flattened, and usually curved; two thin layers of compact bone sandwiching spongy bone	Skull bones, Ribs, Sternum
<u>Irregular Bones</u>	Complex shapes that do not fit into other shape categories	Vertebrae, Hip bones (coxal bones)
<u>Sesamoid Bones</u>	Small, rounded bones embedded within tendons passing over joints	Patella (kneecap)

4. Bone Growth, Remodeling, & Repair

Developmental Changes

- Embryonic skeletons consist primarily of **hyaline cartilage**.
- During fetal development, cartilage is gradually replaced by bone (**ossification**), leaving cartilage only in isolated areas:
 - Bridge of the nose
 - Parts of the ribs (costal cartilages)
 - Articular surfaces of joints

Long Bone Growth (Childhood)

- **Epiphyseal Plates:**

Growth plates made of hyaline cartilage that allow longitudinal growth during childhood.

- **Process:**

1. New cartilage continuously forms on the outer facing surface.
2. Older cartilage on the inner face is broken down and replaced by bone matrix (ossification).

3. Bones are remodeled and lengthened until adulthood, and bones grow wider via appositional growth.

Bone Fractures & Repair Stages

Bone Fracture

A physical break or crack in a bone, most commonly caused by trauma.

Fracture Types

- **Closed (Simple):** Break does not penetrate through the skin.

- **Open (Compound):**

Broken bone end penetrates through the skin surface.

- **Comminuted:**

Bone breaks into many small fragments (common in the elderly/brittle bones).

- **Compression:**

Bone is crushed (common in porous/osteoporotic bones).

- **Depressed:**

Broken bone portion is pressed inward (typical of skull fractures).

- **Impacted:** Broken bone ends are driven forcefully into each other (e.g., breaking a fall with outstretched arms).

- **Spiral:** Ragged, twisting break caused by excessive torsion (common sports fracture).

- **Greenstick:**

Incomplete fracture where one side breaks and the other bends (common in children due to flexible bone matrix).

4 Stages of Fracture Healing

1. **Hematoma Formation:**

Blood vessels rupture,

forming a localized blood-filled swelling.

2. **Fibrocartilaginous (Soft) Callus Formation:**

New capillaries grow; fibroblasts and chondrocytes create a fibrous/cartilage splint across the gap.

3. **Bony (Hard) Callus Formation:**

Osteoblasts and osteoclasts replace fibrocartilage with a spongy bone callus.

4. **Bone Remodeling:** Bony callus is remodeled by mechanical stress over weeks to months, leaving a strong, permanent bone patch.

5. Regional Skeletal Anatomy

A. Axial Skeleton

Comprises 3 main parts:

Skull, **Vertebral Column**, and **Bony Thorax** (plus the associated laryngeal skeleton / hyoid).

1. The Skull

- **Cranium:** 8 bones enclosing and protecting the brain (Frontal, Parietal, Temporal, Occipital, Sphenoid, Ethmoid).

- **Facial Bones:** 14 bones forming facial structure (Maxillae, Zygomatic, Nasal, Lacrimal, Palatine, Vomer, Inferior conchae, Mandible).

- **Sutures:** Immovable fibrous joints uniting all skull bones except the mandible.

- **Mandible:** The only freely movable bone of the skull.

- **Foramen Magnum:** Large opening in the occipital bone allowing the spinal cord to connect to the brainstem.

- **Paranasal Sinuses:** Air-filled cavities lined with mucous membranes located in the frontal, ethmoid, sphenoid, and maxillary bones.

- **Fetal Skull:** Large relative to body length; features fibrous **fontanelles** (soft spots) allowing skull compression during birth and brain growth.

- **Hyoid Bone:** U-shaped bone in the anterior neck;

the only bone that does not articulate with any other bone; serves as a movable base for the tongue.

2. The Vertebral Column

- **Structure:** 26 individual irregular bones separated by shock-absorbing **intervertebral discs**.

- **Divisions:**

- **Cervical Vertebrae:** 7 bones (C1 - C7)

- **Thoracic Vertebrae:** 12 bones (T1 - T12)

- **Lumbar Vertebrae:** 5 bones (L1 - L5)

- **Sacrum:** 5 fused vertebrae

- **Coccyx:** 3 to 5 fused vertebrae

Abnormal Curvatures:

- **Kyphosis ("Humpback" / "Hunchback"):**

Excessive posterior curvature of the thoracic spine (often caused by osteoporotic compression fractures).

- **Lordosis ("Swayback"):**

Excessive anterior curvature of the lumbar spine (associated with obesity and late pregnancy due to forward shift in center of gravity).

- **Scoliosis:**

Abnormal lateral curvature and rotation of the spine (most common in adolescent girls).

3. The Bony Thorax (Thoracic Cage)

- **Sternum:** Flat bone composed of manubrium, body, and xiphoid process.

- **Ribs (12 pairs):**

- **True Ribs (Pairs 1–7):**

Attach directly to the sternum via individual costal cartilages.

- **False Ribs (Pairs 8–12):**

Attach indirectly to the sternum or lack sternal attachment.

- **Floating Ribs (Pairs 11–12):**

False ribs with no anterior sternal attachment.

- **Thoracic Vertebrae:**

Posterior attachment point for all 12 pairs of ribs.

B. Appendicular Skeleton

1. Upper Extremities

- **Pectoral (Shoulder)**

Girdle: Clavicle (collarbone) and Scapula (shoulder blade); lightweight and exceptionally mobile.

- **Arm:** Single long bone—**Humerus**.

- **Forearm:** Two parallel long bones—**Radius** (lateral, thumb-side) and **Ulna** (medial, pinky-side), connected by an interosseous membrane.

- **Hand:**

- **Carpals (8):**

Wrist bones (Scaphoid, Lunate, Triquetrum, Pisiform, Trapezium, Trapezoid, Capitate, Hamate).

- **Metacarpals (5):**

Palm bones (numbered 1–5 from thumb to little finger).

- **Phalanges (14):** Finger bones (Proximal, Middle, Distal; thumb has only proximal and distal).

2. Pelvic Girdle & Lower Extremities

- **Pelvic Girdle (Coxal / Hip Bones):** Formed by 3 pairs of fused bones: **Ilium**, **Ischium**, and **Pubis**. Bears the weight of the upper body and protects pelvic organs (bladder, reproductive organs, lower bowel).

- **Male vs. Female Pelvis:**

- **Female:** Broader, wider pelvic brim (rounder inlet), larger subpubic angle (90 degrees), lighter/shallower for childbirth.

- **Male:** Narrower, heart-shaped inlet, acute subpubic angle (<90 degrees), heavier bones.

- **Thigh:** Single long bone—**Femur** (heaviest, strongest bone in the body).

- **Leg: Tibia** (shinbone, medial, weight-bearing) and **Fibula** (lateral, non-weight bearing).

- **Foot:**

- **Tarsals (7):** Ankle/heel bones (including Calcaneus and Talus).

- **Metatarsals (5):** Sole bones.

- **Phalanges (14):** Toe bones.

- **Foot Arches:**

Two longitudinal arches (medial and lateral) and one transverse arch.

6. Joint Classification & Mechanics

Structural vs. Functional Classification



Types of Synovial Joints

Synovial Type	Axial Movement	Movement Description	Anatomical Examples
<u>Plane Joint</u>	Nonaxial	Gliding / sliding motions across flat articular facets	Intercarpal joints, Interatarsal joints
<u>Hinge Joint</u>	Uniaxial	Angular motion in a single plane (flexion / extension)	Elbow joint, Knee, Interphalangeal joints
<u>Pivot Joint</u>	Uniaxial	Rotation around a single central longitudinal axis	Proximal radioulnar joint, Atlantoaxial joint (C ₁ - C ₂)
<u>Condyloid Joint</u>	Biaxial	Side-to-side and back-and-forth movement	Metacarpophalangeal (knuckle) joints, Radiocarpal joint
<u>Saddle Joint</u>	Biaxial	Concave/convex surfaces fitting together; allows opposition	Carpometacarpal joint of the thumb (Carpal #1)
<u>Ball-and-Socket</u>	Multiaxial	Universal movement in all planes, including rotation	Shoulder joint (glenohumeral), Hip joint

7. Skeletal Pathology & Clinical Disorders

- **Osteoarthritis**

(Degenerative Joint Disease) Most common chronic wear-and-tear arthritis; associated with aging and breakdown of articular cartilage.

- **Rheumatoid Arthritis:**

Chronic, systemic autoimmune disorder where the immune system attacks joint tissues; begins with bilateral inflammation and thickening of synovial membranes, often leading to joint deformity.

- **Gouty Arthritis (Gout):**

Deposition of needle-shaped **urate** (uric acid) crystals in soft joint tissues caused by **hyperuricemia**; characteristically affects the base of the great toe.

- **Osteoporosis:**

Age-related bone loss where bone resorption outpaces bone deposition, leaving bones porous and fragile.

- **Osteomalacia & Rickets:**

Softening/weakening of bones due to severe **calcium or vitamin D deficiency** (termed **rickets** in children, causing bone deformities).

- **Osteomyelitis:**

Bacterial infection of bone and bone marrow.

- **Paget's Disease (Osteitis Deformans):**

Disorder characterized by excessive, disorganized bone cell destruction and abnormal remodeling.

- **Ankylosing Spondylitis:**

Hereditary, progressive inflammatory spinal disease leading to fusion of vertebrae.

- **Meningomyelocele (Spina Bifida):**

Congenital neural tube defect where the spinal column fails to close completely around the spinal cord.

- **Carpal Tunnel Syndrome:**

Compression neuropathy caused by pressure on the **median nerve** beneath the

transverse carpal ligament
at the wrist.

- ***Congenital Clubfoot***

(Talipes): Congenital lower limb deformity where the foot and ankle are twisted inward (= 1 in 1000 births, twice as common in males 50 % bilateral; linked to genetics and maternal smoking)

- ***Subluxation***

or incomplete dislocation of a joint (e.g., cervical whiplash).

- ***Avulsion Fracture:*** Occurs when a powerful tendon or ligament pulls off a bone fragment during injury.

- ***Bursitis & Tendonitis:***

Inflammation of a bursa (fluid-filled friction-reducing sac) or tendon sheath, usually resulting from acute trauma or overuse friction.