System: Skeletal

Functions:
- Support
- Protection
- Movement
- Storage
  - Minerals
    - Ca⁺⁺ - used in many processes in body
    - Must be maintained at certain levels in blood.
  - Marrow
    - Haematopoietic stem cells
    - Fat
- Blood Production – Haematopoiesis

Metabolism of bone & its hormonal control
- Calcitonin → Ca⁺⁺ salt deposit in bone
- Parathyroid hormone → Resorption of Ca⁺⁺ from bone by osteoclasts → increases blood Ca⁺⁺ levels.
- Estrogen → Restrains Osteoclast activity & Promotes deposition of new bone.

Bone Composition:
- Organic
  - Collagen & other proteins
  - 35%
  - Flexibility
  - Tensile Strength
- Inorganic
  - Mineral Salts
  - 65%
  - Compression Strength
  - Reason why it preserves so well.
Bone & Associated Tissue:

- **Bone**
  - Compact
    - Thicker
    - Denser
    - Comprised of **Osteons** – basic units of compact bone
  - Cancellous (Spongy)
    - Trabeculae (struts) relay stress to the dense compact bone
    - Houses marrow in between trabeculae.
    - Blood Vessels

- **Cartilage:**
  - Articular (Hyaline)
    - Avascular
    - Ground Substance – fibres + H₂O

Bone Development:

- **Intramembranous**
  - Ossification Within Membranes
    - Cranial bones of skull
    - Clavicles

- **Endochondral**
  - From Cartilage
    - Hyaline cartilage
    - Primary ossification centre in diaphysis
    - Secondary ossification centre in epiphyses
    - Epiphyseal plate (growth plate)

Bone Remodelling:

- Bone is living tissue
- Requires blood supply & Constant remodelling
- Bone remodells in response to:
  - Calcium requirements in body...and
  - Mechanical Stress
- **Resorption** – destruction of old bone matter by **Osteoclasts:**
  - Large multinucleated cells
  - Plasma membrane attaches to bone
  - Forms a seal
  - Secretes enzymes (collagenase), acid & lysosomes
- **Apposition** – deposition of new bone matter by **Osteoblasts:**
  - Large Golgi – cells of high protein & proteoglycan synthesis
  - Secrete osteoid (unmineralised organic bone matrix) into lacunae
  - Osteoid + mineralisation = mature bone
  - **Osteoblasts** trapped in matrix become **osteocytes** when bone formation has ceased.

- **Eg. Bone Remodelling in Response to Stress:**
  - Bone is modelled to more efficiently withstand the force.
**Eg. Long Bone Growth:**

- **Length**
  - Apposition at epiphyseal line
  - By osteoblasts

- **Width**
  - Apposition by osteoblasts
  - Resorption (bone removal) by osteoclasts

**Classification of Bones:**
Appendicular Vs. Axial Skeleton:

![Long bone structure diagram]

**Long Bone Structure:**

- **Diaphysis**
  - Shaft
  - Hollow
  - Strength + Lightness
  - Contains marrow (yellow in adult)

- **Epiphysis**
  - Expanded ends of bones
  - Proximal & Distal
  - Covered in **articular cartilage**.
  - Boundary defined by **epiphyseal line**.

- **Medullary (Marrow) Cavity**
  - Marrow cavity
  - Red Marrow & Yellow (fatty) marrow
  - Site of hematopoiesis (blood cell production)
  - Stores fat
  - Makes bone lighter – but still strong.

- **Periostium**
  - Connective tissue covering
  - Covers all bones
  - Fibrous outer
    - Sharpey’s fibres
  - Inner
    - Osteoblasts
    - Osteoclasts

- **Nutrient Foramen**
  - External opening of the nutrient canal in a bone.
  - Provides blood supply
  - Arteries & Nerves
  - More prevalent towards epiphysis.
Joints:
- Junction between 2 or more bones
- Not necessarily moving joints (Eg. cranial sutures)
- 3 Types:
  - **Fibrous**
    - No movement
    - Joined by fibrous tissue
    - No joint cavity
    - Eg. Cranial Sutures
    - Eg. Syndemoses – between tibia & fibula @ ankle.
  - **Cartilaginous**
    - Varying amount of movement
    - Joined by cartilage
    - No joint cavity
    - 2 types:
      - Synchondroses – eg. Epiphyseal plates
      - Symphyses – eg. Intervertebral joints & pubic symphysis
  - **Synovial**
    - **Articular (hyaline) Cartilage**
      - Covers bone ends
      - Protects bone – prevents bone-bone contact
      - Resists shock
      - Avascular - nutrients in synovial fluid diffuse to it.
      - Cells = Chondrocytes
    - **Synovial fluid**
      - Lubricates joint
      - Provides nutrition for cartilage
    - **Synovial membrane (synovium)**
      - Lines everything inside the joint that isn’t lined by articular cartilage
    - **Ligaments & Tendons**
      - Fibres – Collagen
      - Poorly vascularised
- **Types of Synovial Joints:**
  - Plane – intertarsal joints in hand
  - Hinge – elbow/knee
  - Pivot – proximal radioulnar joint
  - Saddle – carpometacarpal joint of thumb
  - Ball & Socket – shoulder/hip
  - Condyloid – metacarpophalangeal joints

- **Synovial Joint Movements:**
  - Gliding
  - Angular
    - Flexion/extension/abduction/adduction/circumduction/plantarflexion/dorsiflexion
  - Rotation
  - Special
    - Inversion/eversion/supination/pronation/protraction/retraction/elevation/depression/opposition

- **Synovial Joint Stability:**
  - Articular surfaces shape
    - Bony congruity
  - Ligaments
    - Capsular
    - Intracapsular
    - External
  - Muscle tone

- **Movement Limiters:**
  - Shape of bone ends
  - Location of ligaments
  - Length of ligaments
  - Other body surfaces

**Bursae and Tendon Sheaths:**
- Found in close association with synovial joints
- ‘bags of lubricant’
  - Lined by synovial membrane
  - Contain synovial fluid
  - Reduces friction between adjacent structures
Bone repair mechanisms

- 1. Hematoma Formation
- 2. Fibrocartilaginous Callus Formation
- 3. Bony Callus Formation
- 4. Bone Remodelling
Shoulder Girdle (Pectorial Girdle):

- **Functions:**
  - Manipulation of environment – not locomotion
  - Attaches upper limb to axial skeleton
  - Clavicle acts as ‘strut’ - transmits force to axial skeleton. 
    - Gives upper arm reach.
  - **High Mobility, Low Stability.**

- **Manubrium of Sternum (breastplate)**
  - Flat bone
  - Quadrangular shape

- **Clavicle**
  - Long bone
  - **Articulations:**
    - Manubrium of Sternum
    - Acromion of Scapula

- **Scapula**
  - Connects Humerus → Clavicle
  - **Landmarks:**
    - Lateral Border
    - Medial Border
    - Superior Border
    - Spine
    - Acromion
    - Coracoid Process
    - Glenoid Cavity
  - **Articulations:**
    - Lateral ends of Clavicle
    - Head of Humerus

- **Humerus**
  - Long Bone
  - **Landmarks:**
    - Head
    - Greater Tubercle
    - Lesser Tubercle
    - Medial Epicondyle
    - Lateral Epicondyle
    - Olecranon Fossa
  - **Articulations:**
    - Glenoid Process of Scapula
    - Radius
    - Ulnar

- **Ulna: “Elbow”**
  - ‘Little-Finger-Side’
  - Wide at Proximal End
  - Thin at Distal End
  - **Landmarks:**
    - Olecranon Process (Posterior Proximal)
    - Trochlear Notch
    - Styloid Process of Ulna
    - Head of Ulna (Articulates with Wrist via Disc of Fibrocartilage)
    - Radial Notch (Articulates with Head of Radius)
  - **Articulations:**
    - Trochlea of Humerus (Via Trochlear Notch between Coronoid & Olecranon Processes)
      - When fully extended, Olecranon Process ‘Locks’ into Olecranon Fossa of Humerus
    - Bones of Wrist
    - Radius – via Interosseous Membrane (flat, flexible ligament spanning entire length)
• **Radius: “Rod”**
  - ‘Thumb-Side’
  - Thin at Proximal end
  - Wide at Distal end
• **Landmarks:**
  - Head – concave (Articulates with Capitulum of Humerus)
  - Ulnar Notch (Articulates with Head of Ulna)
  - Styloid Process Of Radius
  - Distal End – Concave (Articulates with Carpal Bones of Wrist)
• **Articulations:**
  - Humerus
  - Bones of Wrist
  - Ulna – via Interosseous Membrane (flat, flexible ligament spanning entire length)

  **Summary of Shoulder Girdle & Arm Bones & Landmarks**
‘Hand’:
  o Carpals (“Wrist”):
    ▪ Trapezium
    ▪ Trapezoid
    ▪ Capitate
    ▪ Hamate
    ▪ Pisiform
    ▪ Triquetral
    ▪ Lunate
    ▪ Scaphoid
  o Metacarpals (“Palm”):
    ▪ Metacarpals # 1-5
  o Phalanges (“Fingers”):
    ▪ Distal # 1-5
    ▪ Middle # 1-5
    ▪ Proximal # 1-5

**NB: Some Lovers Try Positions That They Can’t Handle**
Scaphoid, Lunate, Triquetrium, Pisiform, Trapezium, Trapezoid, Capitate, Hamate.

- AcromioClavicular Joint:
  o Features:
    ▪ Joins the Clavicle to the Acromion
    ▪ Synovial Plane
    ▪ Has an ‘Articular Disc’ (oval plate of fibrocartilage) – for congruence between bones.
  o Bones:
    ▪ Clavicle
    ▪ Acromion of Scapula
  o Ligaments:
    ▪ Coracoacromial
    ▪ Acromioclavicular
    ▪ Coracoclavicular
      ▪ Conoid
      ▪ Trapezoid
**GlenoHumeral Joint:**

- **Features:**
  - Joins Humerous & Glenoid Fossa (cavity) of Scapula
  - Synovial ball & socket
  - Glenoid Fossa = Shallow → allows huge angle of movement.
    - High Mobility
    - Low Stability
  - Glenoid Labrum: “Glenoid lip”
    - Ring of cartilage around Glenoid Fossa
    - Deepens socket
    - Helps with stability
  - SubAcromial (SubDeltoid) Bursa
    - Acts as a cushion
    - Reduces friction
  - Synovial Capsule
    - Very loose
    - Synovial sheath of Biceps Brachii

- **Bones:**
  - Head of Humerus
  - Glenoid Fossa of Scapula

- **Ligaments:**
  - GlenoHumeral Ligaments
  - CoracoHumeral Ligament
  - Transverse Humeral Ligaments
    - Bridges the Intertubercular Groove
    - Tendon of Long Head of Biceps Brachii passes underneath
  - *Fibrous (Articular) Capsule
    - Fused with Rotator Cuff muscles
    - Provides stability

![GlenoHumeral Joint Diagram](image-url)
- **Elbow Joint**
  - **HumeroUlnar Joint:**
    - **Features:**
      - Joins Distal Humerus to Proximal Ulna
      - Synovial Hinge Joint
      - Uniaxial – Flexion & Extension Only
      - Very Stable – Due to Bony Congruency & Ligaments
    - **Bones:**
      - Humerus
        - Medial Epicondyle
          - Trochlear
          - Coronoid Fossa
        - Lateral Epicondyle
          - Capitulum
          - Radial Fossa
      - Ulna
    - **Ligaments:**
      - Ulnar Collateral Ligament
      - Annular Ligament
      - Radial Collateral Ligament

![Diagram of Elbow Joint](image-url)
- **RadioUlnar Joint:**
  - **Proximal:**
    - **Features:**
      - Joins Radius & Ulna
      - Synovial Pivot Joint
      - Uniaxial – Pronation & Supination Only
    - **Bones:**
      - Radius
      - Ulna
    - **Ligaments:**
      - Annular Ligament
  - **Distal:**
    - **Features:**
      - Joins Radius & Ulna
      - Synovial Pivot + Articular Disc
      - Uniaxial – Pronation & Supination Only
    - **Bones:**
      - Radius
      - Ulna
    - **Ligaments:**
      - Dorsal RadioUlnar Ligament
      - Volar RadioUlnar Ligament
- **Wrist Joint:**
  - **CarpiRadialis Joint:**
    - **Features:**
      - Joins Radius & Proximal Carpals
      - Synovial Condyloid
      - Biaxial: Flexion/Extension + Abduction/Adduction = Circumduction
    - **Bones:**
      - Radius
      - Proximal Carpals
    - **Ligaments:**
      - Palmar Carpal Ligament
      - Flexor Retinaculum (Transverse Carpal Ligament) – Roof of Carpal Tunnel
      - Dorsal RadioCarpal Ligament
- **InterCarpal Joints:**
  - **Features:**
    - Joins Adjacent Carpals
    - Synovial Plan
  - **Bones:**
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
    - Pisiform
    - Triquetral
    - Lunate
    - Scaphoid
  - **Ligaments:**
    - The various Palmar Intercarpal Ligaments
<table>
<thead>
<tr>
<th>Joint</th>
<th>Synovial type</th>
<th>Movements</th>
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<td>Intercarpal</td>
<td>plane</td>
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<td>1&lt;sup&gt;st&lt;/sup&gt; Carpometacarpal</td>
<td>saddle</td>
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</tr>
<tr>
<td>Interphalangeal</td>
<td>Hinge</td>
<td>Extension, flexion</td>
</tr>
</tbody>
</table>
The Pelvic Girdle & The Lower Limb

Bones:

- **The “Bony Pelvis”:**
  - **Sacrum:**
    - **Type/Features:**
      - Irregular Bone
      - The 5 last vertebrae fused together.
    - **Articulations:**
      - Last Lumbar Vertebra
      - The 2 Hip Bones (Sacroiliac Joints)
      - The Coccyx
  - **Coxal Bones (hip bones):**
    - **Type/Features:**
      - Irregular Bones
      - Made up of 3 Bones during Childhood:
        - Ilium
        - Ischium
        - Pubis
    - **Landmarks:**
      - Acetabulum ("Wine Cup") – Hemispherical Socket
      - Pelvic Brim
      - **Ilium**
        - Iliac Crest
        - Tubercle of the Iliac Crest
        - Anterior Superior Iliac Spine
        - Posterior Superior Iliac Spine
        - Anterior Inferior Iliac Spine
        - Posterior Inferior Iliac Spine
        - Greater Sciatic Notch – Sciatic Nerve passes through
        - Iliac Fossa
      - **Ischium**
        - Ischial Tuberosity –(Huge Sacrotuberous Ligaments run from here to sacrum)
      - **Pubis**
        - Pubic Tubercle
        - Pubic symphysis
        - Obturator Foramen – blood vessel & nerves pass through
        - Pubic Arch/Subpubic Angle (Wide in females)
    - **Articulations:**
      - Sacrum
      - Femurs
      - The other Coxal Bone (pubic symphysis)
• **Femur:**
  - **Type/Features:**
    - Long bone
    - Longest & Strongest bone of the body.
    - Angle of Inclination - 125°
    - Angle of Anteversion - 10°
    - Neck of femur – prone to fracture due to lack of trabeculae.
  - **Landmarks:**
    - Head
    - Neck
    - Greater Trochanter
    - Lesser Trochanter
    - Lateral Epicondyle
    - Medial Epicondyle
    - Adductor Tubercle
    - Patellar Surface
  - **Articulations:**
    - Acetabulum of the Coxal Bones of the Hip
    - Patella
    - Tibia

• **Patella**
  - **Type/Features:**
    - Triangular Sesamoid Bone
    - Enclosed in Quadriceps Tendon
    - Protects Knee Joint Anteriorly
    - Improves Leverage of thigh muscles across the knee.
  - **Landmarks:**
    - Lateral Facet
    - Medial Facet
    - Apex
  - **Articulations:**
    - Femur – Patellar Surface (extended knee)
    - Femur – Lateral & Medial Condyles (Flexed knee)
- **Tibia**
  - **Type/Features:**
    - Long Bone
    - 2nd largest bone in the body.
    - Transmits the Body’s weight (not fibula)
    - Shaft is vertical within the leg
  - **Landmarks:**
    - Condyles – Medial & Lateral
    - Tibial Plateau – (superior articular surface)
    - Tibial Tuberosity
    - Medial Malleolus
  - **Articulations:**
    - Condyles of Femur
    - Tibia – Fibular Notch (proximally)
    - Trochlea of Talus Bone of Tarsals of the Foot.

- **Fibula**
  - **Type/Features:**
    - Slender Long Bone
    - Attached to Tibia by *Tibiofibular Syndesmosis* (Incl. Interosseous Membrane)
    - Unlike Radius & Ulna, the leg is fixed (can’t supinate/pronate)
    - No function in weight-bearing – mainly for muscle attachment
  - **Articulations:**
    - Tibia Proximally & Distally
    - Trochlea of Talus Bone of Tarsals of the Foot.

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![Diagram of Tibia and Fibula](www.MedStudentNotes.com)
Joints:

- **Sacro-Ilial**
  - **Features:**
    - Synovial Planar Joint
    - Loosens during labour.
  - **Bones:**
    - Sacrum
    - Ilium
  - **Ligaments:**
    - Anterior Sacroiliac Ligament
    - Posterior Sacroiliac Ligament
    - Interosseous Sacroiliac Ligament

- **Pubic Symphysis**
  - **Features:**
    - Cartilagenous Joint
    - Loosens during labour
  - **Bones:**
    - Left & Right Pubis
  - **Ligaments:**
    - Ligamentous Capsule encases Fibrocartilagenous Disc.

- **Hip Joints**
  - **Features:**
    - Synovial, MultiAxial Ball & Socket
    - Acetabular Labrum (lip) of fibrocartilage – deepens socket – High Bony Congruency
    - Central fat-filled acetabular fossa.
  - **Bones:**
    - Rounded head of Femur
    - Acetabulum of Innominate Bones.
  - **Ligaments:**
    - **Iliofemoral Ligament** (anterior)-[From Anterior Inferior Iliac Spine → Intertrochanteric Line]
      - Limits extension, lateral rotation, adduction & abduction
    - **Pubofemoral** (medial)-[From Iliopubic Eminence → Inferior Aspect of Intertrochanteric Line]
      - Limits extension, lateral rotation & abduction
    - **Ischiofemoral** (posterior)-[From Posterior aspect of Acetabulum → Greater Trochanter]
      - Limits extension, medial rotation & adduction
    - **Ligamentum Teres (Ligament of Head of Femur)**
      - Not for stability – provides passage for vessels
**Knee Joint:**

- **Features of The Knee Joint:**
  - Synovial Modified Bicondylar **Hinge** Joint
  - **Relatively Unstable:**
    - Some Gliding & Rolling
    - Some Rotation
    - Ligaments provide the stability – not Bony Congruity.
  - Poor Bony Congruity
  - **2 Parts:**
    - **Tibiofemoral Joint**
    - **PatelloFemoral Joint**
  - Femur sits on an angle – Medial Condyle of Femur extends further distally to accommodate the angle of articulation with the Tibia.

- **Menisci:**
  - Fibrocartilage on Tibial Plateaus
  - Deepens the socket – increases congruity
  - Shock absorption
  - Peripheral Aspects are Vasculated – Central Aspects aren’t → heal very slowly
  - **Lateral:**
    - More freely movable than Medial Meniscus due to attachments
    - **Attachments:**
      - Post. Cruciate Ligament – via Post. Meniscofemoral Ligament
      - Weak attachment to Joint Capsule
      - Medial Meniscus – via Transverse Ligament
  - **Medial:**
    - More firmly attached – but higher chance of injury – due to less give + connections to other things
    - **Attachments:**
      - Intercondylar Areas – Anterior & Posterior
      - Medial Collateral ligament
      - Joint Capsule

- **Bones:**
  - Femur
  - Patella
  - Tibia
**Ligaments:**
- Fibrous Capsule
  - Thick on Medial & Lateral aspects
  - ‘Sleeve’ around joint.
- Extracapsular:
  - Patellar Ligament – Very Strong
  - Collaterals (Medial & Lateral)
- Intracapsular:
  - Cruciates (Anterior & Posterior – Named in respect to their attachment to the Tibia)
    - Anterior
      - Stops Forward Displacement of Tibia on Femur
      - Tightens During Extension
    - Posterior
      - Stops Backward Displacement of Tibia on Femur
      - Tightens During Flexion
  - Transverse Ligament (between Menisci)
  - Meniscofemoral Ligament (from Lateral Meniscus → Posterior Cruciate Ligament)

**Bursae:**
- SupraPatella Bursa
  - Continuous with Synovial Joint Cavity
  - Sits underneath Quads Tendon
- Subcutaneous PrePatellar Bursa
  - Anterior to Patella
  - For kneeling
- Deep Infrapatella Bursa
  - Sits on top of Fat Pads below Patellar Tendon
The Axial Skeleton

Bones:

- **Vertebral Column:**
  - **General Info:**
    - 33 Vertebrae
    - 5 Regions:
      - 7x Cervical
      - 12x Thoracic
      - 5x Lumbar
      - 5x Sacral (fused by adulthood)
      - 4x Coccygeal
    - Bones increase in size towards the bottom. (due to increased load/weight)
    - Protects Spinal Chord
    - Fibrocartilaginous Intervertebral Discs

- **Curvatures:**
  - **2x Primary:** (Concave Anteriorly)
    - Ie. Thoracic
    - & Sacral
  - **2x Secondary** (Concave Posteriorly)
    - Ie. Cervical
    - & Lumbar

- **Abnormalities:**
  - **Kyphosis:** Excess 1° curvature
  - **Lordosis:** Excess 2° curvature
  - **Scoliosis:** Lateral Deviation
**Typical Vertebrae:**

- Body
- Vertebral Arch
- Vertebral Foramen (canal)
- Transverse Processes
- Spinous Processes
- Articular Processes
  - Superior
  - Inferior
- Intervertebral Foramen (passage of the spinal nerve root between vertebrae)

- **7x Cervical:** Distinguishing Features:
  - Small Body
  - Very Large Vertebral Foramen
  - Transverse Foramina: Holes in Transverse Processes → passage of vertebral arteries
  - Dual Spinous Processes

- **12x Thoracic:** Distinguishing Features:
  - Medium Sized Body
  - Thick Lamina
  - Single Spinous Process
  - Costal Facet on Transverse Processes & Body – for Ribs
5x Lumbar: Distinguishing Features:
- Very Large Body
- Smaller Vertebral Foramen
- No Costal Facets
- Chode-like Spinous Processes

5x Sacrum: Distinguishing Features:
- Obvious
- Don’t bother with landmarks of this

4x Coccyx: Distinguishing Features:
- Obvious
- Don’t bother with landmarks of this

Special “Atypical” Vertebrae:
- C1 - Atlas:
  - No Body
  - Just a ring of bone
    - Anterior Arch
    - Posterior Arch
  - Transverse Foramina: Holes in Transverse Processes → passage of vertebral arteries
  - Transverse Ligament – for Dens of Axis
  - Skull Sits on top of this bone

- C2 - Axis:
  - Small body with a protuberance: The “Dens of Axis”
  - Wide Lamina & Vertebral Foramen
  - Transverse Foramina: Holes in Transverse Processes → passage of vertebral arteries
- **Joints:**
  - **Atlanto-Occipital Joint:**
    - Synovial Egg & Spoon Joint
    - Between the Skull & The Atlas
    - Allows you to nod (the ‘yes’ joint)
  - **Atlanto-Axial Joint:**
    - 2 Parts:
      - Synovial Pivot –
        - Dens of Axis & Transverse Ligament of Atlas
      - Synovial Planar –
        - Superior Articular Surface of Axis & Inferior Articular Surface of Atlas.
    - Allows the head to turn (the ‘no’ joint)
  - **Zygodiphyseal (Facet) Joints:**
    - Synovial Planar Joints
    - Between the Superior & Inferior Articular Processes of 2 Vertebrae

- **Intervertebral Discs:**
  - Cartilaginous Joints (Symphyses)
  - Allows slight movement between vertebrae
  - Nucleus can herniate out → ‘Slipped Disc’
    - If the herniation puts pressure on a spinal nerve → pain.