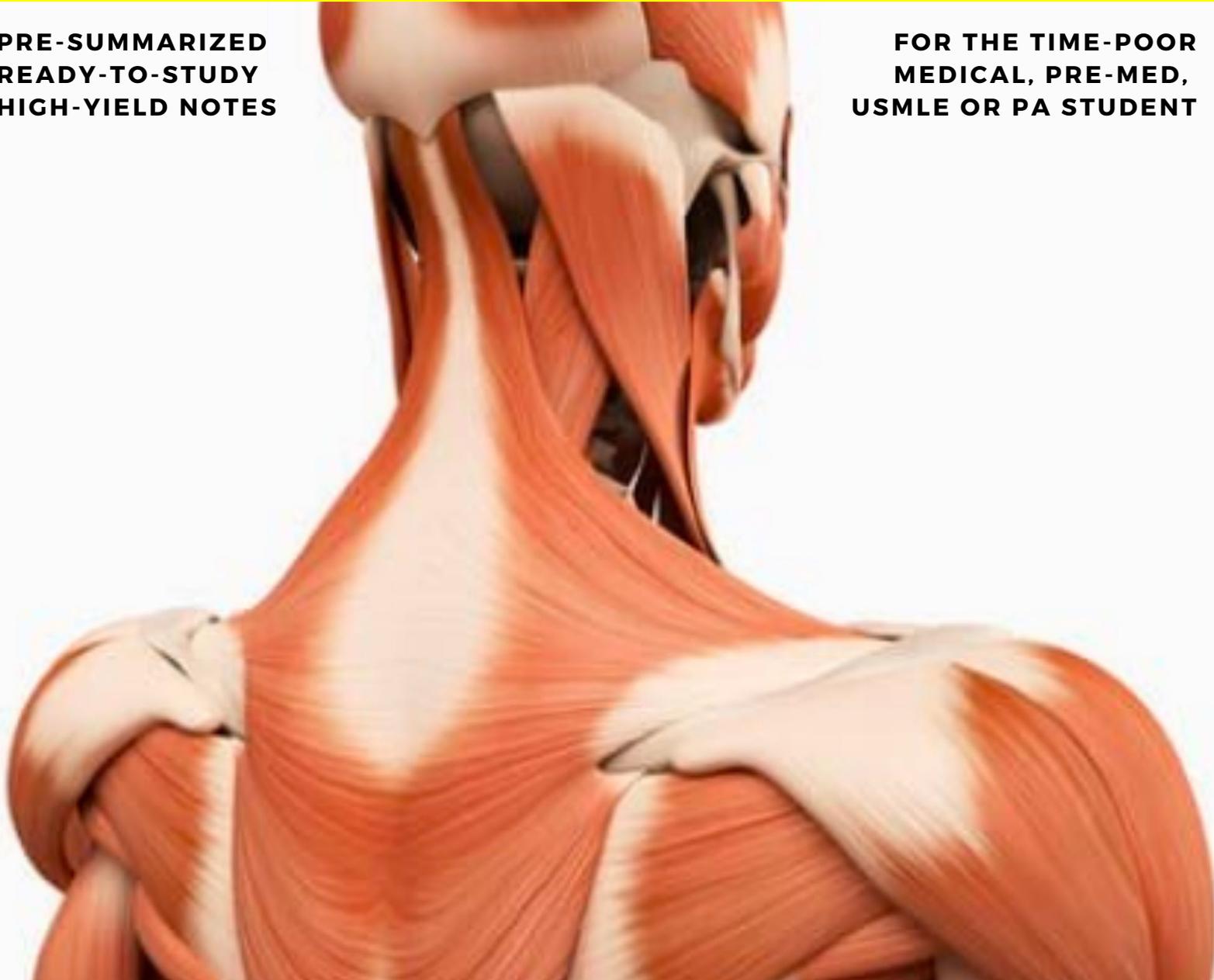


ANATOMY, PHYSIOLOGY & PATHOLOGY NOTES OF THE MUSCULOSKELETAL SYSTEM

FOURTH EDITION

PRE-SUMMARIZED
READY-TO-STUDY
HIGH-YIELD NOTES

FOR THE TIME-POOR
MEDICAL, PRE-MED,
USMLE OR PA STUDENT



PDF



212 PAGES

A Message From Our Team

Studying medicine or any health-related degree can be stressful; believe us, we know from experience! The human body is an incredibly complex organism, and finding a way to streamline your learning is crucial to succeeding in your exams and future profession. Our goal from the outset has been to create the greatest educational resource for the next generation of medical students, and to make them as affordable as possible.

In this fourth edition of our notes we have made a number of text corrections, formatting updates, and figure updates which we feel will enhance your study experience. We have also endeavoured to use only open-source images and/or provide attribution where possible.

If you are new to us, here are a few things to help get the most out of your notes:

- 1. Once saved, the notes are yours for life!** However, we strongly advise that you download and save the files immediately upon purchasing for permanent offline access.
- 2. Sharing notes is prohibited.** All files are share-protected and our system will automatically revoke access to and lock files if it detects a customer attempting to share or distribute our notes.
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 - b. You may save the files to an external hard drive for backup purposes only.
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Table Of Contents:

What's included: Ready-to-study anatomy, physiology and pathology notes of the musculoskeletal system presented in succinct, intuitive and richly illustrated downloadable PDF documents. Once downloaded, you may choose to either print and bind them, or make annotations digitally on your ipad or tablet PC.

Anatomy & Physiology Notes:

- GENERAL OVERVIEW OF THE SKELETAL SYSTEM
- GENERAL OVERVIEW OF THE MUSCULAR SYSTEM
- GENERAL MUSCLE PHYSIOLOGY
- PRINCIPLES OF BIOMECHANICS
- MUSCLE REFLEXES
- BONES OF THE SKULL
- BONES OF THE AXIAL SKELETON
- BONES OF THE UPPER LIMBS & SHOULDER GIRDLE
- BONES OF THE LOWER LIMBS & PELVIC GIRDLE
- MUSCLES OF THE AXIAL SKELETON
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- INNERVATION OF THE UPPER LIMBS & SHOULDER GIRDLE
- INNERVATION OF THE LOWER LIMBS & PELVIC GIRDLE
- BLOOD SUPPLY OF THE UPPER LIMBS & SHOULDER GIRDLE
- BLOOD SUPPLY OF THE LOWER LIMBS & PELVIC GIRDLE

Pathology Notes:

- BONY INJURIES
- DESCRIBING AN X-RAY
- NEUROVASCULAR COMPROMISES
- MYOSITIS
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- SEPTIC ARTHRITIS
- BONY TUMOURS
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- CRYSTAL ARTHROPATHIES
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- SERONEGATIVE (NON-RHEUMATOID) ARTHRITIS
- ARTHRITIS & RHEUMATOLOGY CASES

GENERAL OVERVIEW OF THE SKELETAL SYSTEM

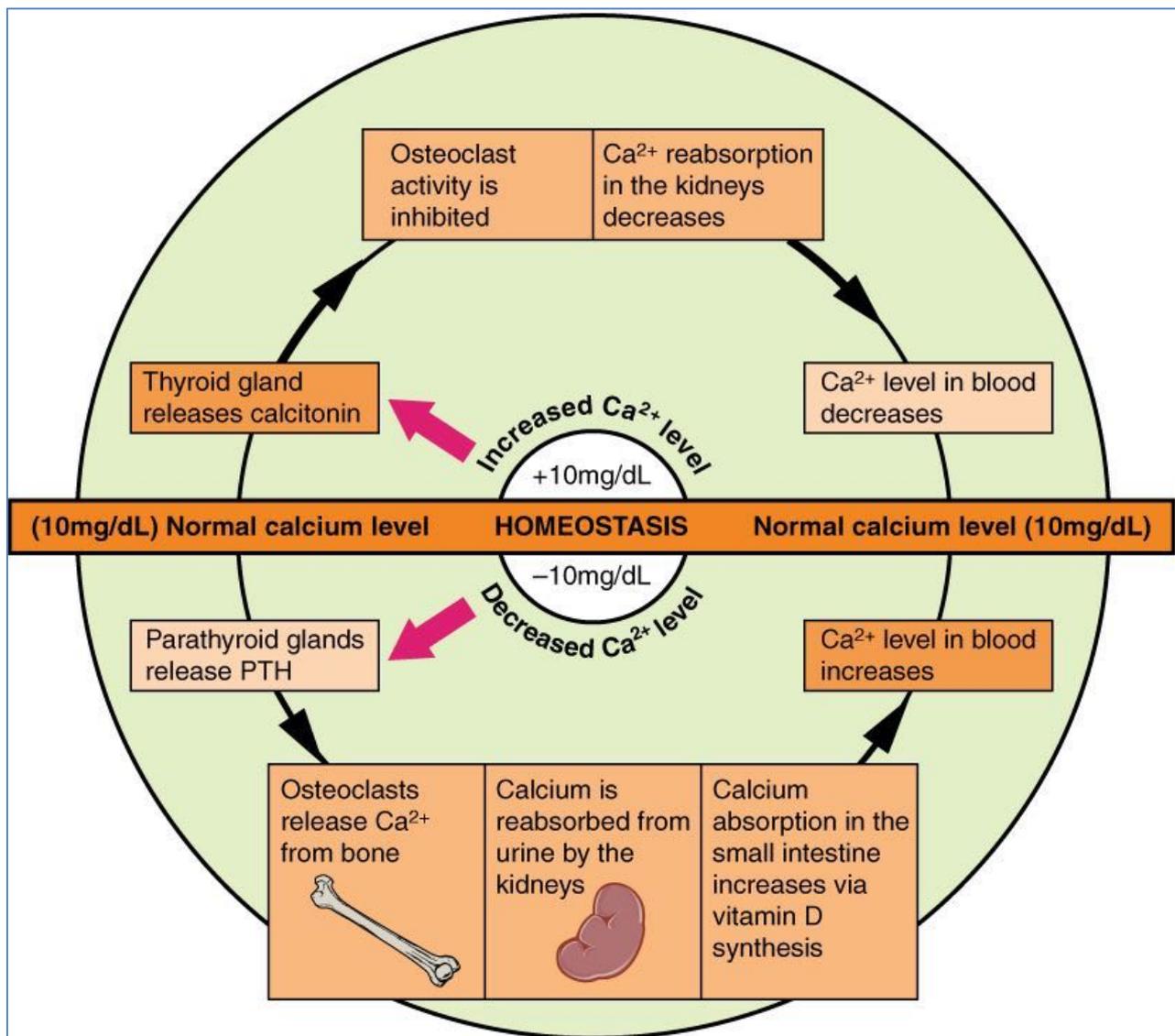
GENERAL OVERVIEW OF THE SKELETAL SYSTEM

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

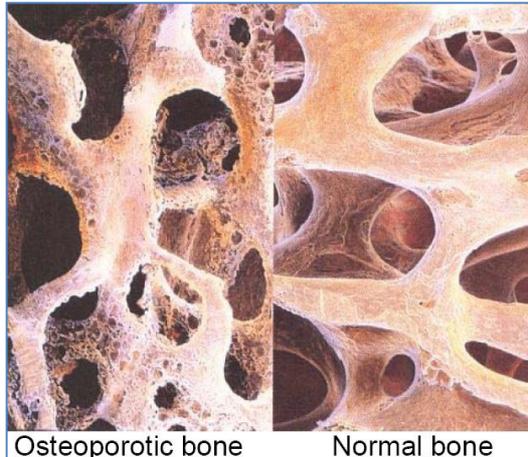
Metabolism of bone & its hormonal control

- **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.



Osteoporosis:

- Bone resorption outstrips deposition → bone density decreases – risk of fractures increases.
 - Cancellous bone is affected first – has a quicker turnover (remodelling rate)
 - Trabeculae become porous & lighter or even disappear
 - Common in Postmenopausal Women: reduced levels of Estrogen → increased osteoclast activity.



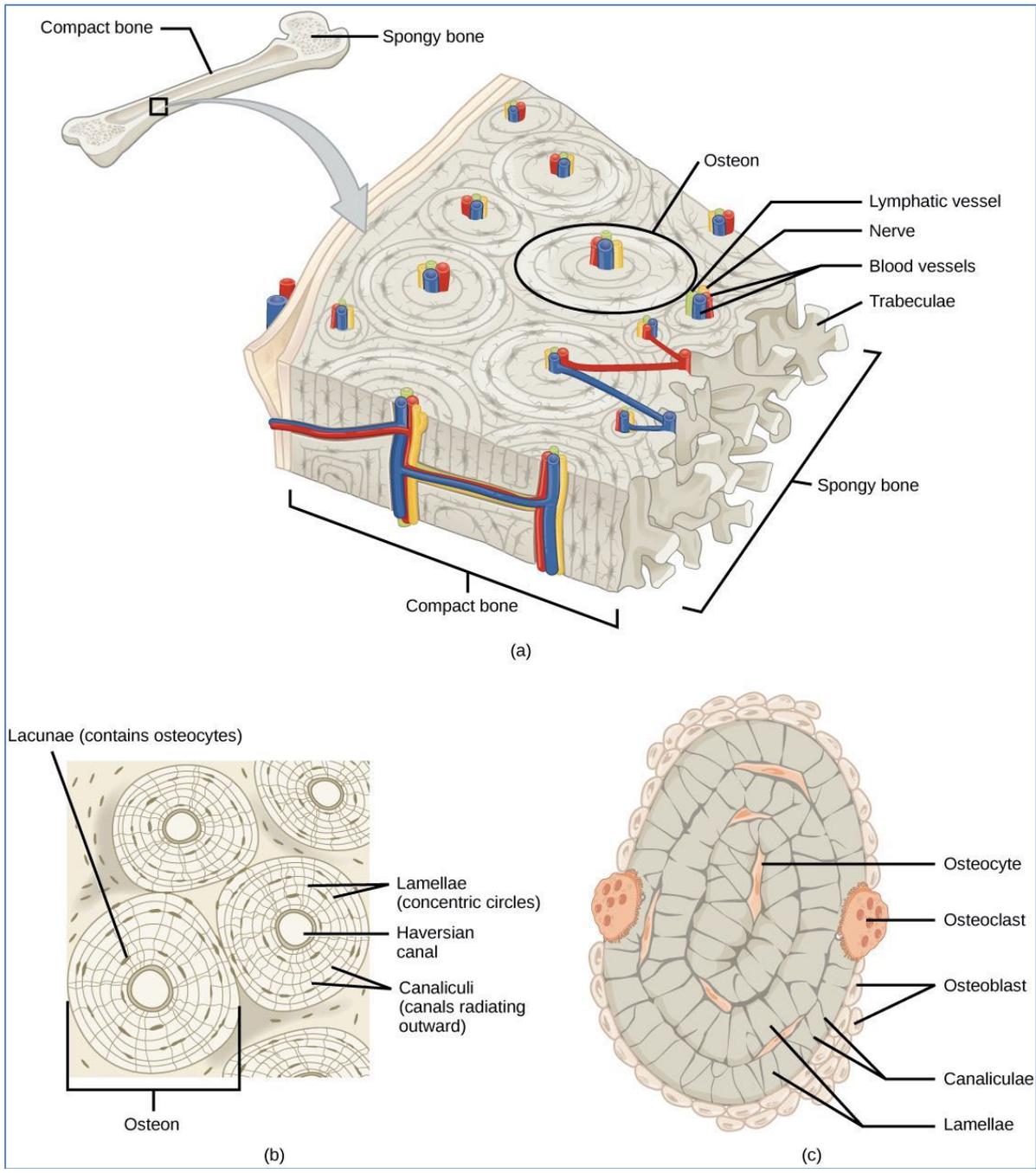
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Bone Composition:

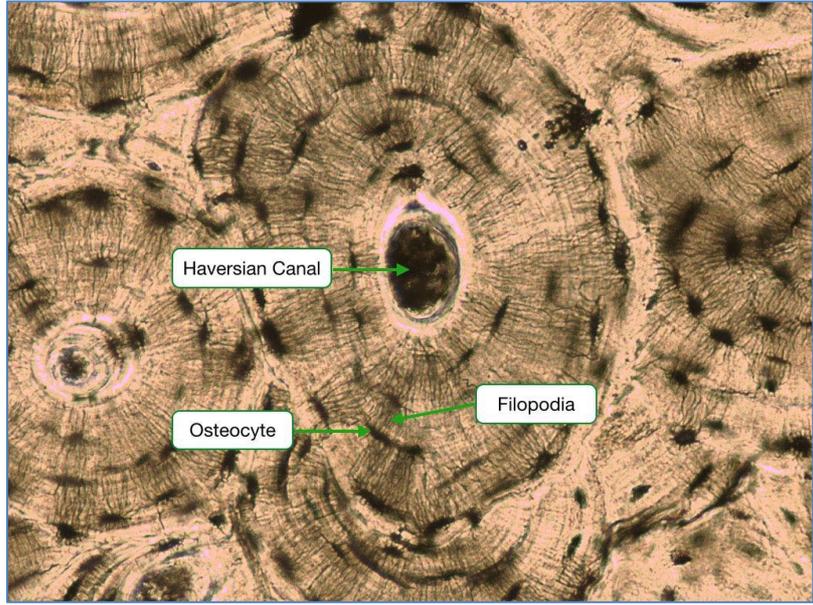
- **Organic**
 - Collagen & other proteins
 - 35%
 - Flexibility
 - Tensile Strength
- **Inorganic**
 - Mineral Salts
 - 65%
 - Compression Strength
 - Reason why it preserves so well.

Bone & Associated Tissue Histology:

- **Bone**
 - **Compact Bone**
 - Thicker
 - Denser
 - Comprised of **Osteons** – basic units of compact bone
 - Haversian Canal
 - Blood Vessels
 - Nerve Fibres
 - Lamellae
 - Rings of Collagen Fibres around Haversian Canals
 - Collagen Fibres oppose each other diagonally
 - Resists torsional stress
 - Lacunae
 - Tiny caverns between the Lamellae
 - Residences of the osteocytes
 - Osteocytes
 - Living cells of bone tissue
 - Maintains health of bone matrix
 - If an osteocyte dies, the surrounding bone matrix is resorbed by osteoclasts.
 - Canaliculi
 - Tiny plasma membrane extensions of the osteocytes
 - Allows communication between osteocytes
 - Allows nutrient sharing between osteocytes



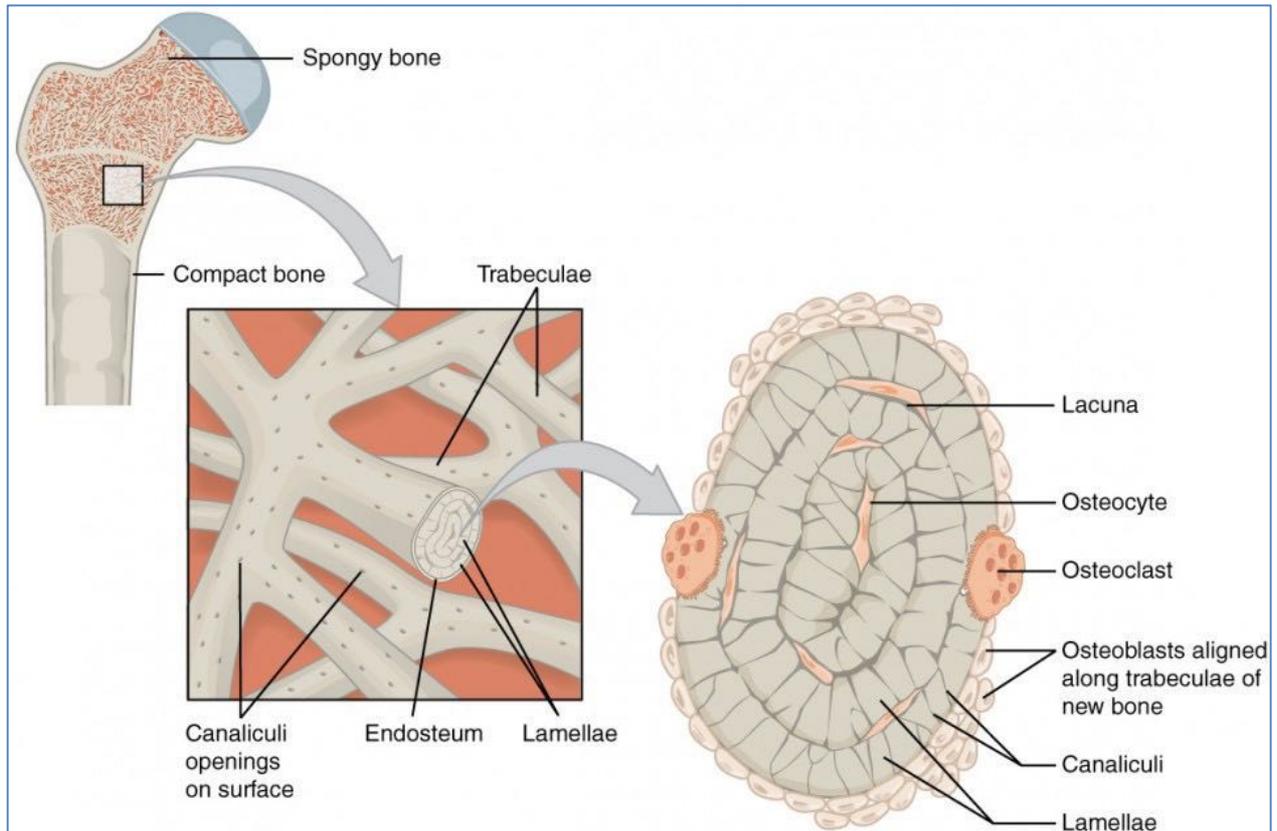
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http://histology.med.yale.edu/bone/bone_reading.php

○ **Cancellous Bone (Spongy)**

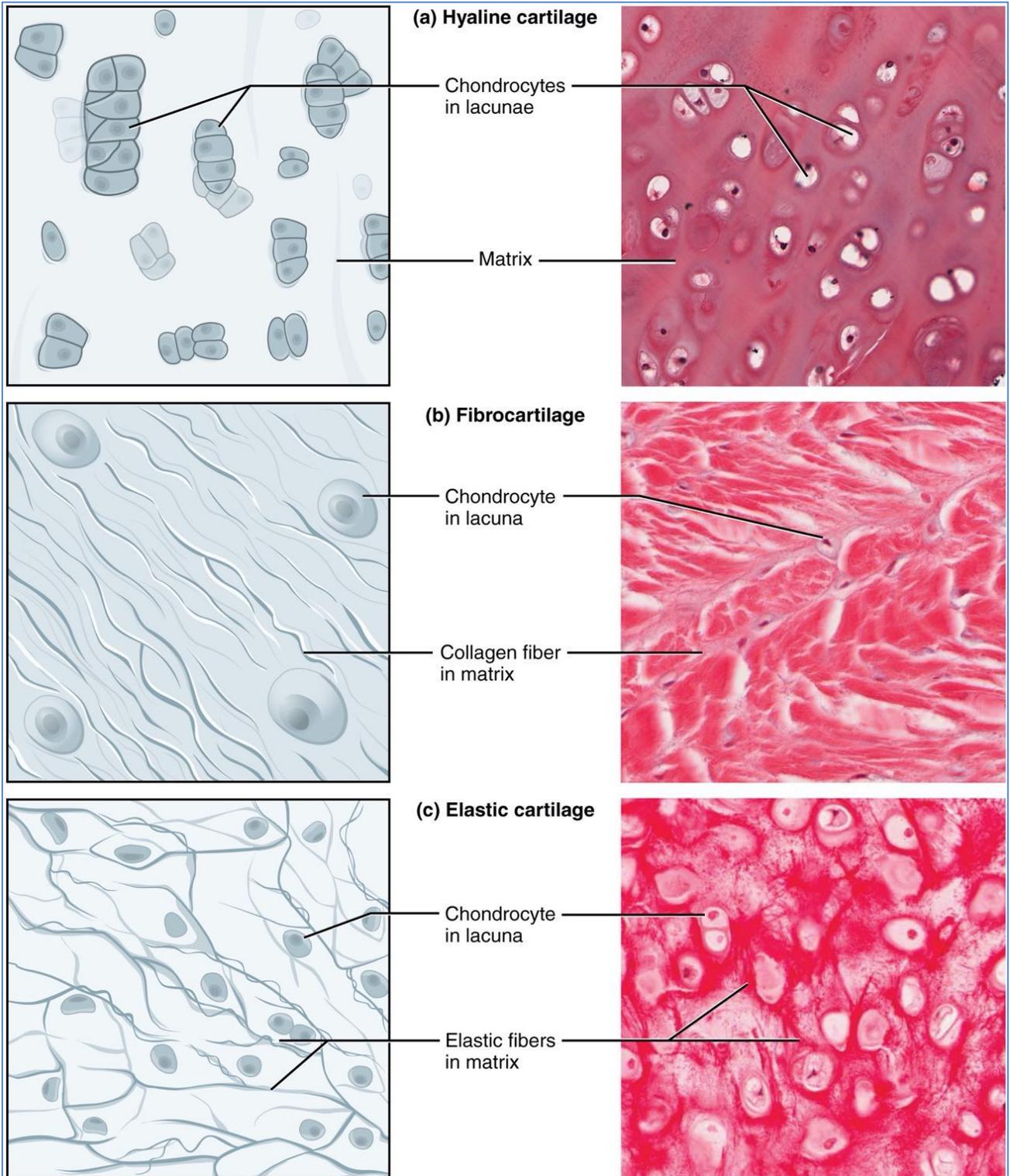
- Trabeculae (struts) relay stress to the dense compact bone
- Houses marrow in between trabeculae.
- Blood Vessels
- Osteoblasts
- Fat Cells



Source: Creative commons 4.0; Openstax

• **Cartilage:**

- Avascular
- Chondrocytes in columns in lacunae
- Ground Substance – fibres + H₂O

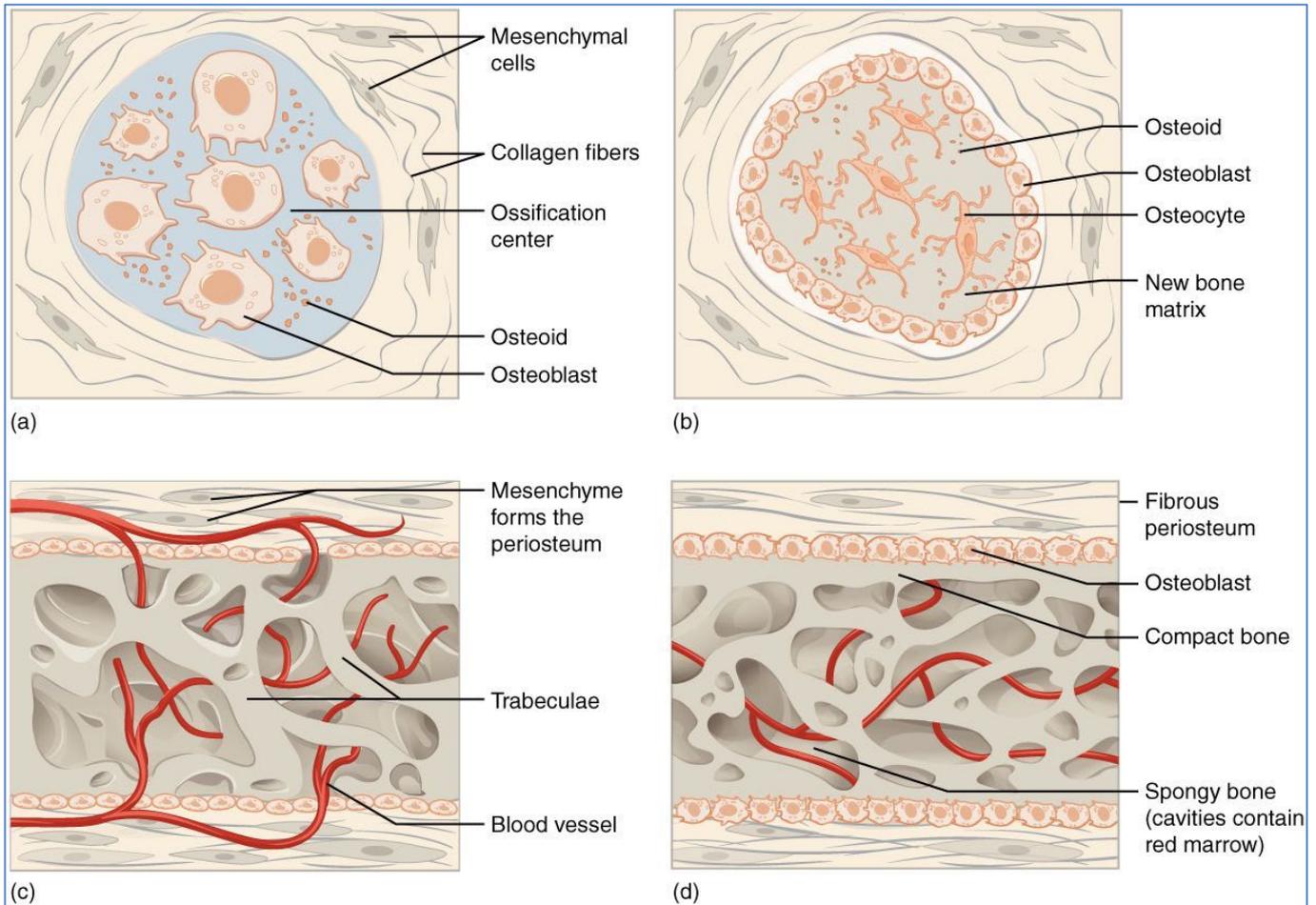


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Bone Development:

- **Intramembranous Bone Formation**

- Ossification Within Membranes
 - Cranial bones of skull
 - Clavicles

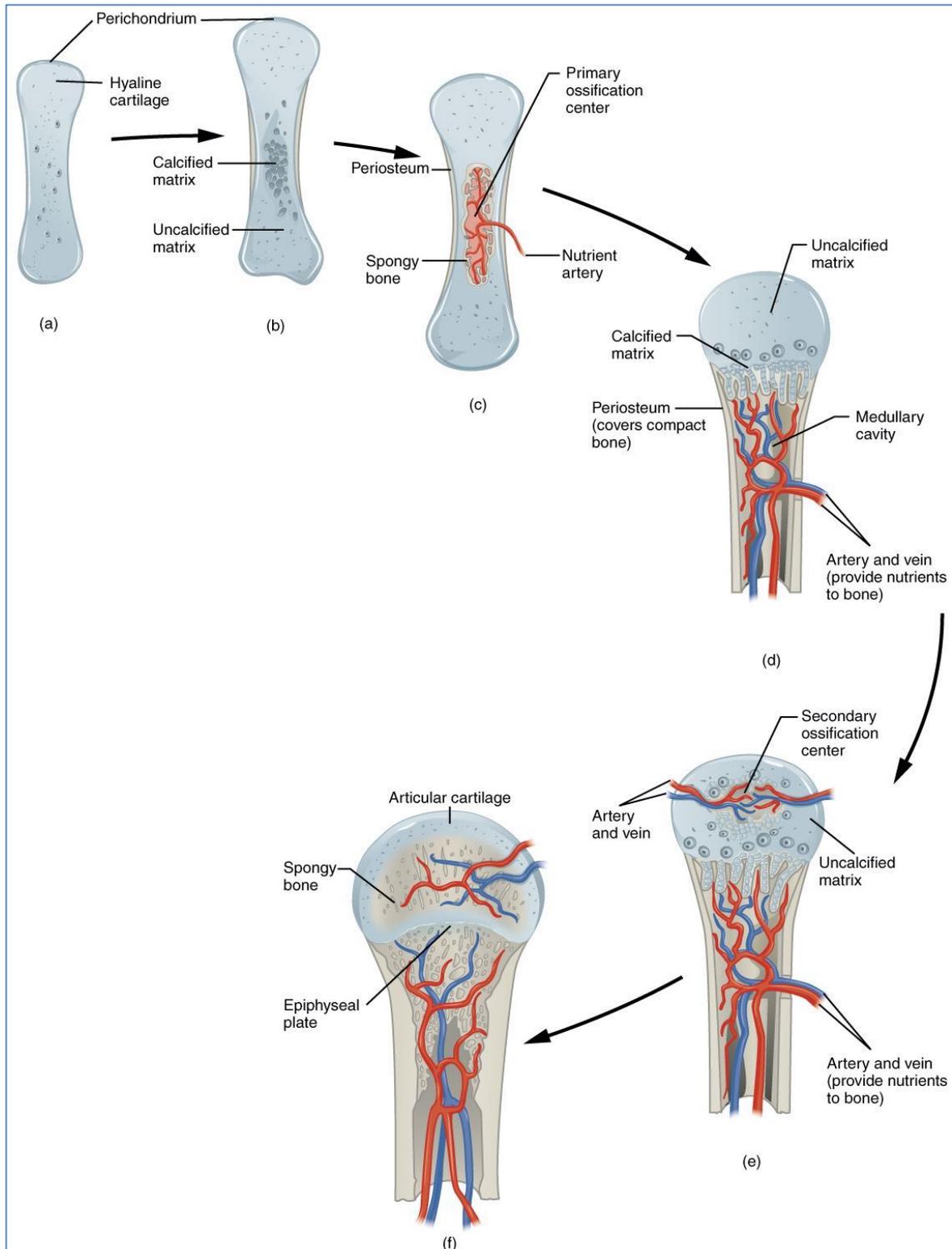


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- **Endochondral Bone Formation**

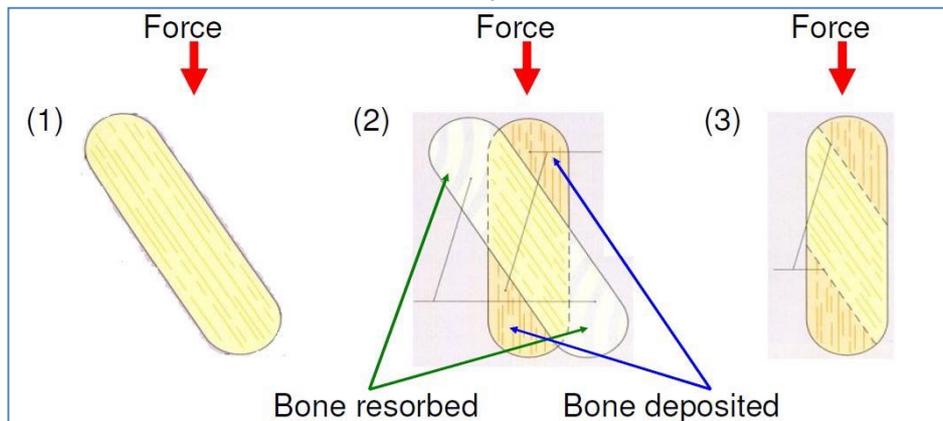
- **From Cartilage**
 - Hyaline cartilage
 - Primary ossification centre in diaphysis
 - Secondary ossification centre in epiphyses
 - Epiphyseal plate (growth plate)
- **5 Phases:**
 - Phase 1 & 2:
 - In Utero
 - Hyaline cartilage template
 - Osteoblasts begin depositing bone
 - Bone Collar forms around diaphysis
 - Cartilage cells in centre die – leaves cavity
 - 1^o Ossification centre forms
 - Phase 3:
 - In Utero
 - Blood vessels penetrate into centre cavity
 - Fibroblasts enter through blood
 - Fibroblasts convert to osteoblasts
 - Spongy bone forms along shaft

- Phase 4:
 - At Birth
 - Elongation of diaphysis
 - 2^o Ossification centre forms in Epiphysis
 - Medullary (Marrow) Cavity forms.
- Phase 5:
 - Growth & Maturation
 - Complete ossification of Epiphyses
 - Hyaline cartilage remains at:
 - Epiphyseal (growth) plate
 - Articular surface

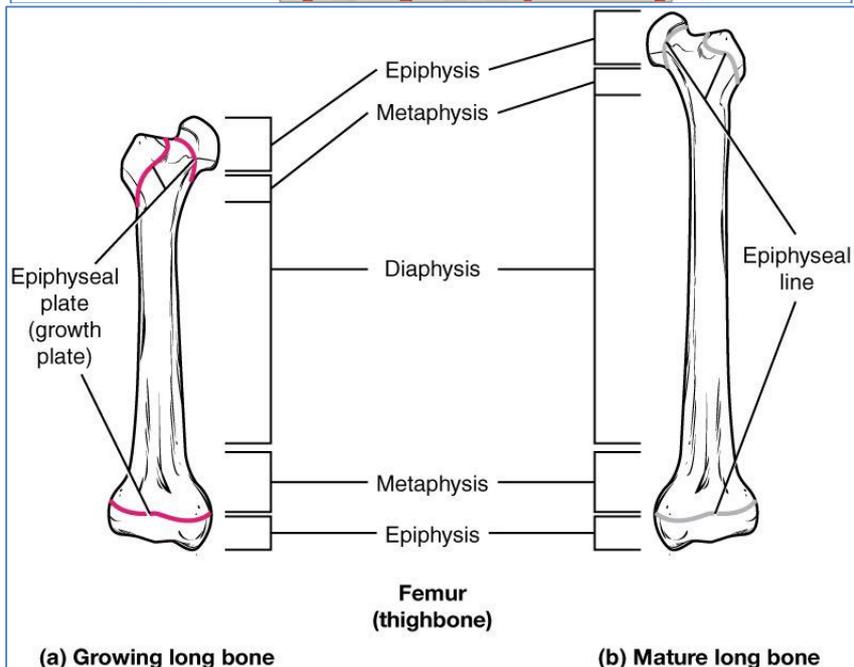
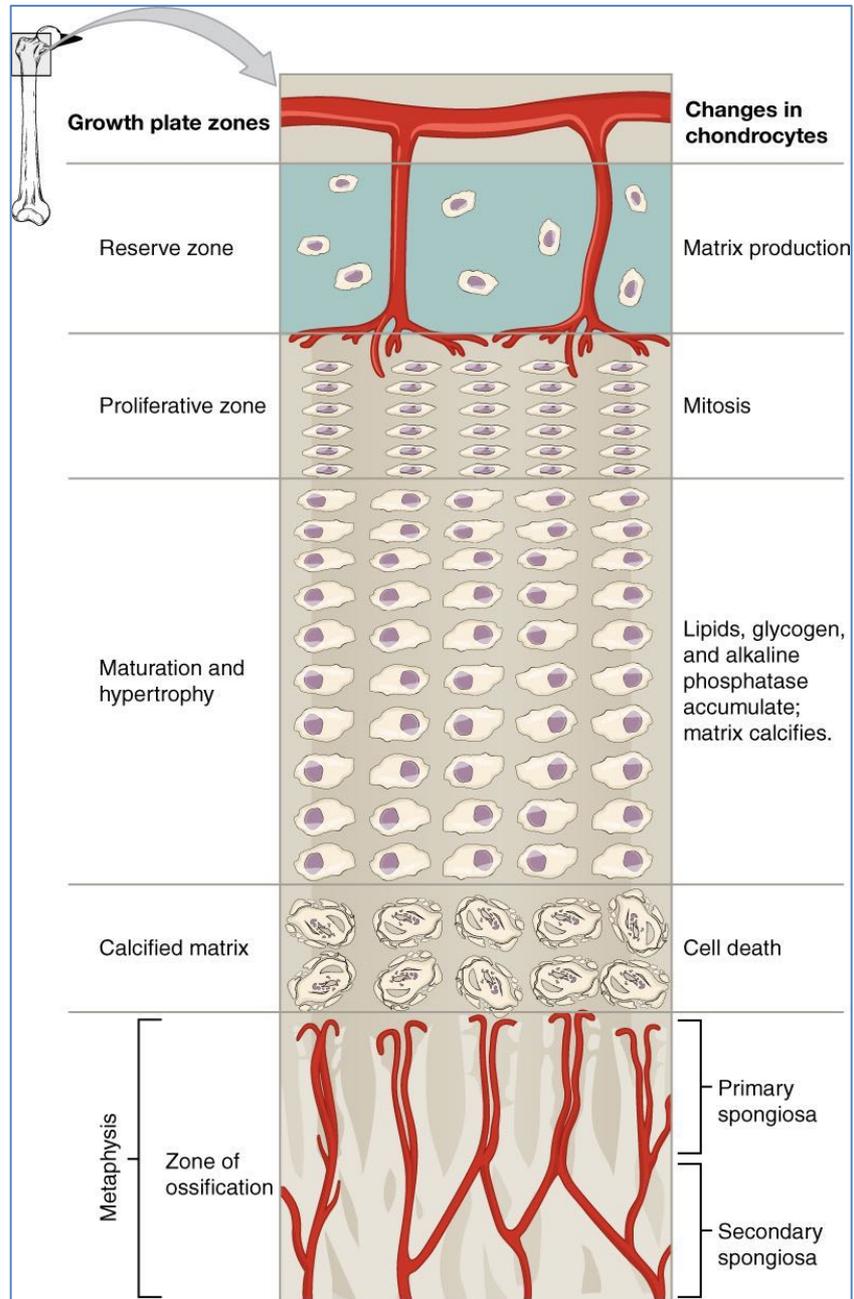


Bone Remodelling:

- Bone is living tissue
- Requires blood supply & Constant remodelling
- Bone remodels 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
 - Creates a recess (Howship's Lacunae)
 - Bone matrix at site gets eroded
 - Endocytoses digested material
 - Packages digested material
 - Exocytoses digested material into extracellular matrix
 - Material taken away by blood
- **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.

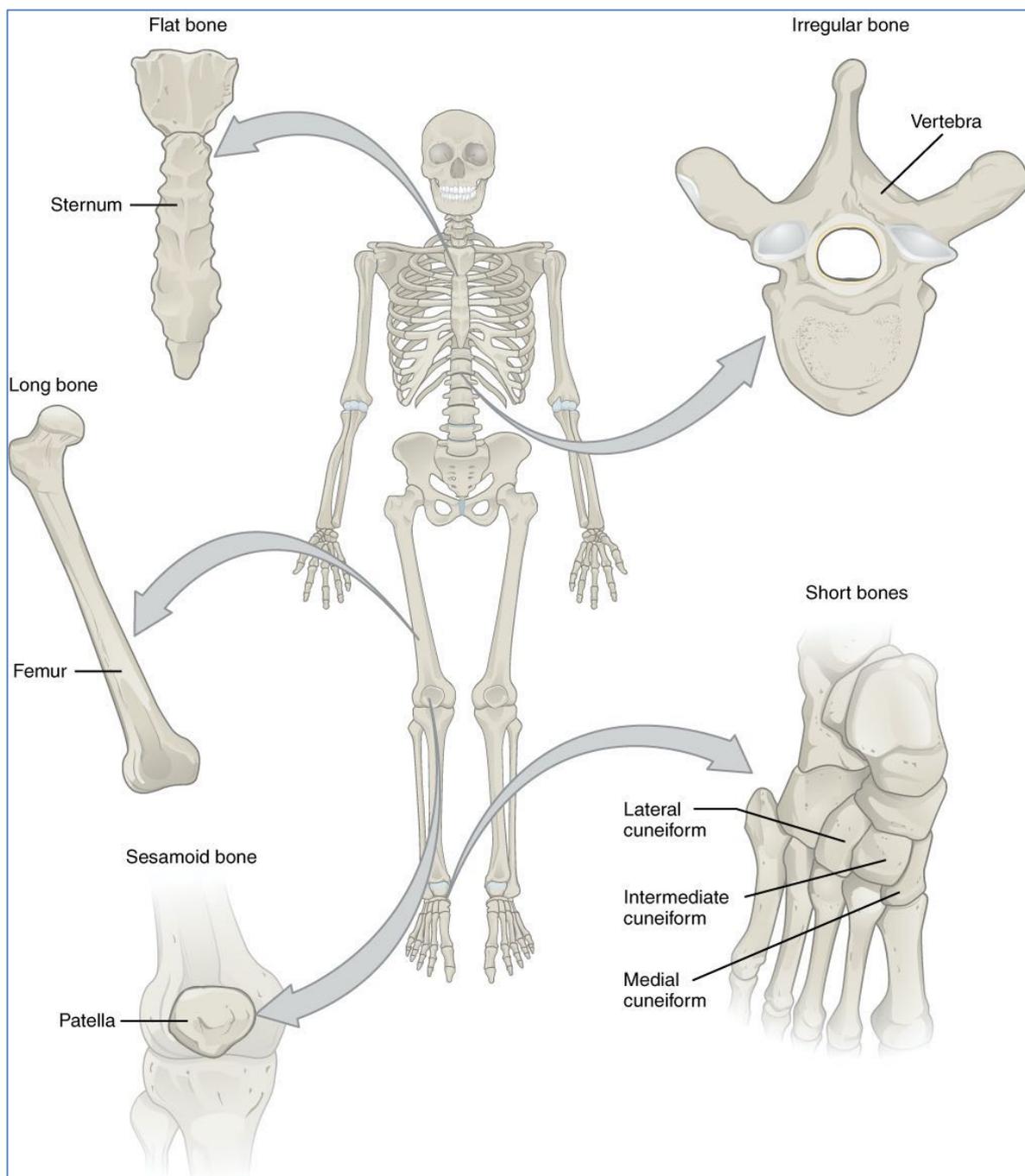


- **Eg: Long Bone Growth:**
 - **Length**
 - Apposition at epiphyseal line
 - By osteoblasts
 - **Width**
 - Apposition by osteoblasts
 - Resorption (bone removal) by osteoclasts

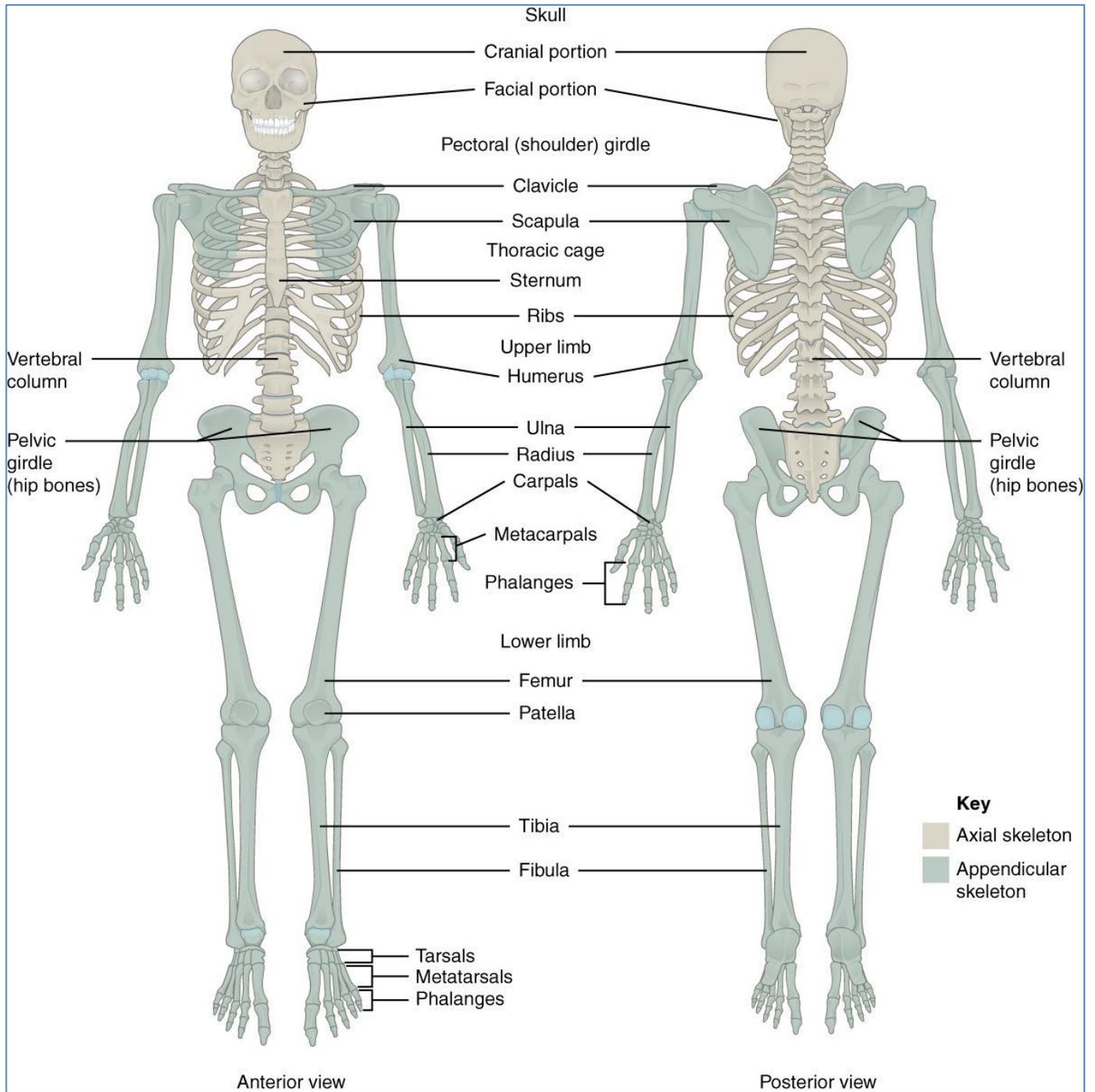


Classification of Bones:

- **Long**
 - Humerus
 - Femur
- **Short**
 - Carpals
 - Tarsals
- **Flat**
 - Sternum
 - Scapula
- **Irregular**
 - Vertebra
 - Innominate Bones (Ossa Coxae)
- **Sesamoid**
 - Patella
 - Other bones inside tendons – can occur in tendons of the big toe



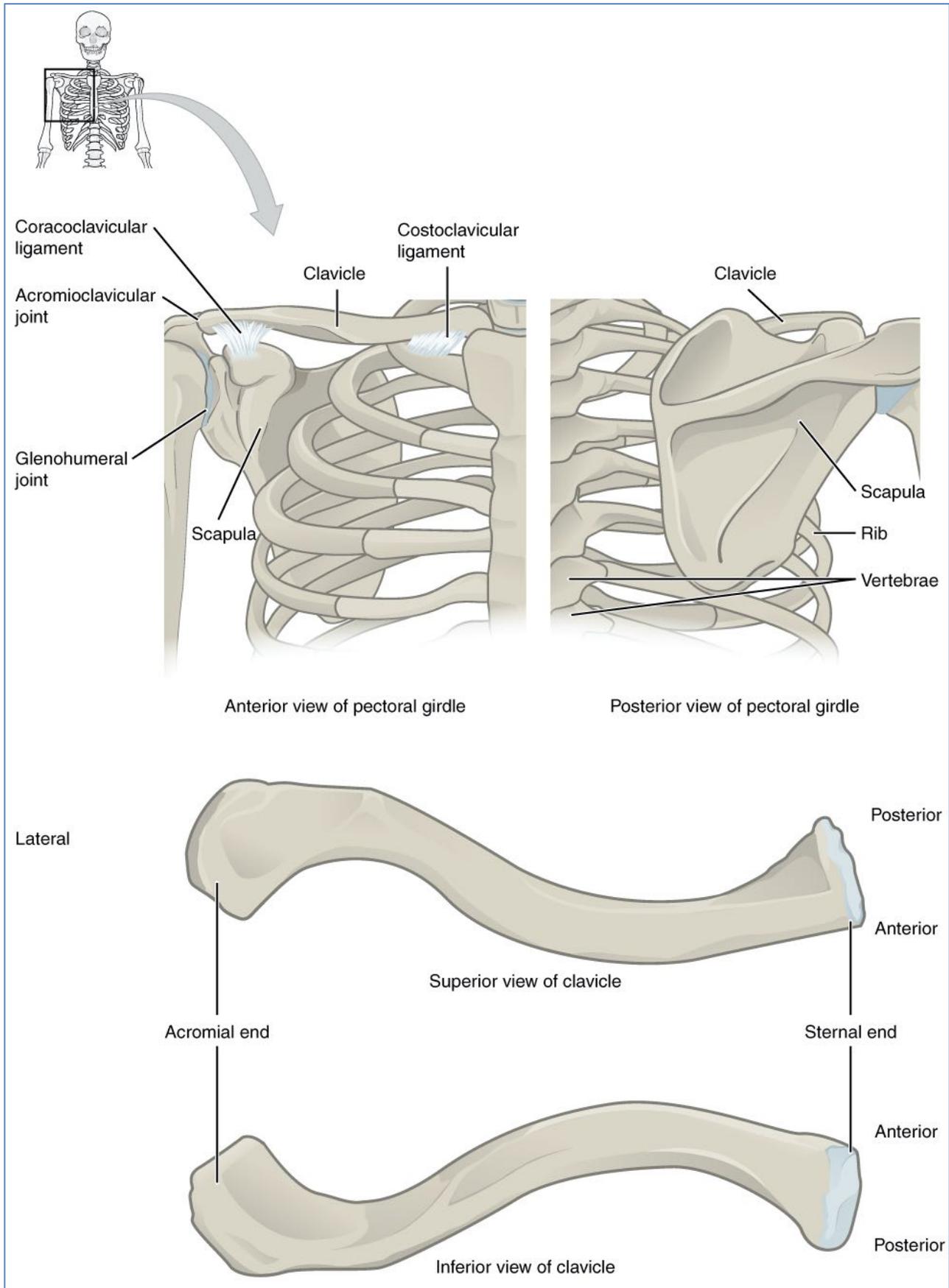
Appendicular Vs. Axial Skeleton:



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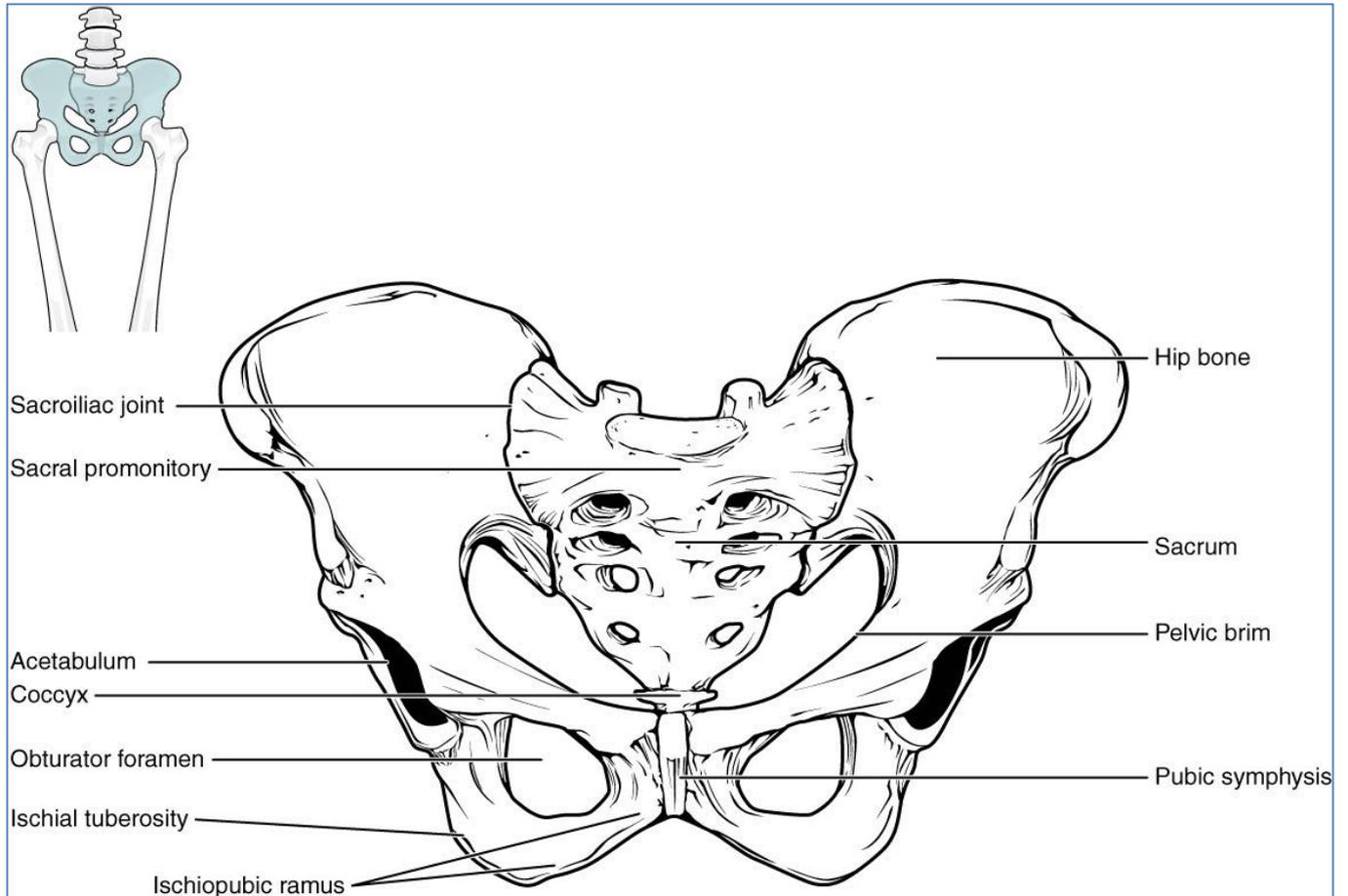
Pectoral Girdle:

- Scapula & Clavicle
- Anchors upper limbs to axial skeleton



Pelvic Girdle:

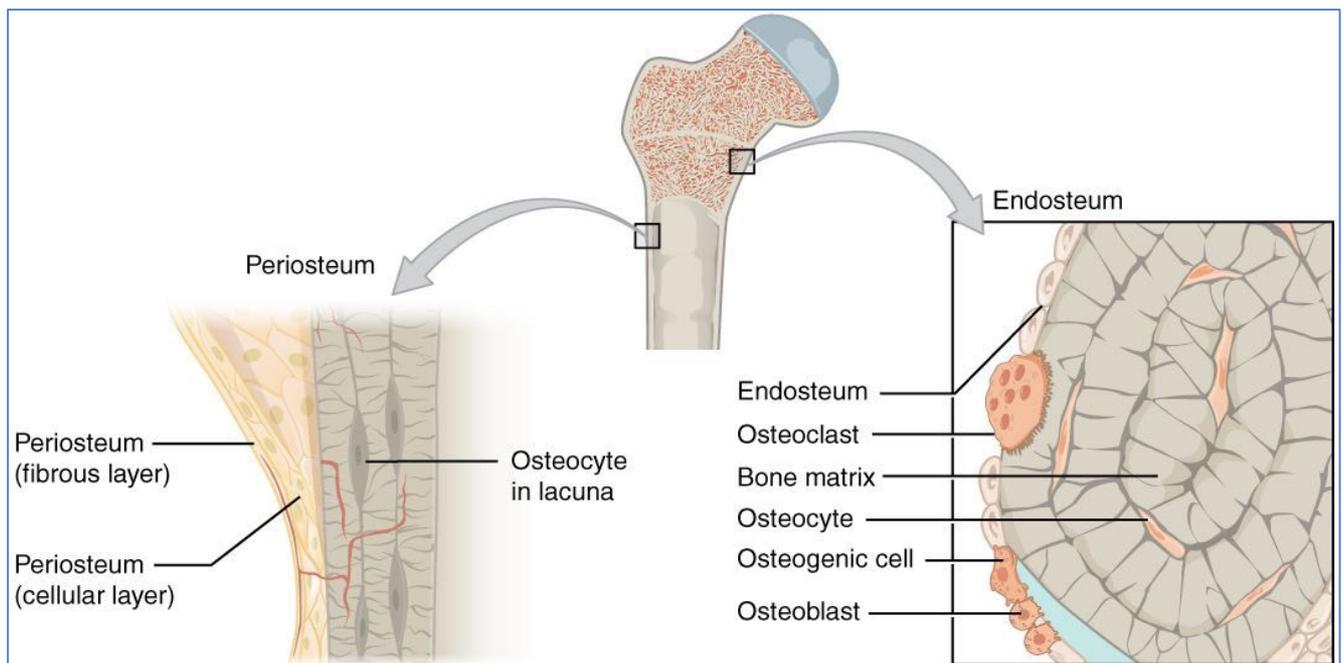
- 2 coxal hip bones: one on each side of sacrum
- Each consists of:
 - o Ilium
 - o Ischium
 - o Pubis
 - o pubic symphysis
- Collectively known as either:
 - o The Ossa Coxae...or
 - o Innominate Bones
- Anchors Lower limbs to Axial Skeleton

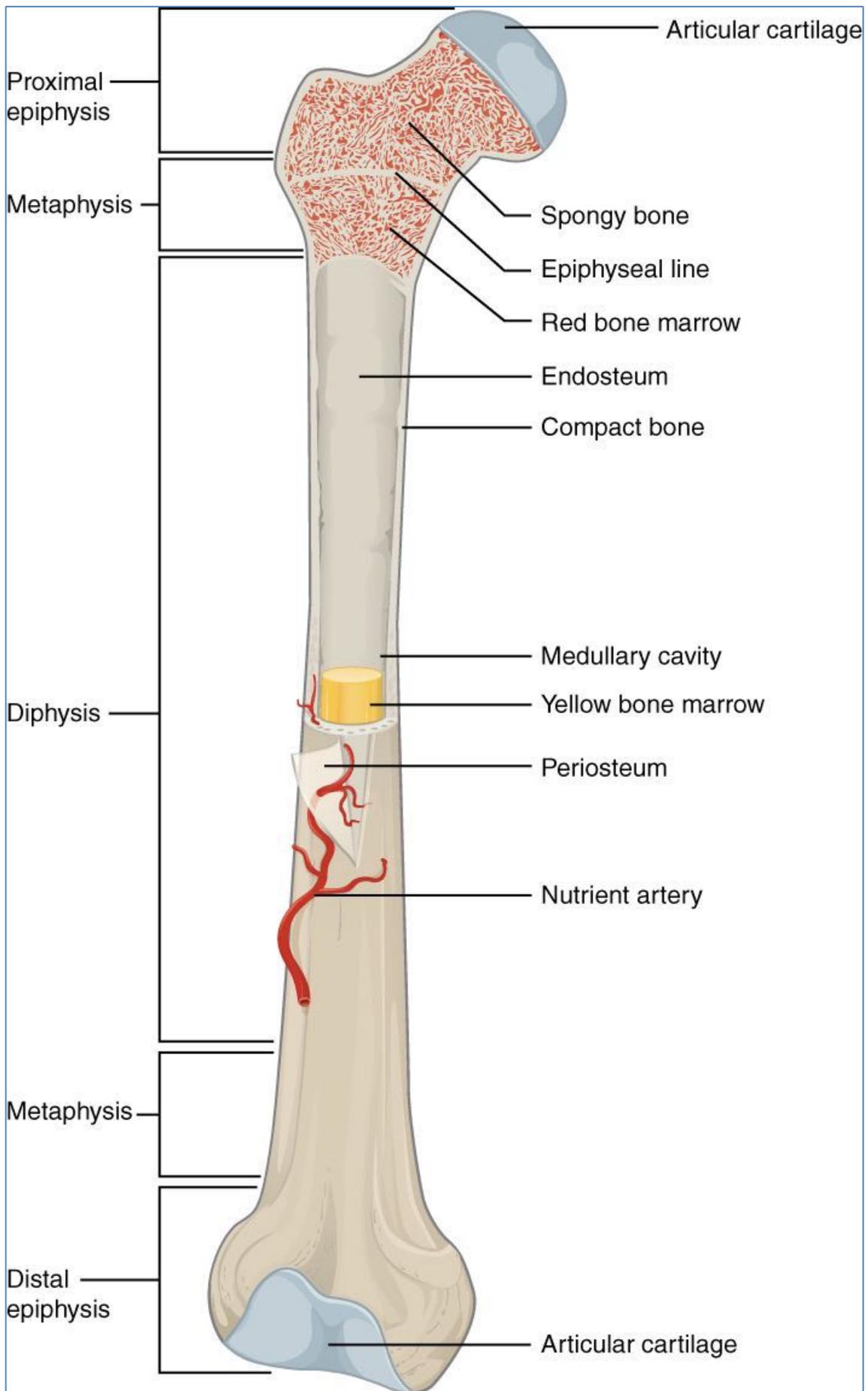


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Long Bone Structure:

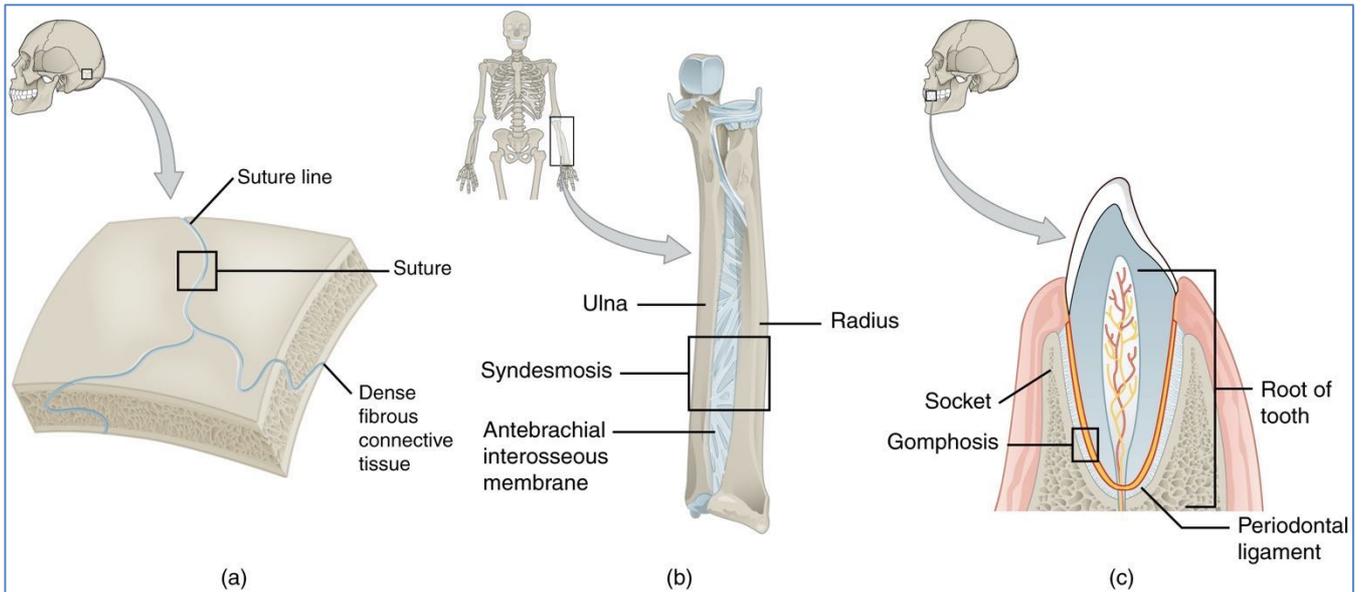
- **Diaphysis**
 - Shaft
 - Hollow
 - Strength + Lightness
 - Contains marrow (yellow in adult)
- **Epiphysis**
 - Expanded ends of bones
 - Proximal & Distal
 - Covered in **articular cartilage**.
 - Boundary defined by **epiphyseal line**.
- **Medullary (Marrow) Cavity**
 - Marrow cavity
 - Red Marrow & Yellow (fatty) marrow
 - Site of haematopoiesis (blood cell production)
 - Stores fat
 - Makes bone lighter – but still strong.
- **Periosteum**
 - 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





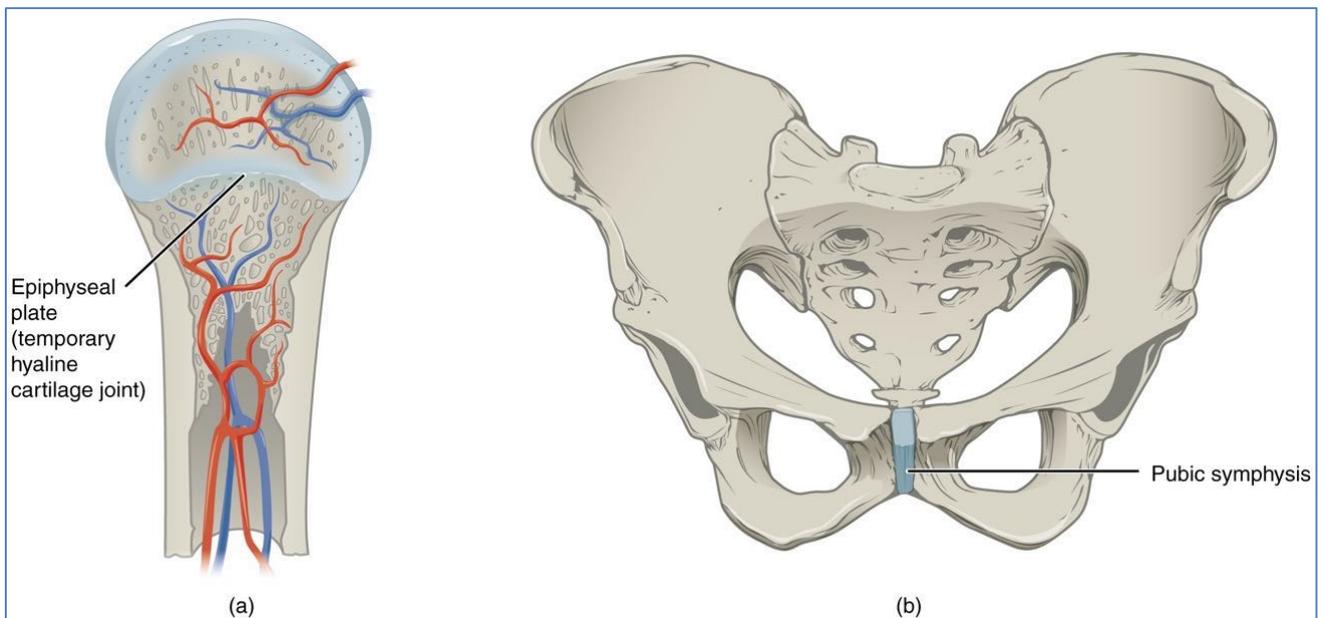
Joints:

- Junction between 2 or more bones
- Not necessarily moving joints (Eg: cranial sutures)
- **3 Types:**
 - **Fibrous Joints**
 - No movement
 - Joined by fibrous tissue
 - No joint cavity
 - Eg: Cranial Sutures
 - Eg: Syndesmoses – between tibia & fibula @ ankle.



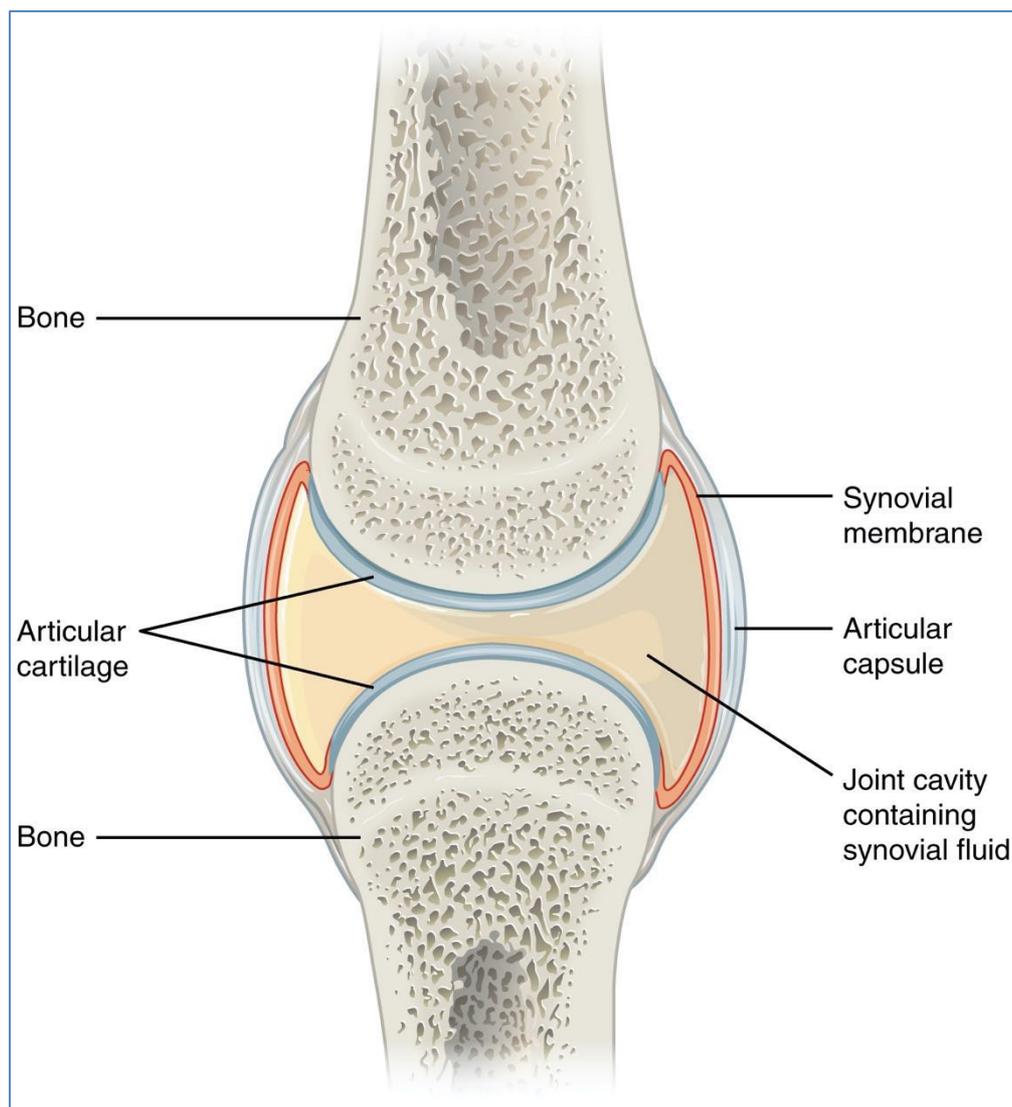
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- **Cartilaginous Joints**
 - Varying amount of movement
 - Joined by cartilage
 - No joint cavity
 - 2 types:
 - Synchondroses – eg. Epiphyseal plates
 - Symphyses – eg. Intervertebral joints & pubic symphysis



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- **Synovial Joints**
 - Movement
 - Joined by articular capsule
 - Where 2 bone-ends meet
 - **Articular (hyaline) Cartilage**
 - Covers bone ends
 - Protects bone – prevents bone-bone contact
 - Thin – 1mm
 - Resists shock
 - Resilient shape - high H₂O content
 - Avascular - nutrients in synovial fluid diffuse to it.
 - Cells = Chondrocytes
 - Ground Substance – high H₂O content
 - **Synovial fluid**
 - Within joint cavity
 - Modified filtrate from blood vessels in synovial membrane
 - 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

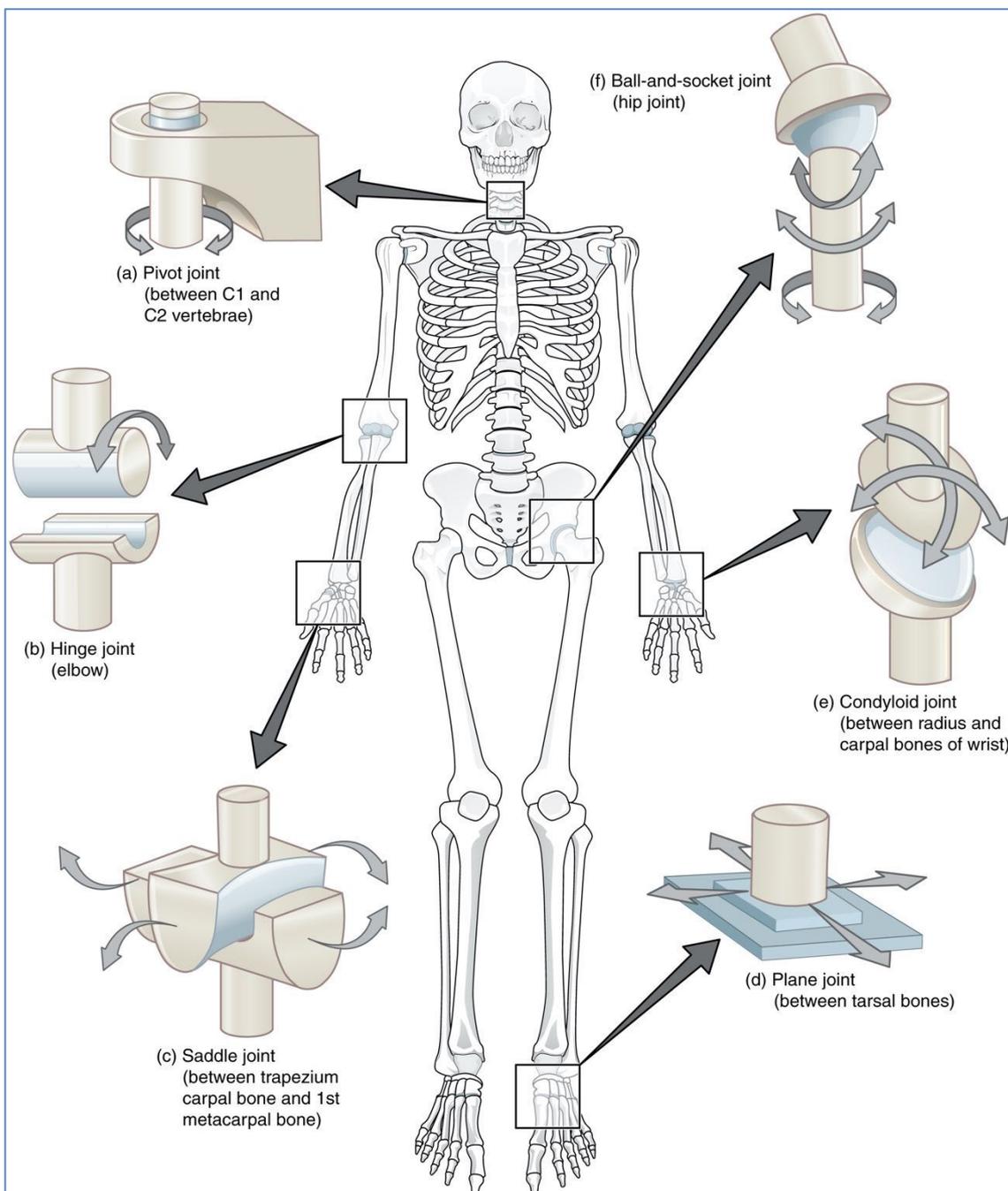


▪ **Types of Synovial Joints:**

- Plane – intertarsal joints in hand
- Hinge – elbow/knee
- Pivot – proximal radioulnar joint
- Saddle – carpometacarpal joint of thumb
- Ball & Socket – shoulder/hip
- Condylod – metacarpophalangeal joints

▪ **Synovial Joint Movements:**

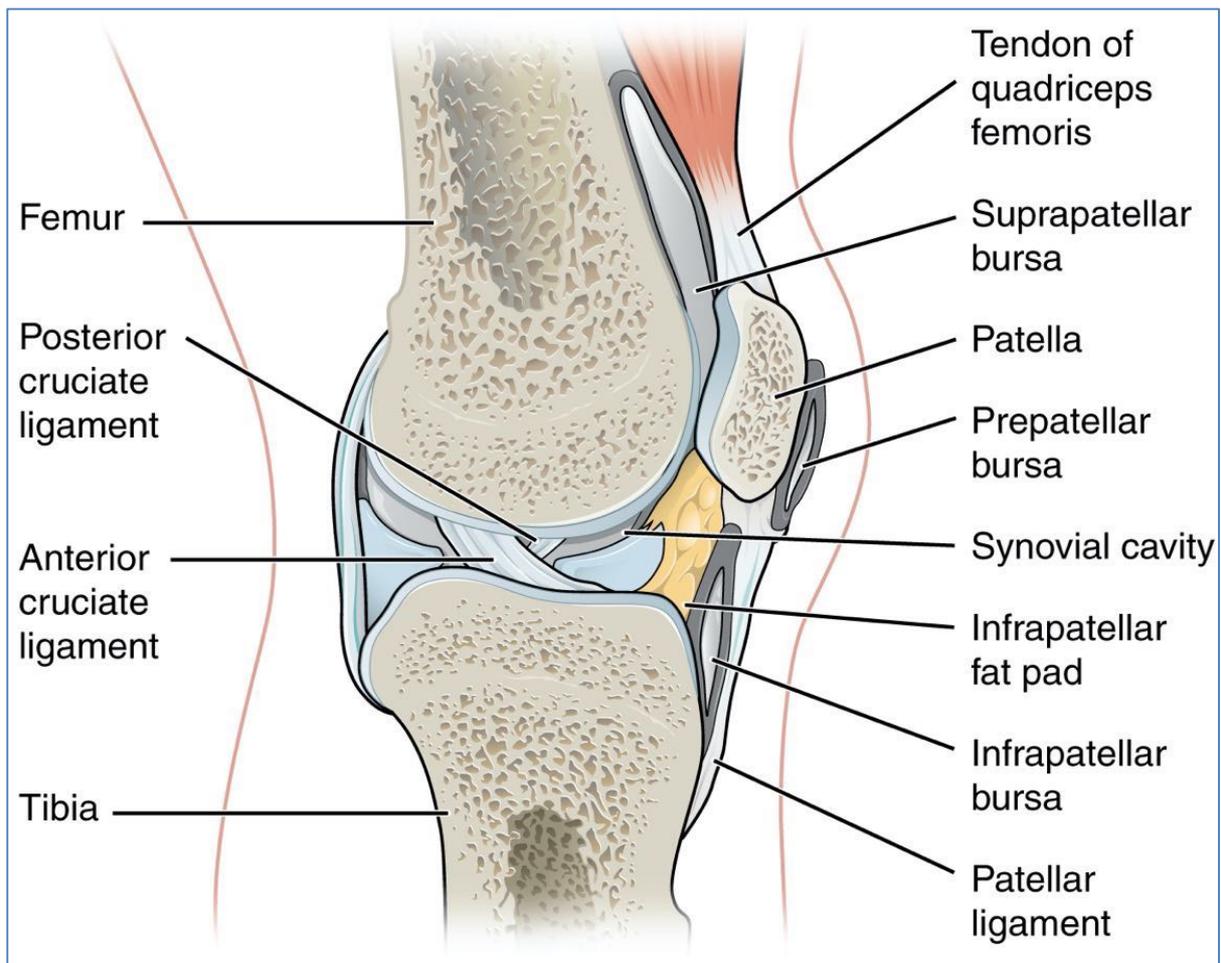
- Gliding
- Angular
 - Flexion/extension/abduction/adduction/circumduction/plantarflexion/dorsiflexion
- Rotation
- Special
 - Inversion/eversion/supination/pronation/protraction/retraction/elevation/depression/opposition



- **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:

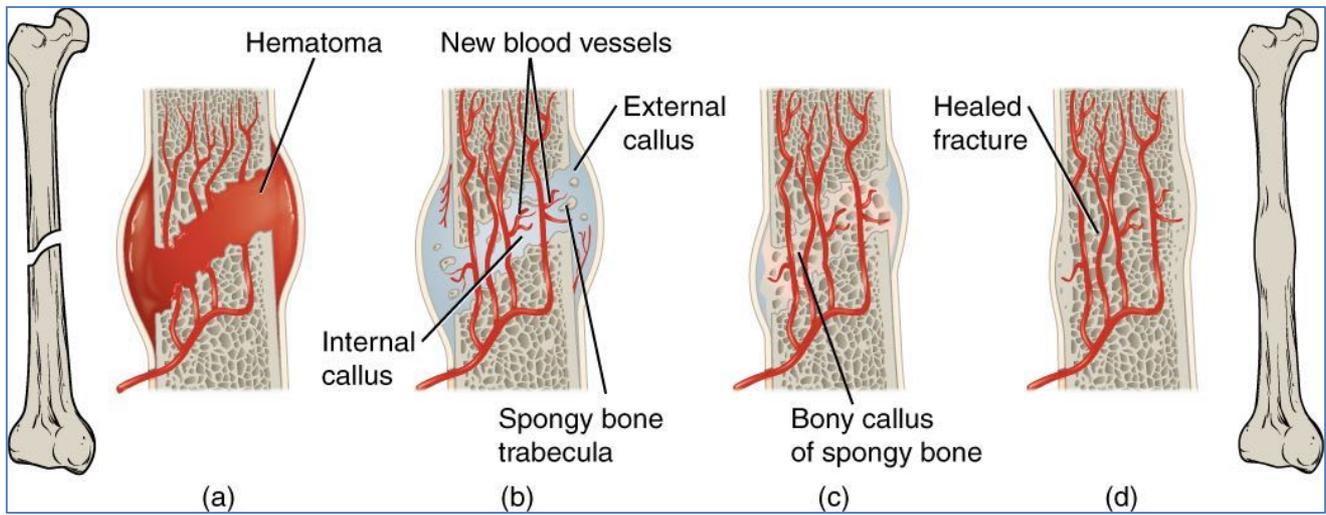
- Found in close association with synovial joints
- 'bags of lubricant'
 - Lined by synovial membrane
 - Contain synovial fluid
 - Reduces friction between adjacent structures



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Bone repair mechanisms

- 1. Hematoma Formation
- 2. Fibrocartilaginous Callus Formation
- 3. Bony Callus Formation
- 4. Bone Remodelling



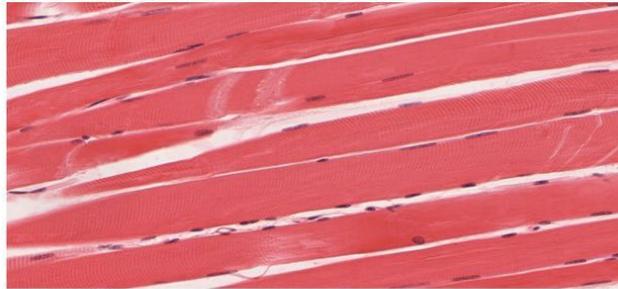
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GENERAL OVERVIEW OF THE MUSCULAR SYSTEM

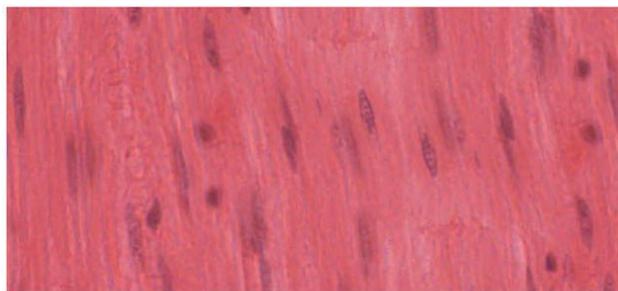
GENERAL OVERVIEW OF THE MUSCULAR SYSTEM

3 Types of Muscle Tissue:

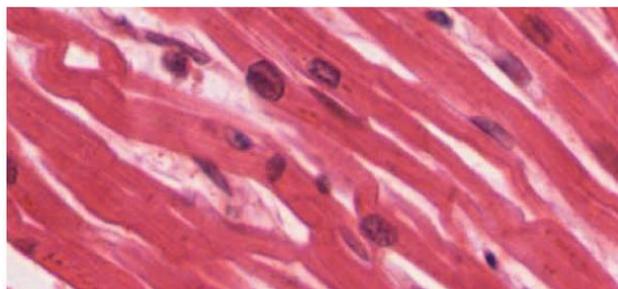
- **Skeletal Muscle:**
 - Attaches to bone for movement (voluntary)
 - Long, Cylindrical
 - Multinucleated
 - Obvious striations → sarcomeres.
- **Smooth Muscle:**
 - In the walls of visceral organs – eg. GI tract/urinary tract/birth canal
 - Spindle-shaped cells
 - Central nuclei
 - No striations → no sarcomeres
 - Cells arranged closely to form sheets (often opposing-laterally perpendicular)
 - Usually involuntary – Controlled by the autonomic nervous system
- **Cardiac Muscle:**
 - Makes up the heart.
 - Long, **Branched**, Cylindrical
 - Striations → sarcomeres
 - Usually single-nucleated
 - Intercalated discs – cell membranes of 2 adjacent cells bound mechanically (desmosomes), chemically & electrically (gap junctions). Essentially makes the entire heart one single muscle.
 - Involuntary – controlled by autonomic nervous system



(a)



(b)



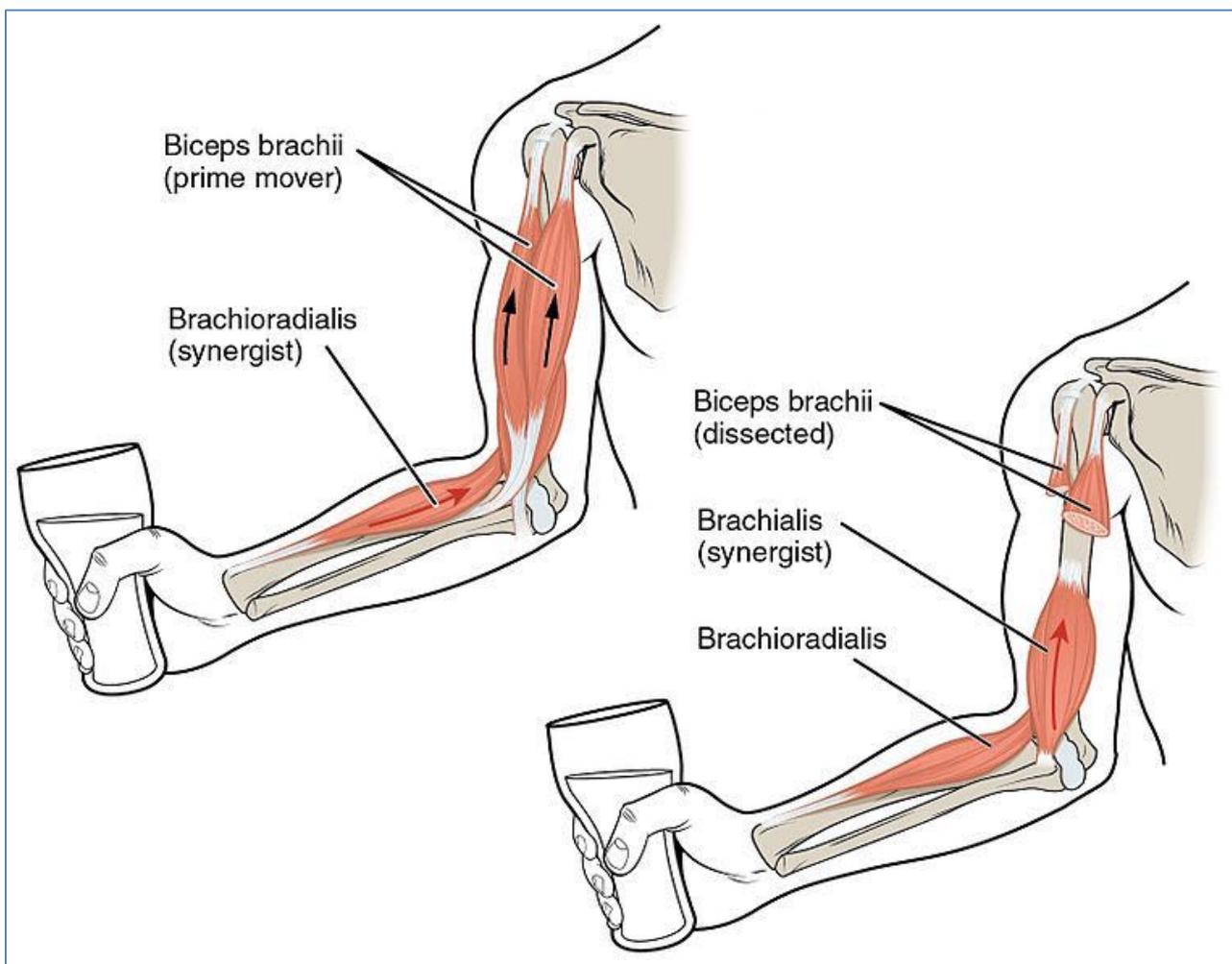
(c)

Functions of Muscle:

- **Skeletal Movement**
- **Circulation of Blood**
- **Motility of GI Tract Contents**
- **Secretion of Glands**
- **Structural Support**

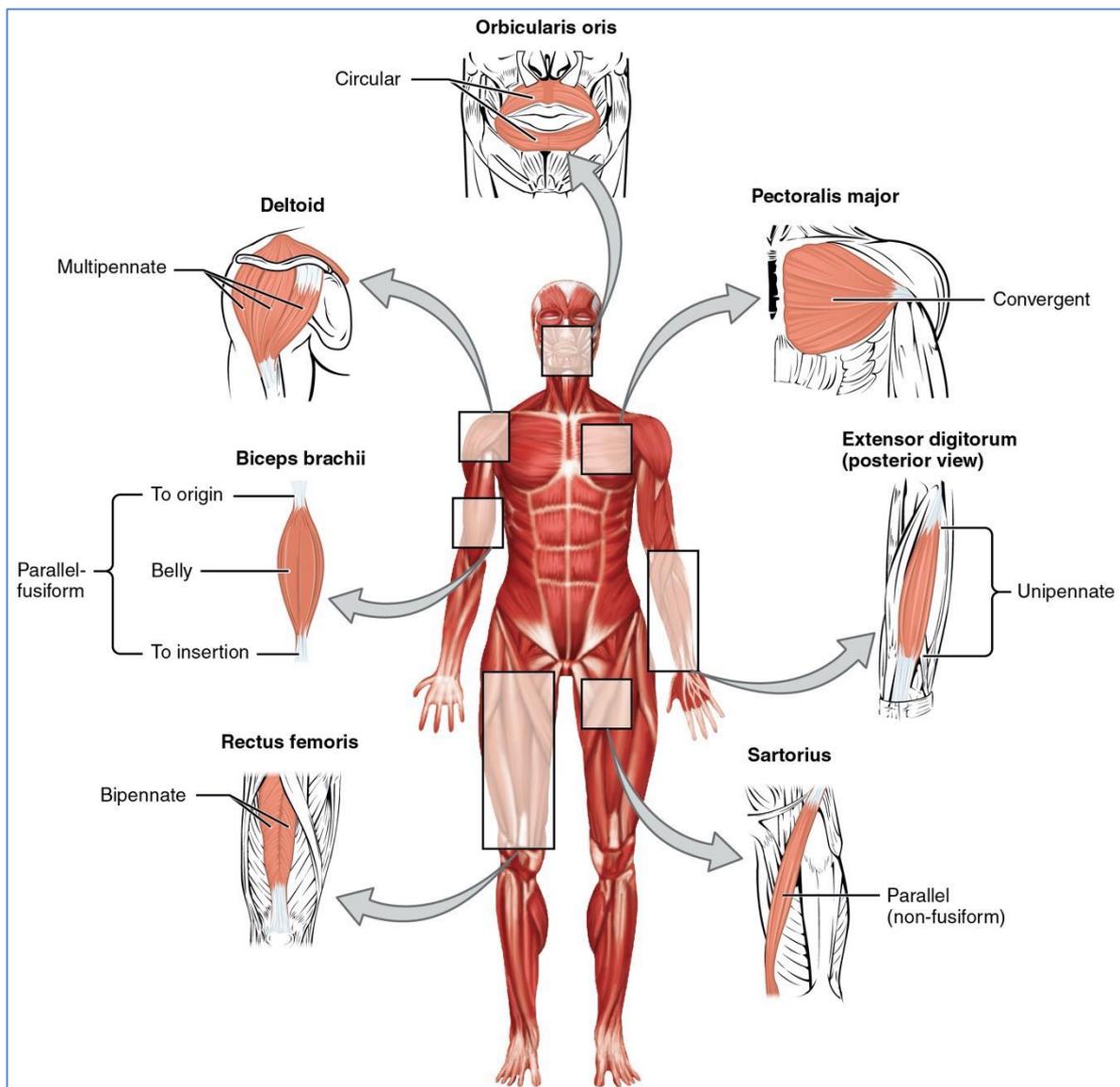
Muscle Nomenclature:

- **Origin**
 - Attachment to the immovable bone
 - Usually proximal (towards centre)
- **Insertion**
 - Attachment to the moveable bone
 - Usually distal (away from centre)
- **Prime Action**
 - Stationary origin
 - Movement of insertion
 - Eg: Bicep curl
- **Reverse Action**
 - Stationary insertion
 - Movement of origin
 - Eg: Chin-up



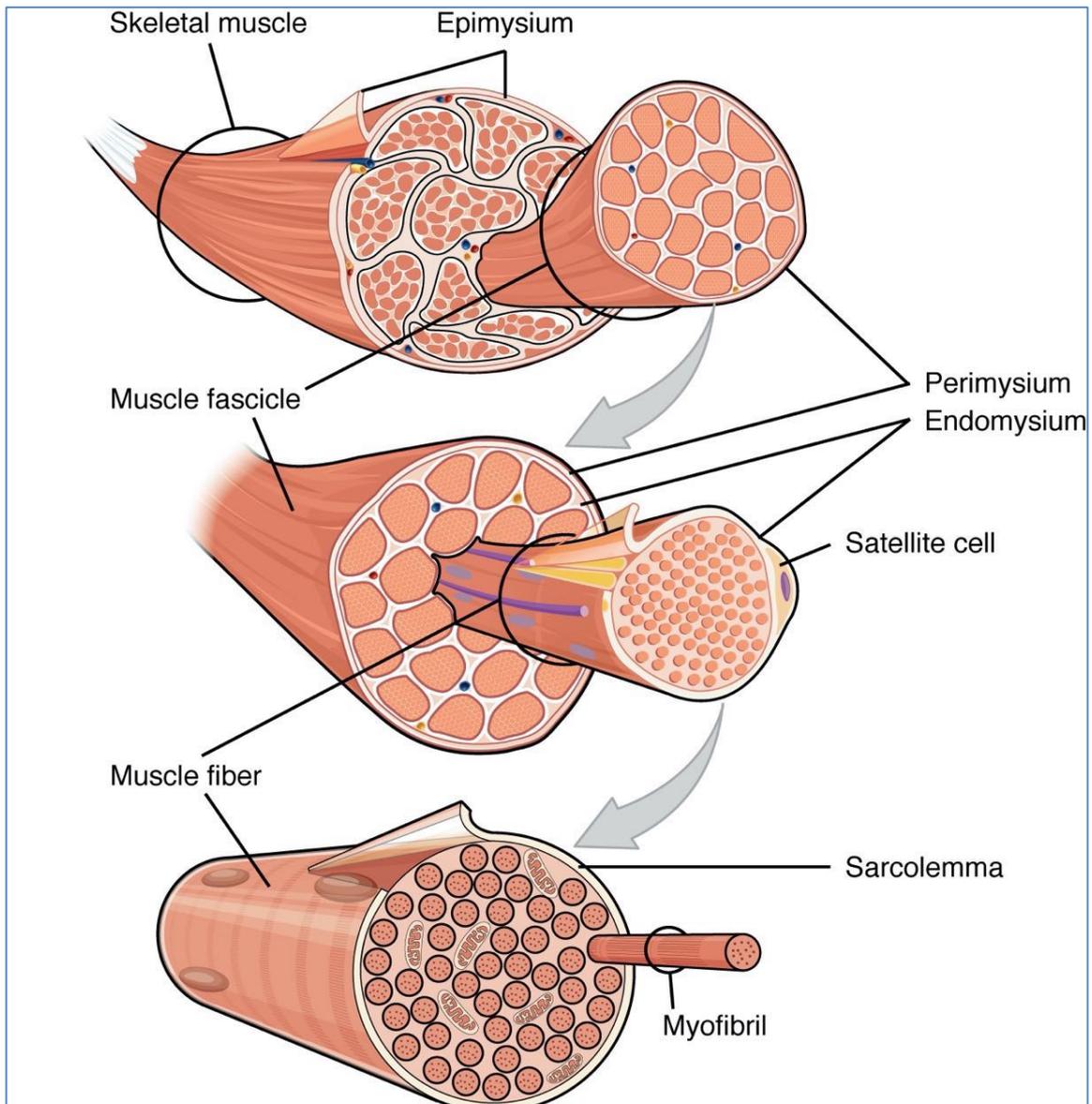
Muscle Morphology:

- **Arrangement of Fascicles:**
 - Determines range of motion
 - Determines power
 - **Parallel**
 - Fascicles run parallel to the long axis of muscles
 - Large Range
 - Less Power
 - Either strap-like or spindle-shaped:
 - Some books classify spindle-shaped parallel muscles as: **Fusiform**
 - **Pennate**
 - Short fibres attach obliquely to a central tendon running the length of the muscle.
 - High Power
 - Less Range
 - **Either:** Uni, Bi or Multi.
 - **Convergent**
 - Broad origin
 - Power & Range
 - Fascicles converge to a single tendon of insertion.
 - **Circular**
 - Fascicles arranged in concentric rings
 - External body openings (mouth, eyes, external anal sphincter)



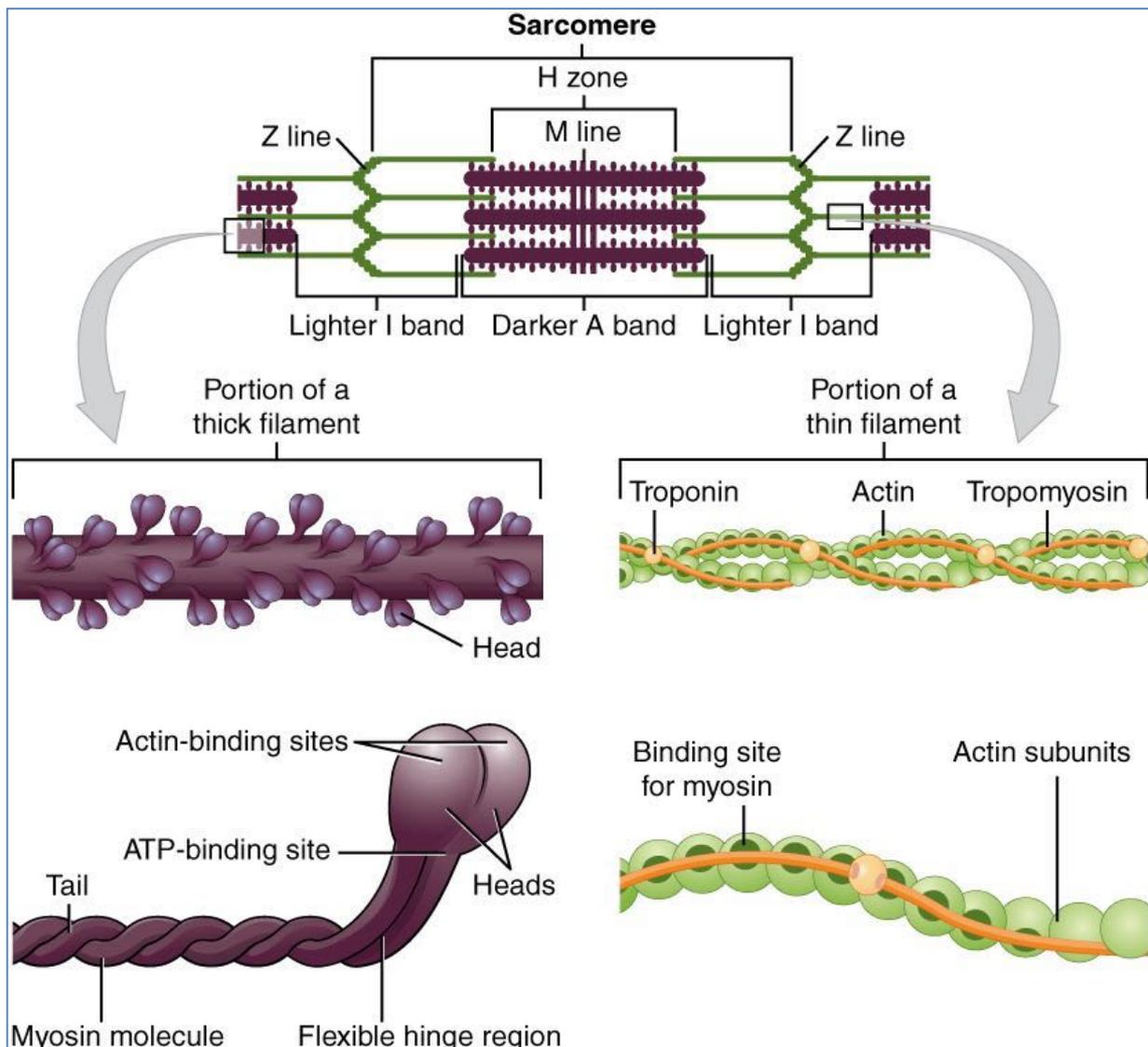
Organisation of Muscle Tissue:

- **Individual Muscle Fibres**
 - Each Muscle Fibre Contains many **Myofibrils (a Muscle Cell's Contractile *Organelles*)**.
 - Each Myofibril contains many **Myo-Filaments (Actin & Myosin)** – Contractile *Proteins*.
- **Endomysium**
 - Connective Tissue
 - Wraps single muscle fibres (cells)
- **Muscle Fascicles**
 - Bundles of muscle fibres (cells)
- **Perimysium**
 - Connective Tissue
 - Wraps Fascicles
- **Single Muscle**
 - Muscle as a whole – eg. The bicep.
- **Epimysium**
 - Connective Tissue
 - Wraps whole muscle.
- **Tendons**
 - A fusing together of all connective tissue layers.
 - Connects muscle to bone

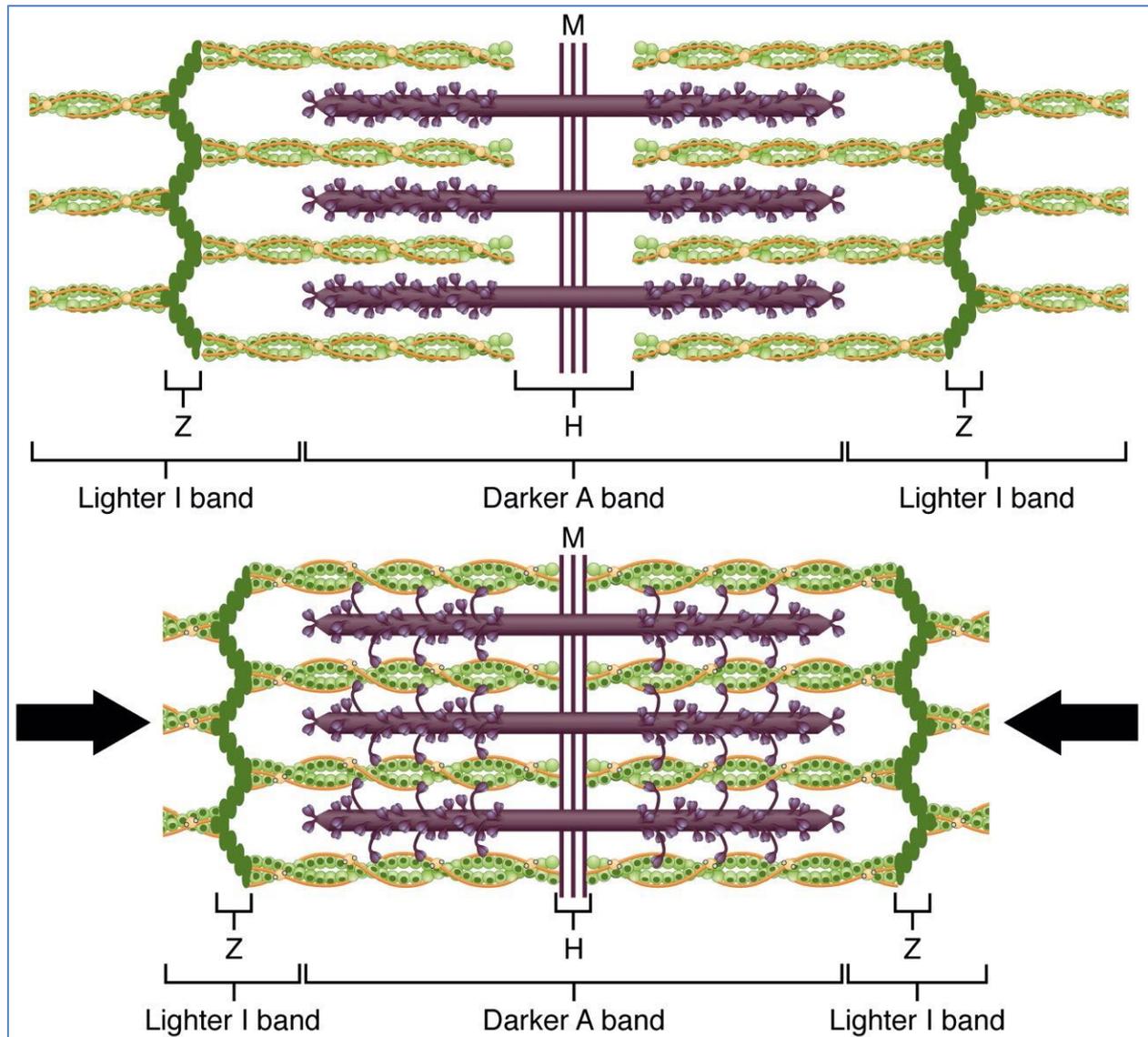


Internal Machinery of Skeletal Muscle Cells:

- **The Sarcomere** is the functional unit of muscles.
- **Each Sarcomere contains Myo-Filaments** (Actin & Myosin) that slide past each other during contraction.
 - **Actin** (Thin Myofilaments)
 - **Globular Actin:**
 - Kidney-shaped polypeptide subunits intertwined → double helix.
 - Bear the active sites → myosin heads attach to during contraction.
 - **Tropomyosin** – 2 strands that spiral along the actin.
 - Stiffens the actin filament
 - Blocks myosin binding sites in relaxed muscle so myosin heads can't bind to the actin
 - **Troponin:**
 - 3 polypeptide complex.
 - Binds to tropomyosin
 - Binds Ca^+
 - **Myosin** (Thick Myofilaments)
 - **Tails:**
 - Rodlike & helical
 - Start at the 'M-line'.
 - Each ends with a 2 flexible hinges supporting a pair of globular **heads**
 - **Heads:**
 - Form '**Cross bridges**' – link thin & thick filaments during contraction.
 - Contain ATPases to generate energy for contraction.



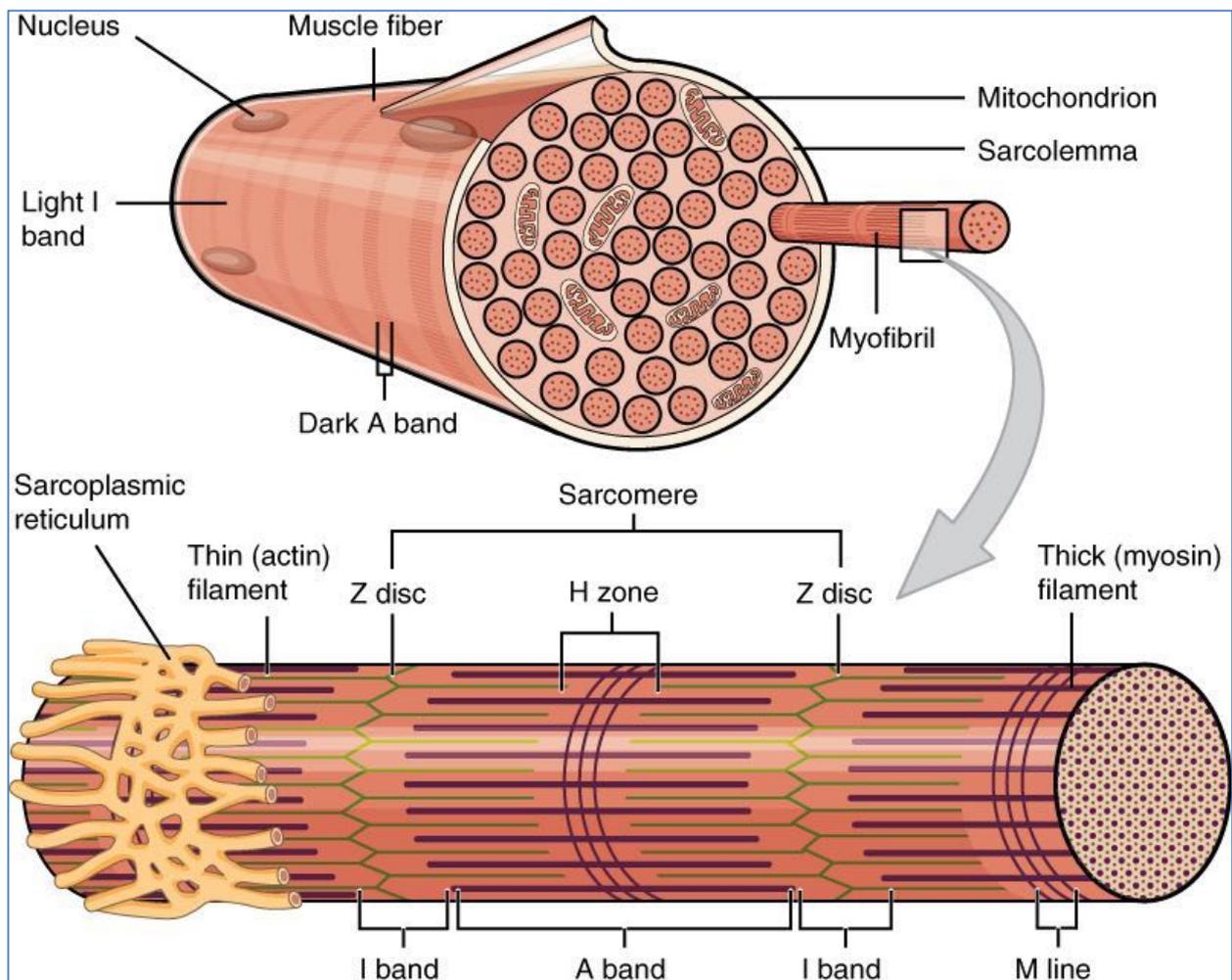
- **When Muscle is Relaxed:**
 - Thick & thin filaments only overlap at the ends.
- **When Muscle is Stimulated:**
 - (by nervous system)
 - Myosin heads latch to myosin binding sites on actin
 - Form **cross bridges**
 - Formed & broken many times in a contraction
 - Act like tiny ratchets
 - Generate tension
 - Propel thin filaments toward centre of sarcomere.
- **Z-Line** – anchors sarcomeres together.
 - Ensures whole cell contraction.



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- **Muscle Fibres (Contractile Cells)**

- **Sarcolemma** (plasma membrane)
 - **Transverse ('T') Tubules**
 - Perpendicular Invaginations of the sarcolemma (PM)
 - Runs between paired terminal cisterna of Sarcoplasmic Reticulum
 - Conducts impulses from sarcolemma deep into cell for mass myofibril contraction.
- **Sarcoplasm** (cytoplasm – large glucose stores + myoglobin – oxygen supply)
- **Sarcoplasmic Reticulum**
 - Tubular network
 - **Stores & Regulates intracellular Ca^{+}** levels necessary for contractions.
 - Surrounds each myofibril (contractile organelle)
 - **Terminal Cisternae** of the SR butt up on either side of the T-Tubules → forms a '**Triad**'
 - Triads occur at every I.Band–A.Band junction.
- Abundant **Mitochondrion** – energy



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