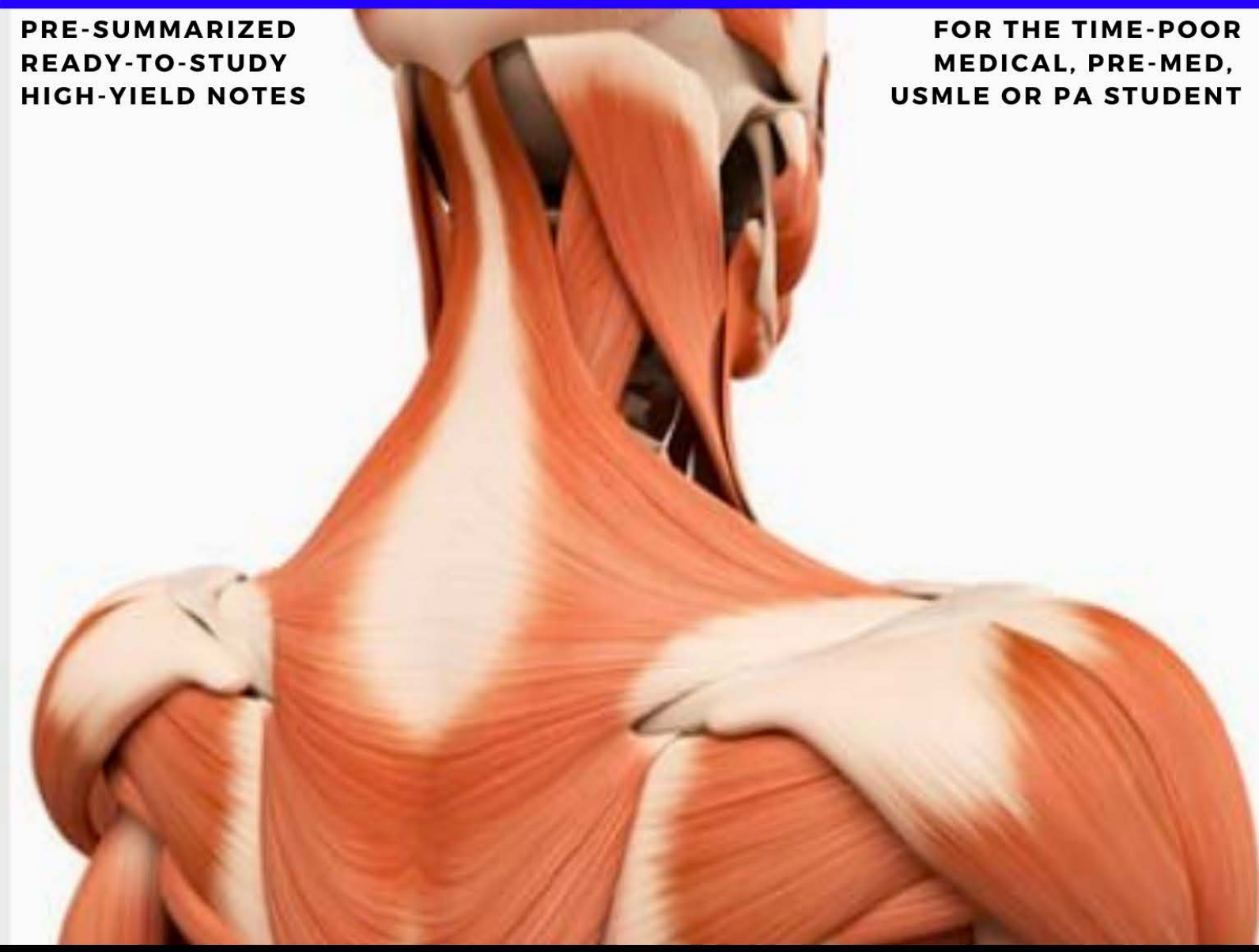
ANATOMY, PHYSIOLOGY & PATHOLOGY NOTES OF THE

MUSCULOSKELETAL SYSTEM

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

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



MEDICAL NOTES
(MBBS, MD, MBChB, USMLE, PA, & Nursing)
Anatomy, Physiology, Pathophysiology, Pathology, Histology & Treatments

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Table Of Contents:

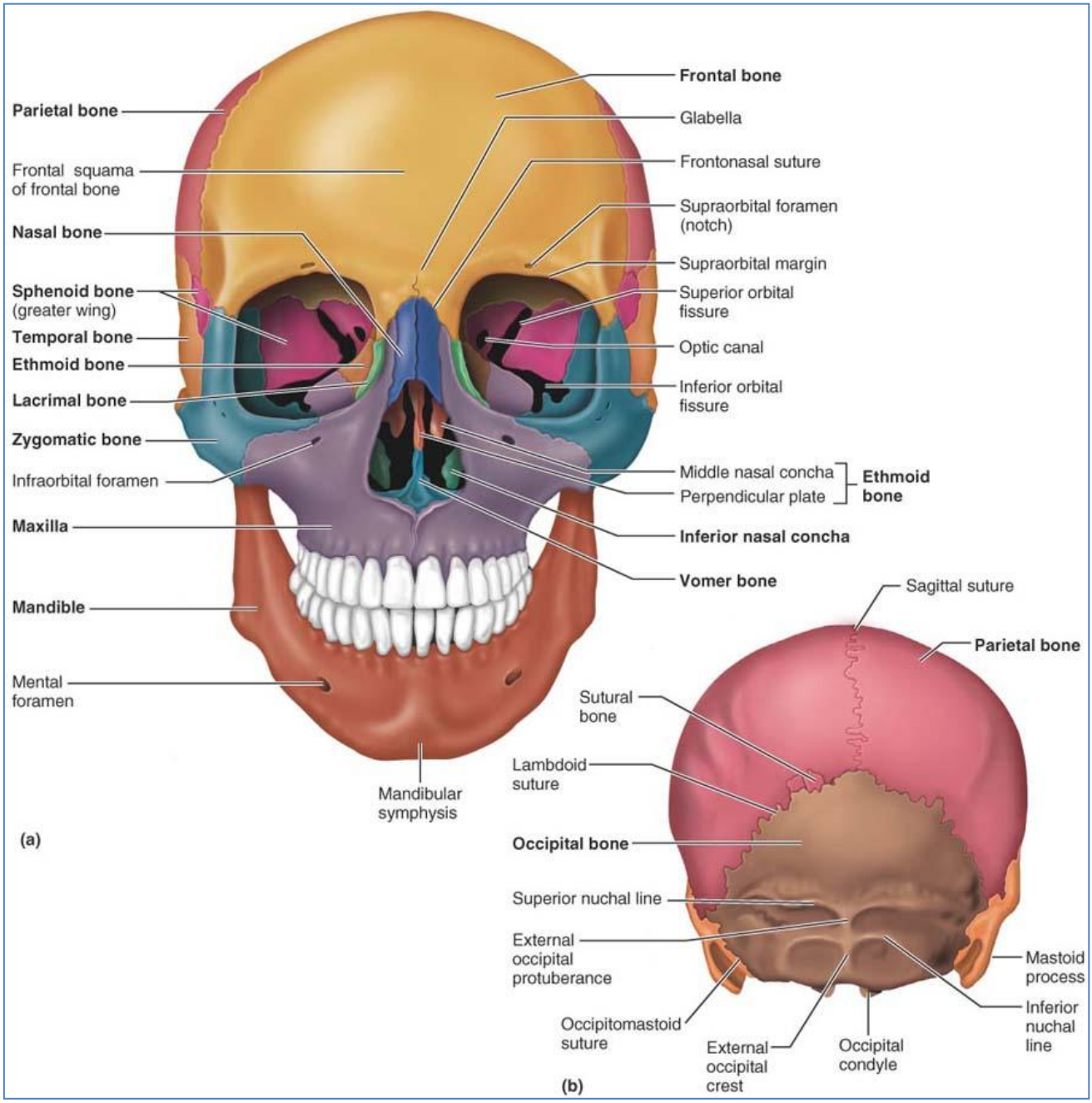
What's included: Ready-to-study anatomy, physiology and pathology notes of the musculoskeletal system presented in succinct, intuitive and richly illustrated downloadable PDF documents. Once downloaded, you may choose to either print and bind them, or make annotations digitally on your iPad or tablet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

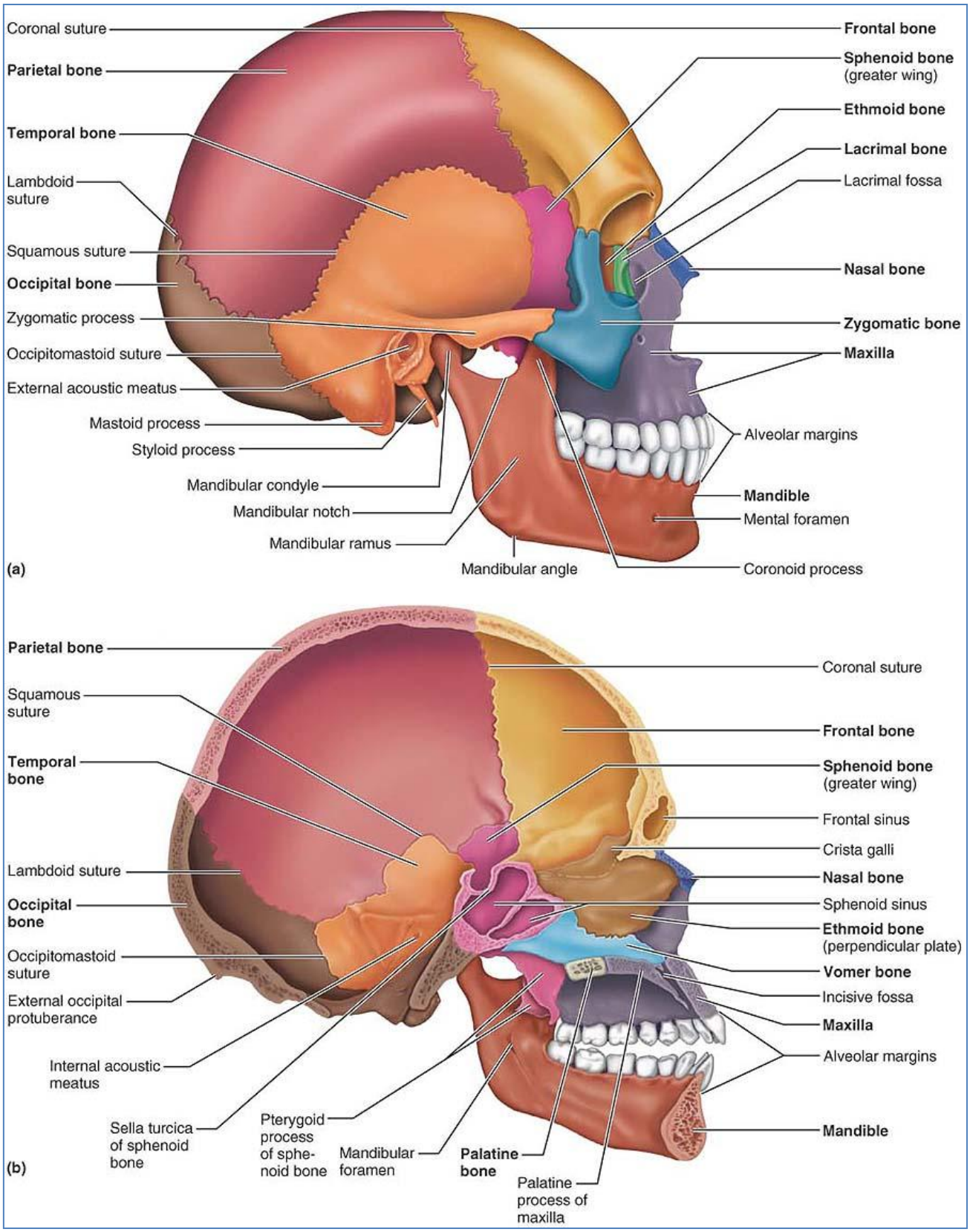
Free Bonus: 'Orthopedics' chapter of Toronto Notes for reference and further detailed reading.

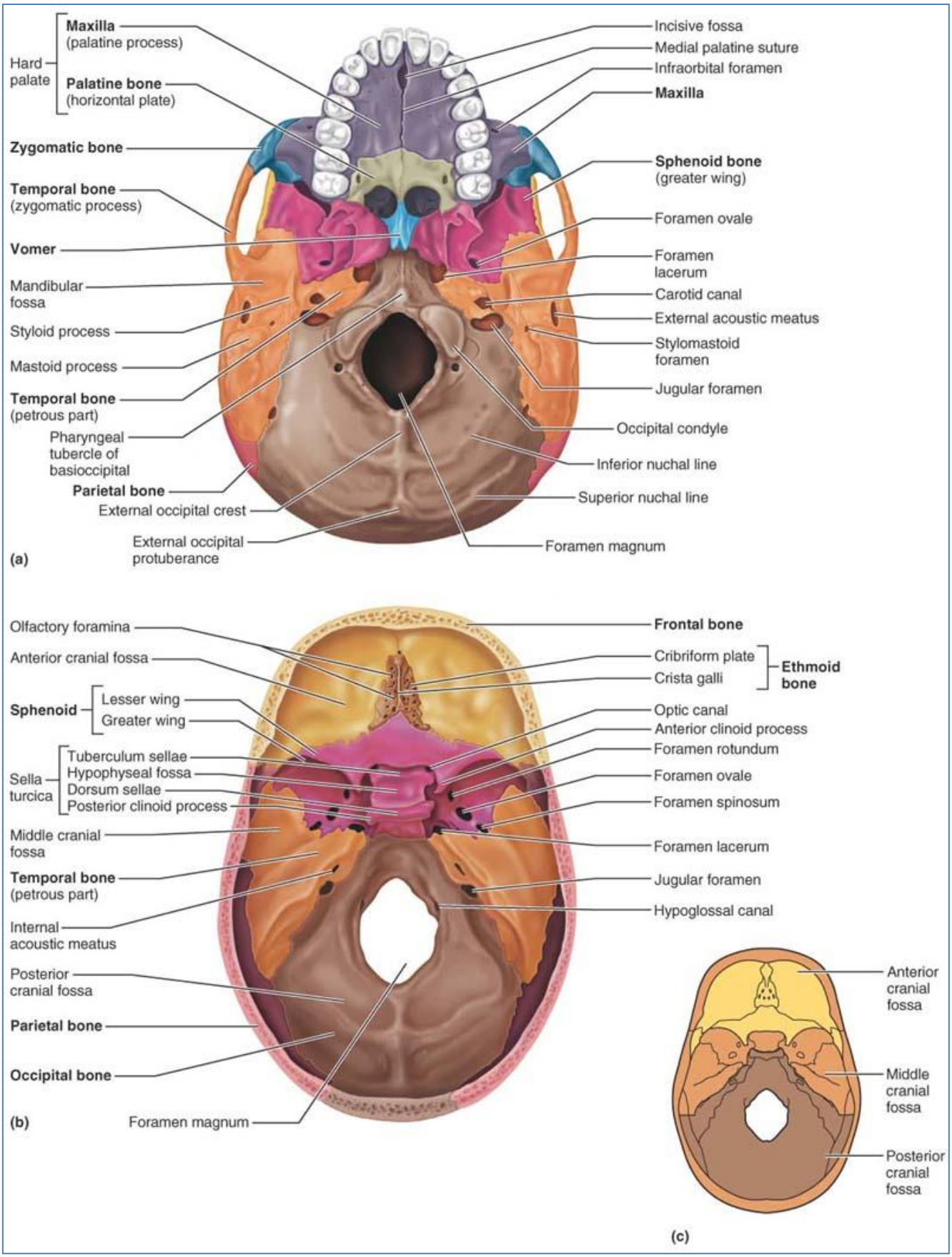
File List:

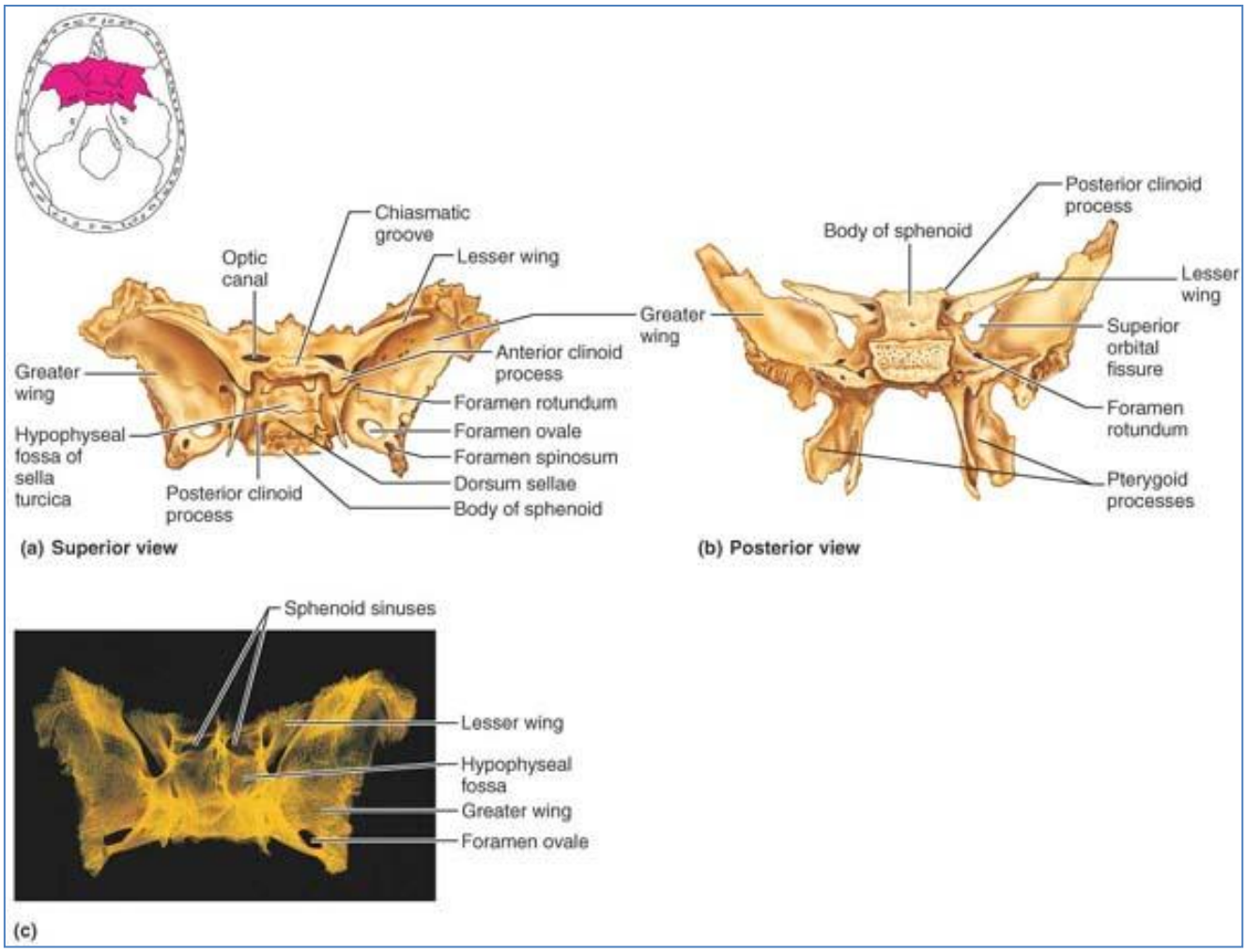
Bones of the Skull

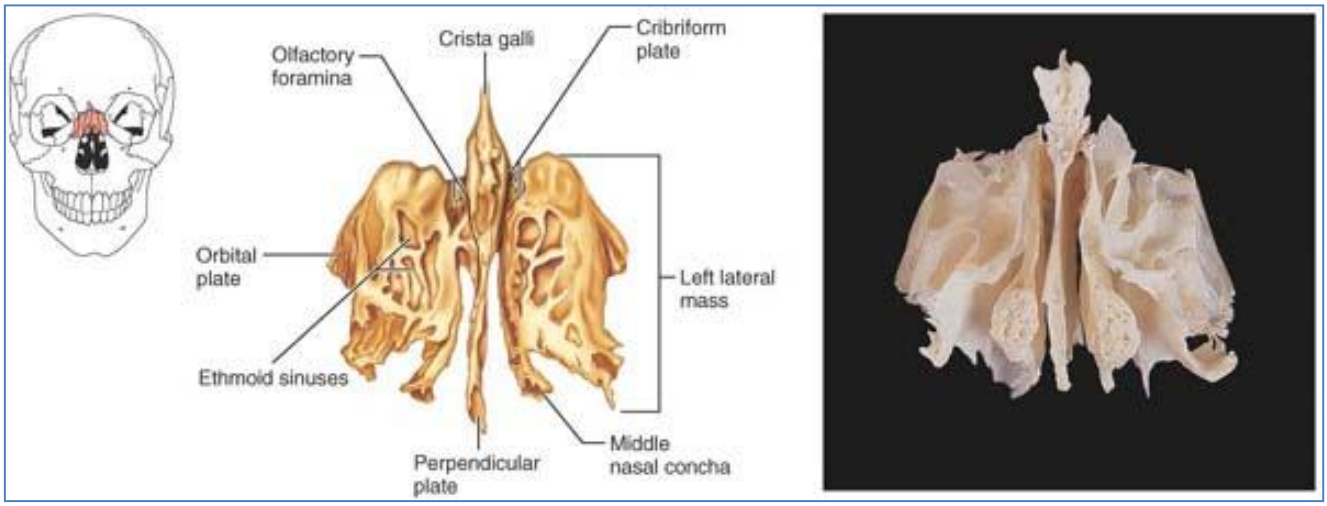
(Need to Know)











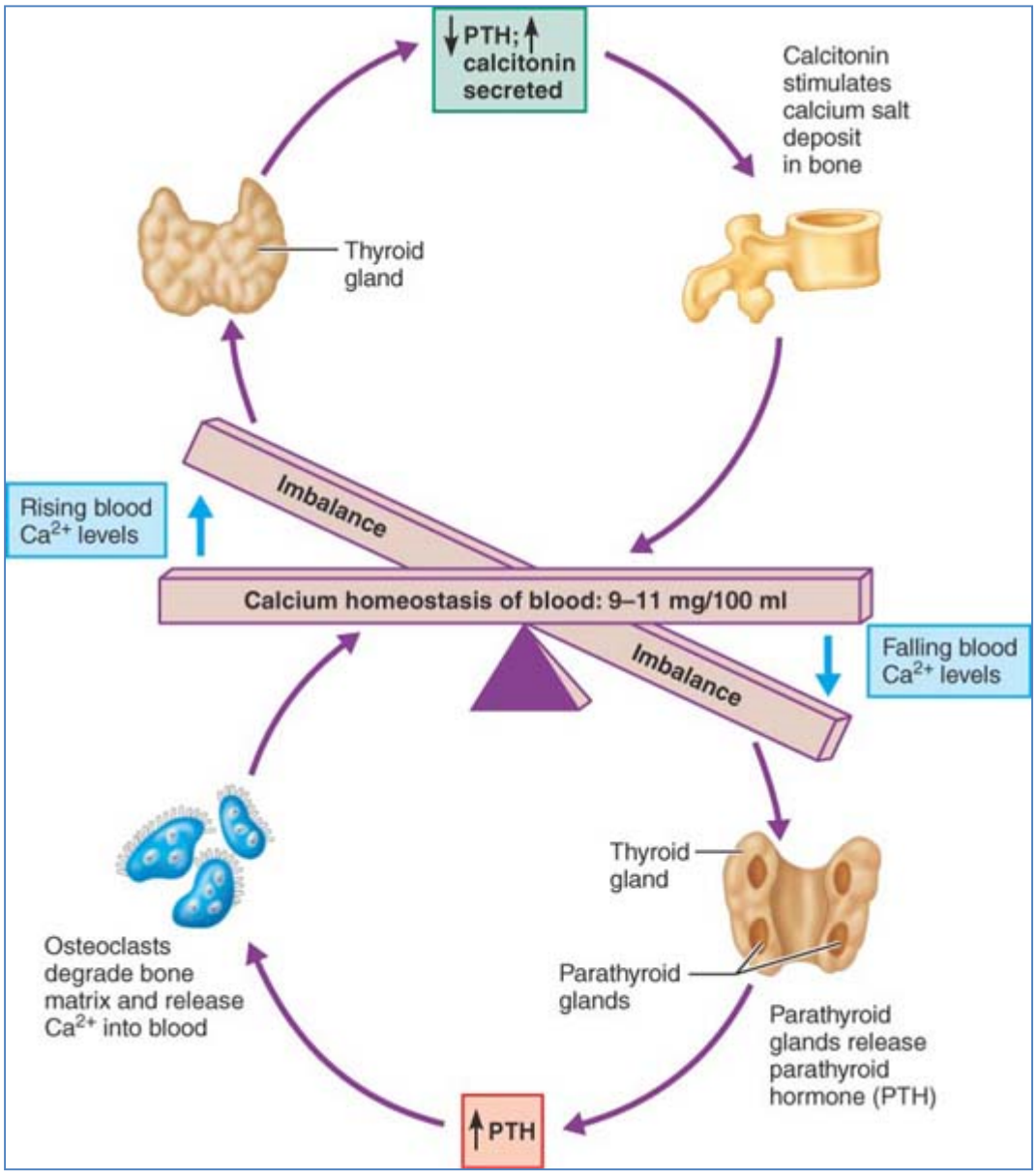
The Skeletal System:

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

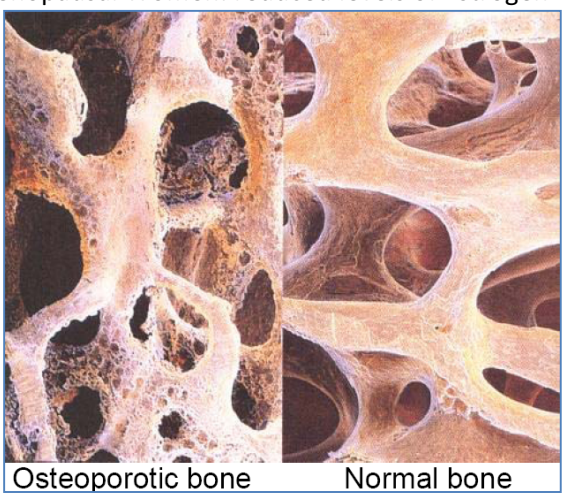
Metabolism of bone & its hormonal control

- **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.

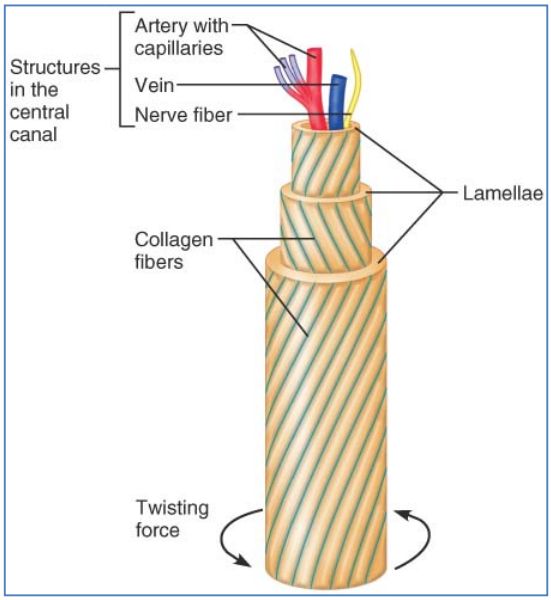


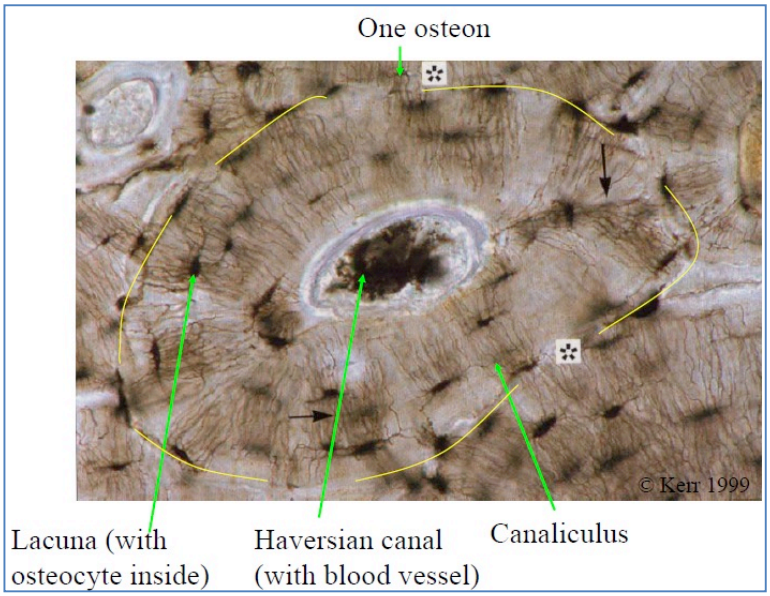
Bone Composition:

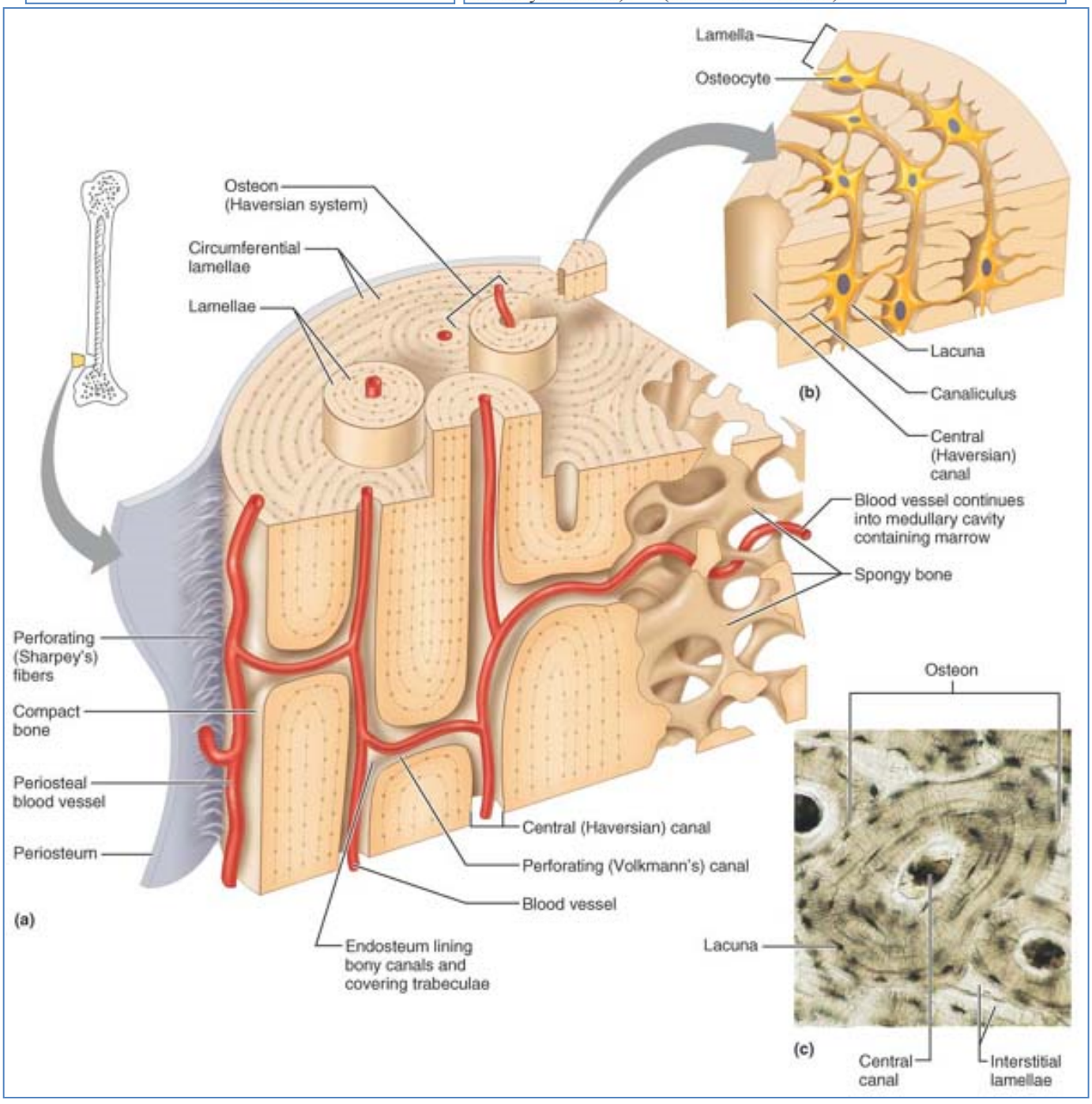
- **Organic**
    - Collagen & other proteins
    - 35%
    - Flexibility
    - Tensile Strength
- **Inorganic**
    - Mineral Salts
    - 65%
    - Compression Strength
    - Reason why it preserves so well.

Bone & Associated Tissue Histology:

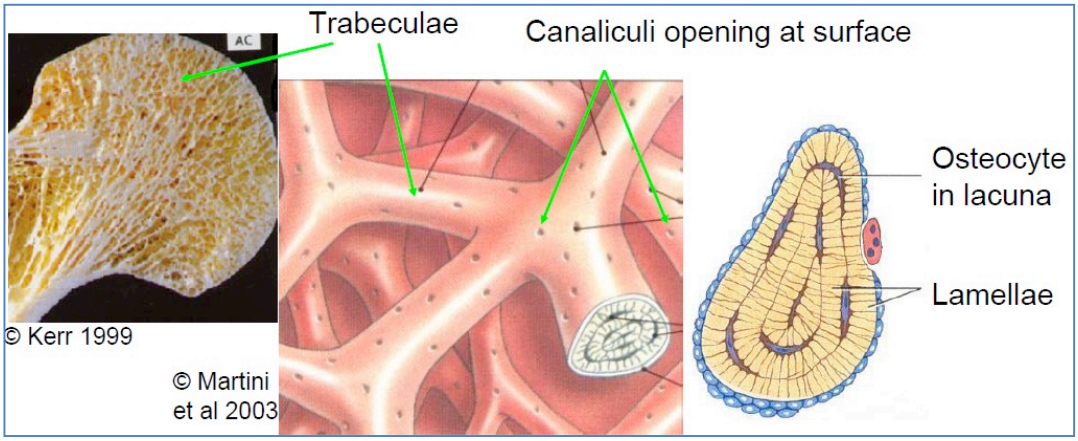
- **Bone**
    - **Compact**
        - Thicker
        - Denser
        - Comprised of **Osteons –** basic units of compact bone
            - Haversian Canal
                - Blood Vessels
                - Nerve Fibres
            - Lamellae
                - Rings of Collagen Fibres around Haversian 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



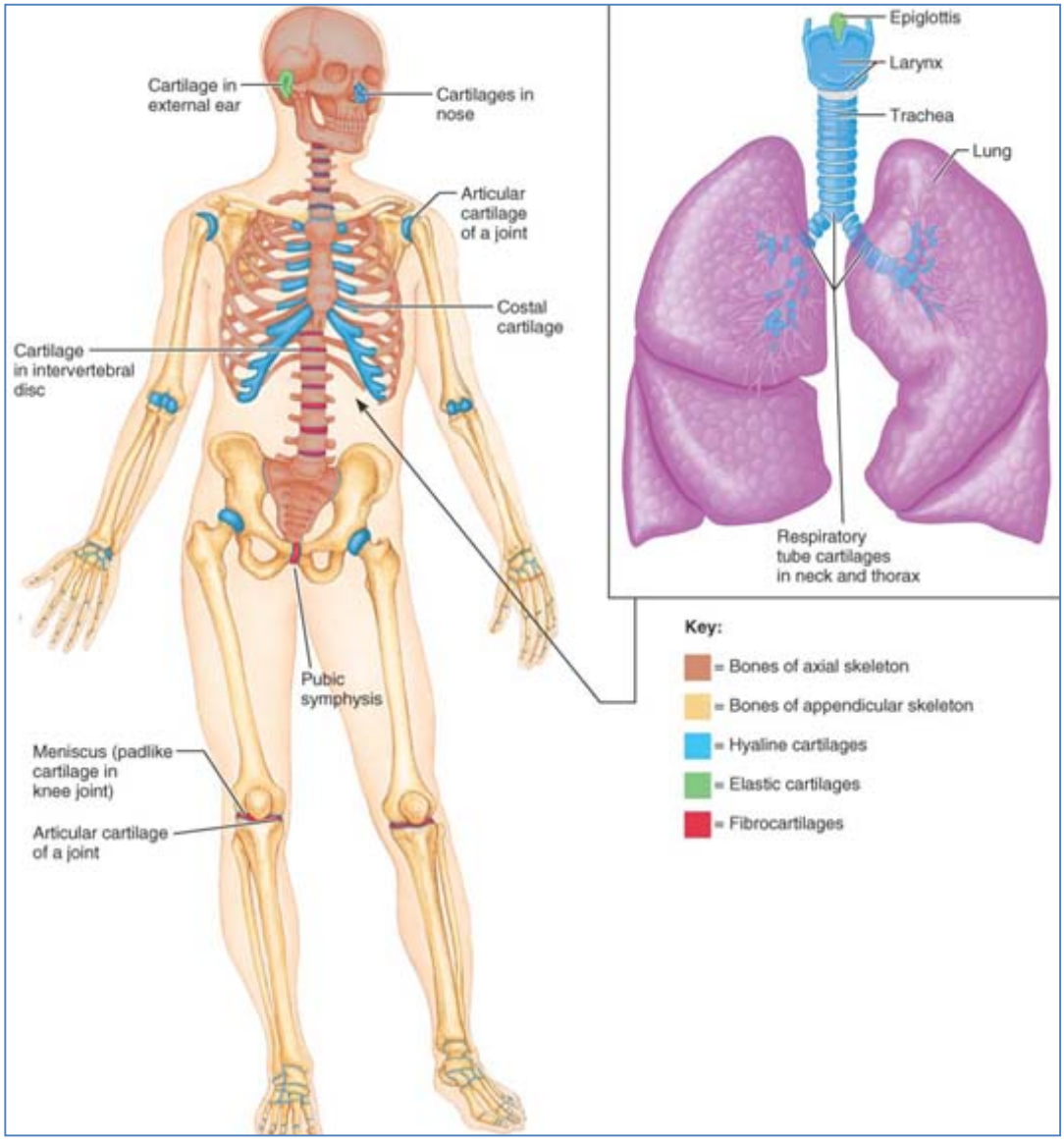




- **Cancellous (Spongy)**
  - Trabeculae (struts) relay stress to the dense compact bone
  - Houses marrow in between trabeculae.
  - Blood Vessels
  - Osteoblasts
  - Fat Cells

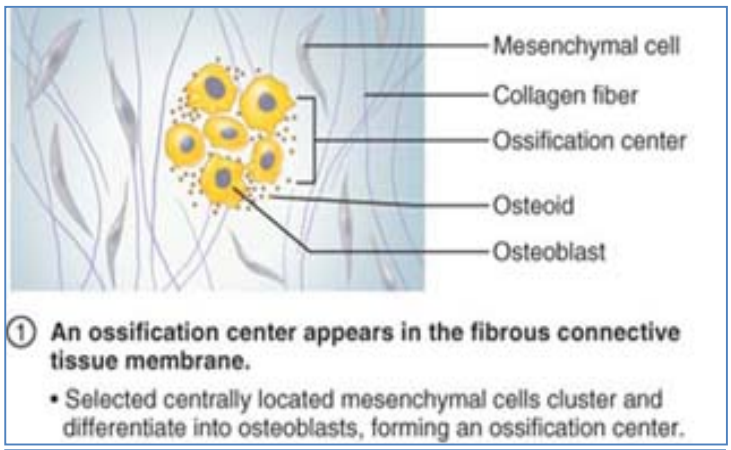


- **<u>Cartilage:</u>**
  - **Articular (Hyaline)**
    - Avascular
    - Chondrocytes in columns in lacunae
    - Ground Substance – fibres + H_2O



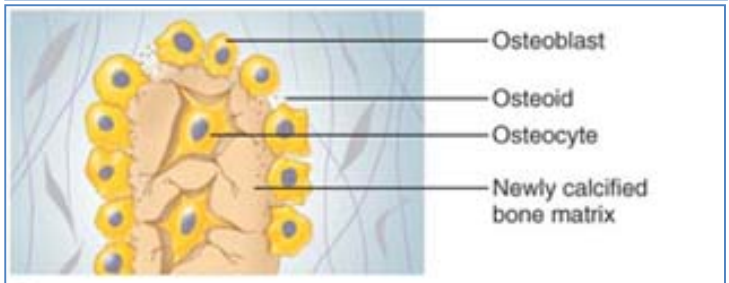
Bone Development:

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



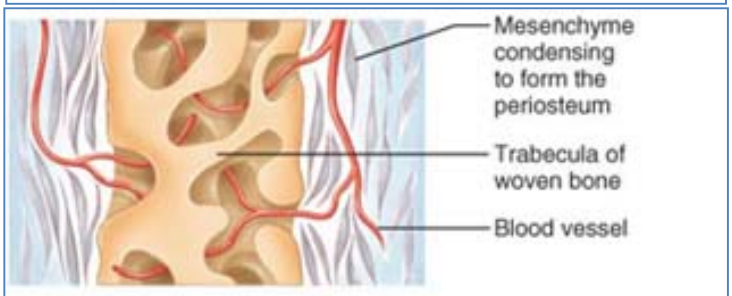
① **An ossification center appears in the fibrous connective tissue membrane.**

- Selected centrally located mesenchymal cells cluster and differentiate into osteoblasts, forming an ossification center.



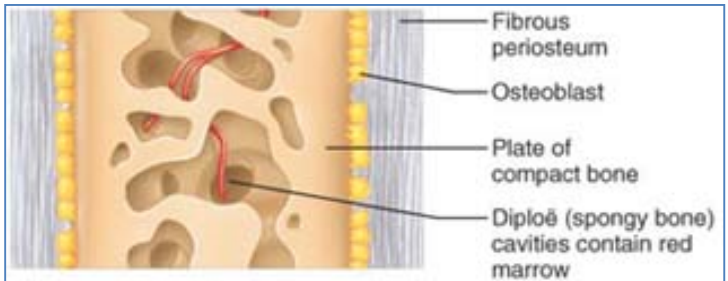
② **Bone matrix (osteoid) is secreted within the fibrous membrane.**

- Osteoblasts begin to secrete osteoid, which is mineralized within a few days.
- Trapped osteoblasts become osteocytes.



③ **Woven bone and periosteum form.**

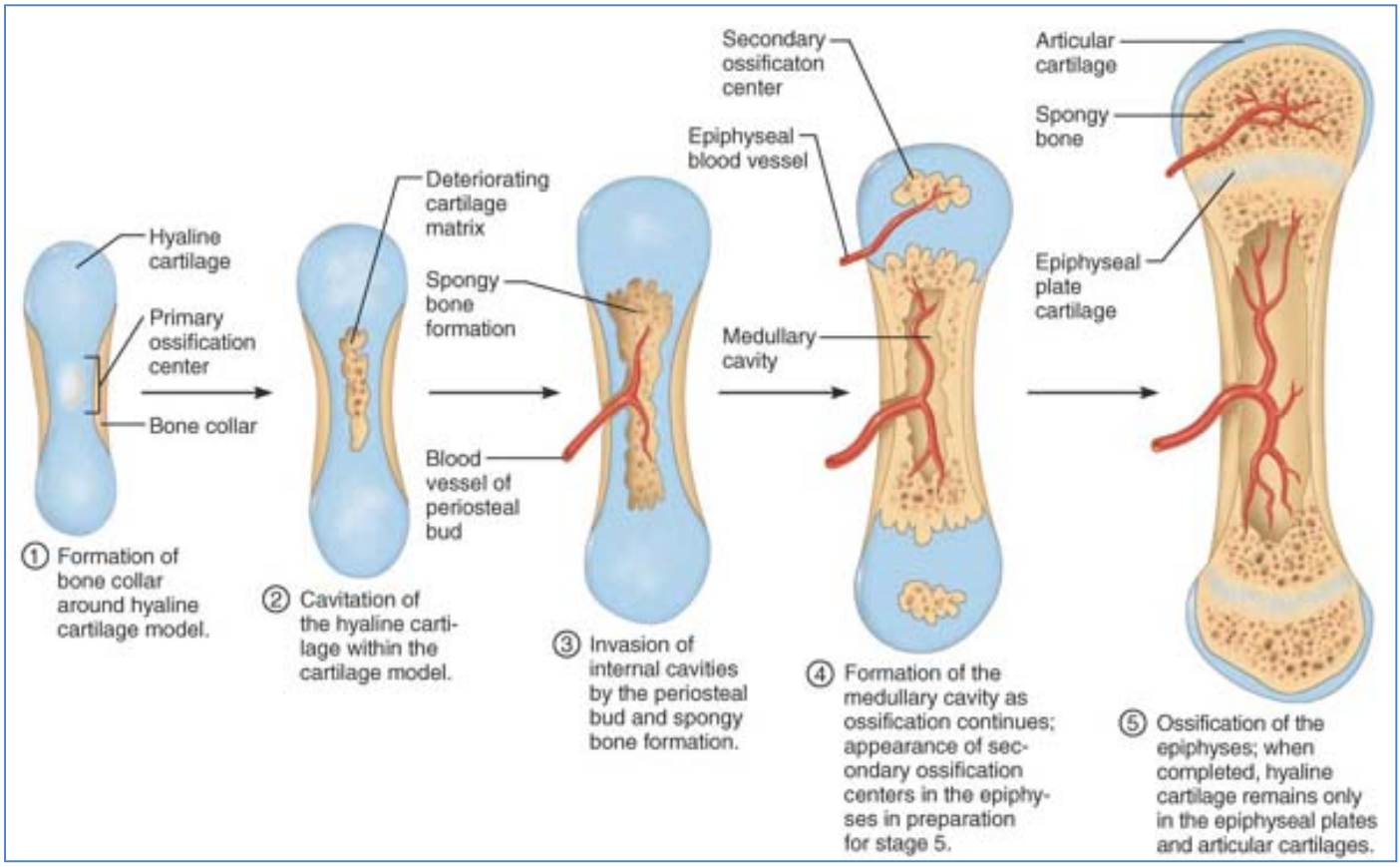
- Accumulating osteoid is laid down between embryonic blood vessels, which form a random network. The result is a network (instead of lamellae) of trabeculae.
- Vascularized mesenchyme condenses on the external face of the woven bone and becomes the periosteum.



④ **Bone collar of compact bone forms and red marro**[redacted]

- Trabeculae just deep to the periosteum thicken, forming a woven bone collar that is later replaced with mature lamellar bone.
- Spongy bone (diploë), consisting of distinct trabeculae, persists internally [redacted] marrow.

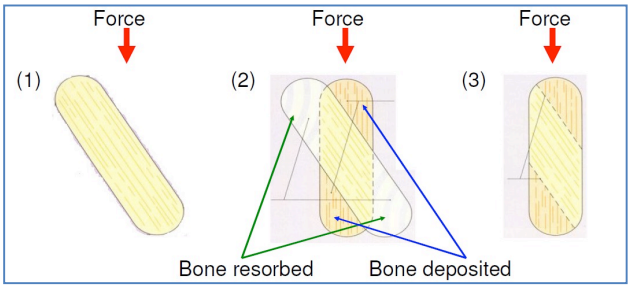
- **Endochondral**
  - From Cartilage
    - Hyaline cartilage
    - Primary ossification centre in diaphysis
    - Secondary ossification centre in epiphyses
    - Epiphyseal plate (growth plate)
  - 5 Phases:
    - Phase 1 & 2:
      - In Utero
      - Hyaline cartilage template
      - Osteoblasts 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



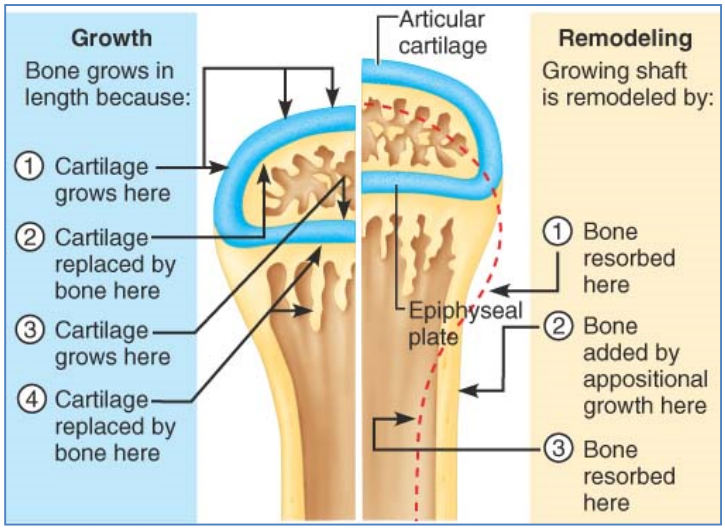
Bone Remodelling:

- 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.

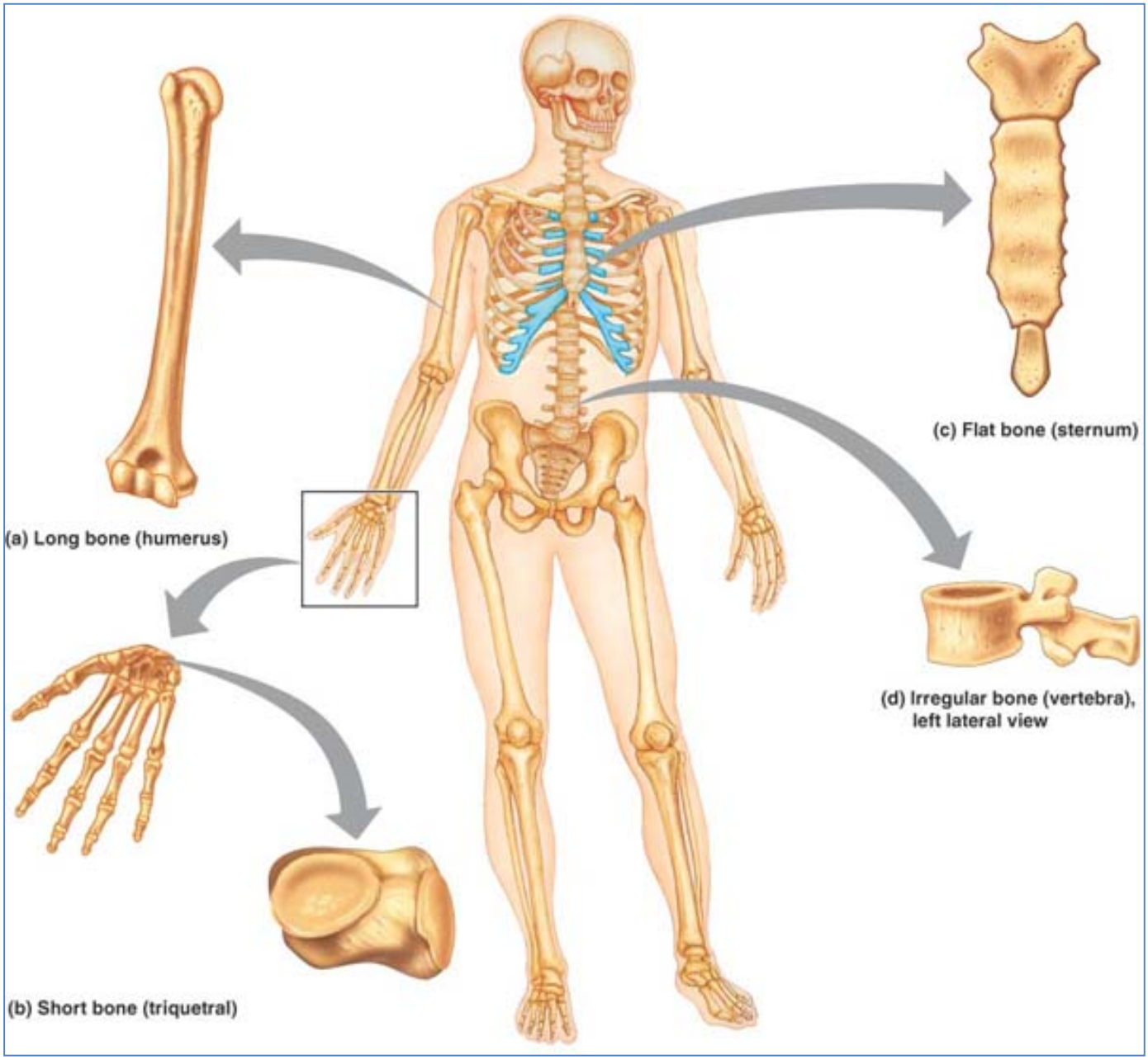


- **Eg. Long Bone Growth:**
  - **Length**
    - Apposition at epiphyseal line
    - By osteoblasts
  - **Width**
    - Apposition by osteoblasts
    - Resorption (bone removal) by osteoclasts

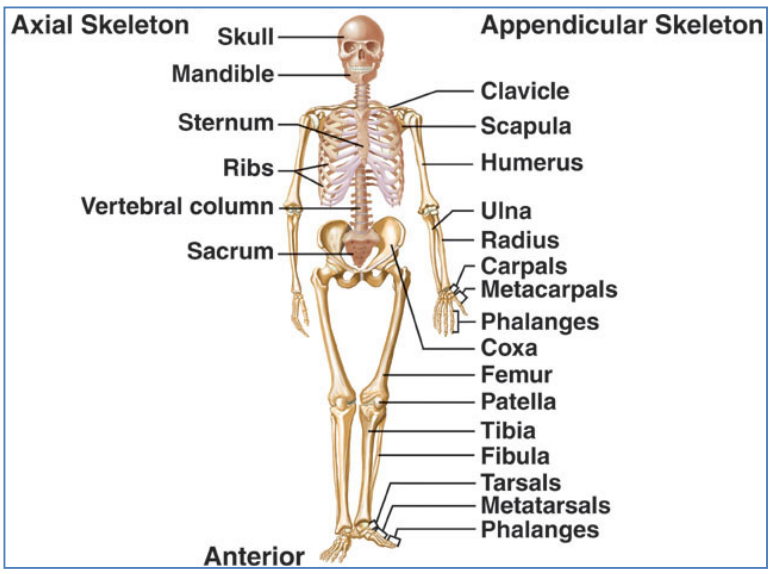


Classification of Bones:

- **Long**
  - Humerous
  - 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

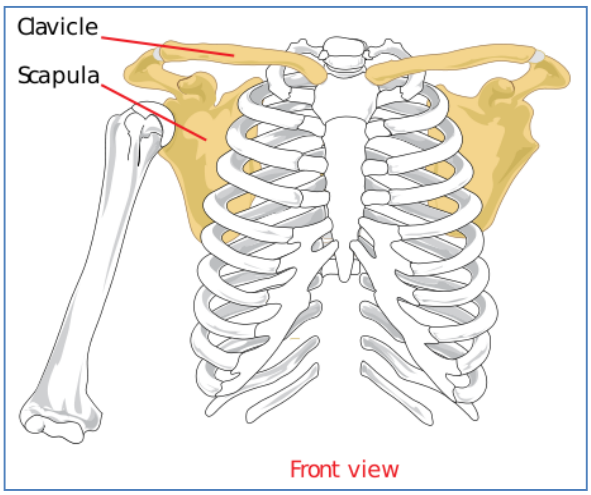


Appendicular Vs. Axial Skeleton:



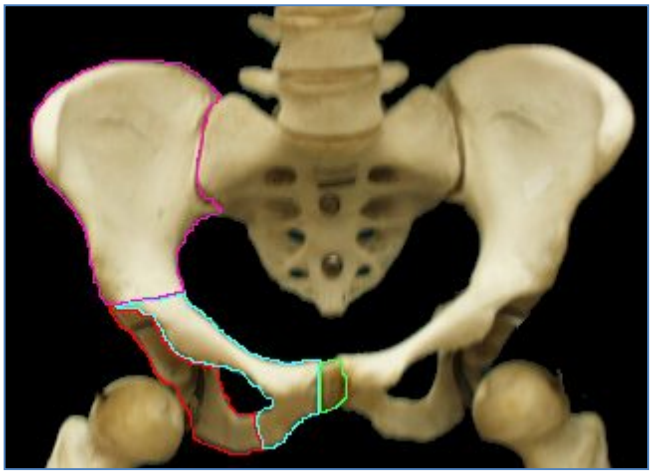
Pectoral Girdle:

- Scapula & Clavicle
- Anchors upper limbs to axial skeleton



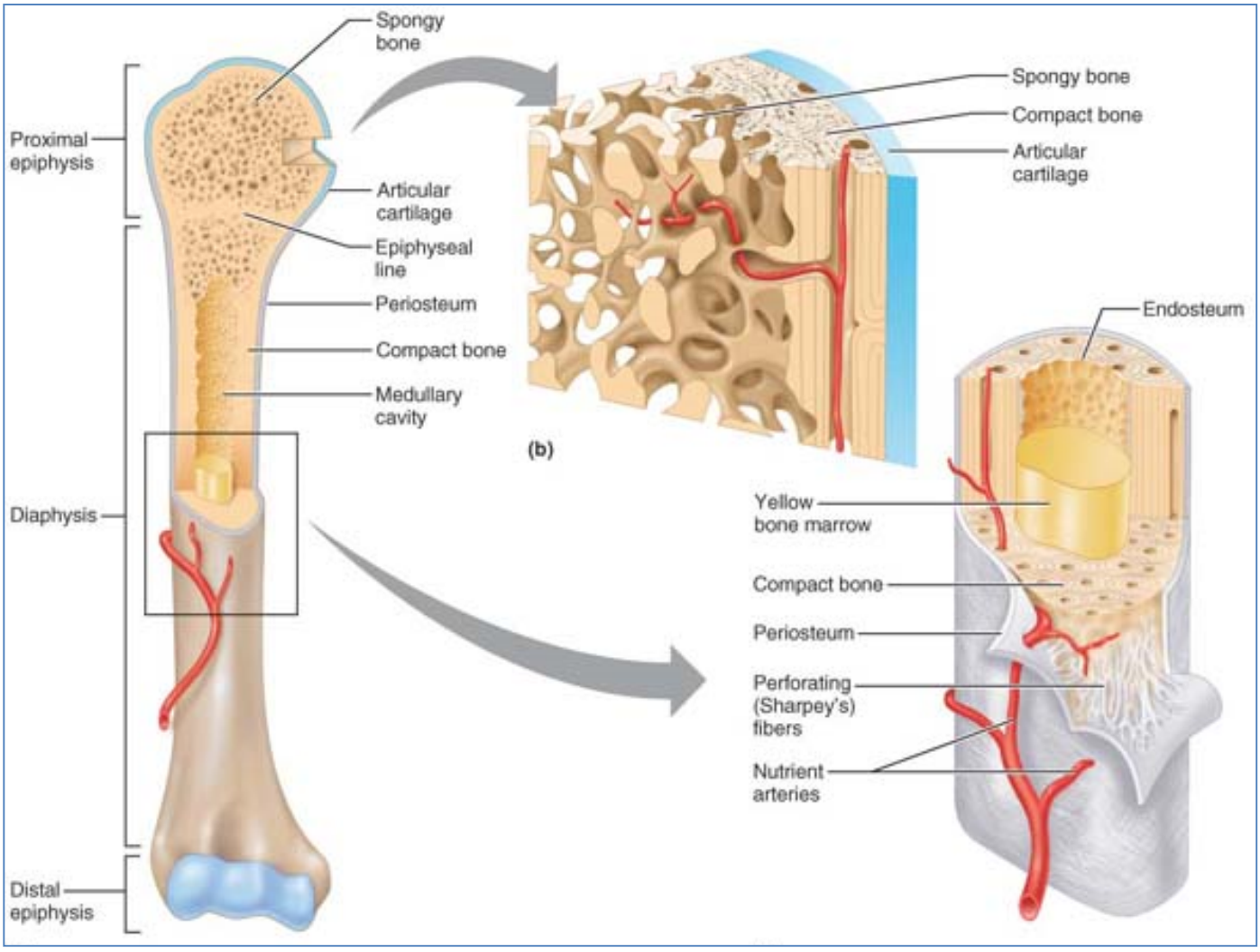
Pelvic Girdle:

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



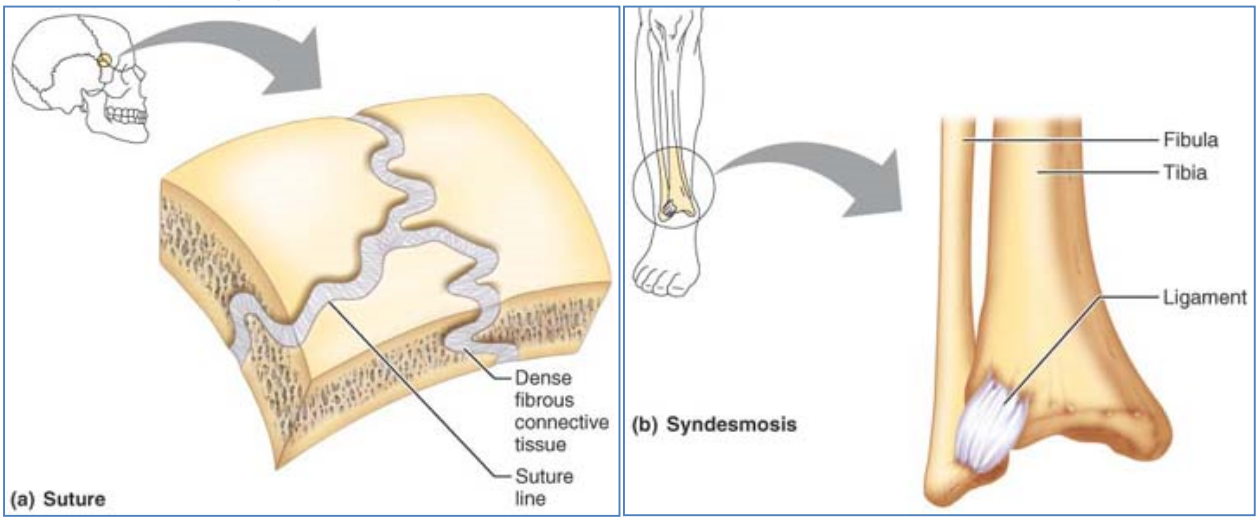
Long Bone Structure:

- **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 hematopoesis (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.

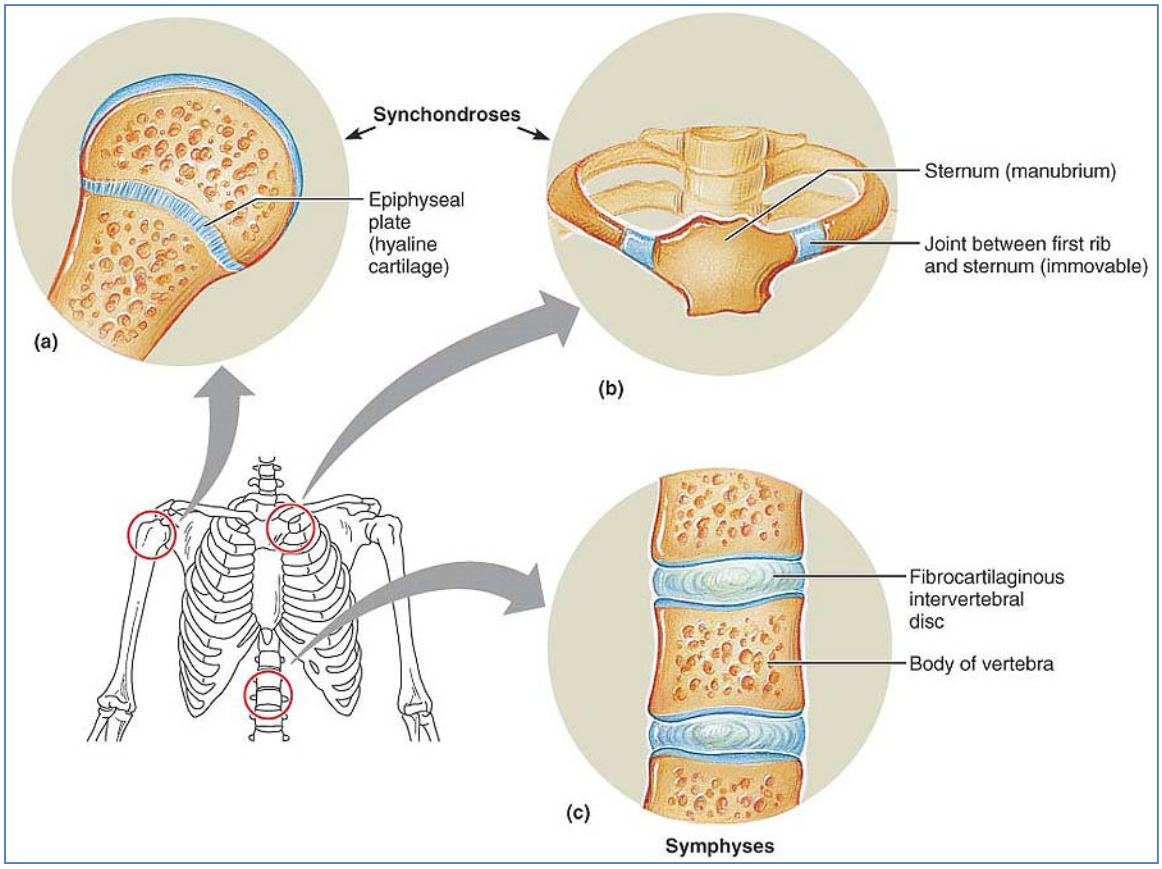


Joints:

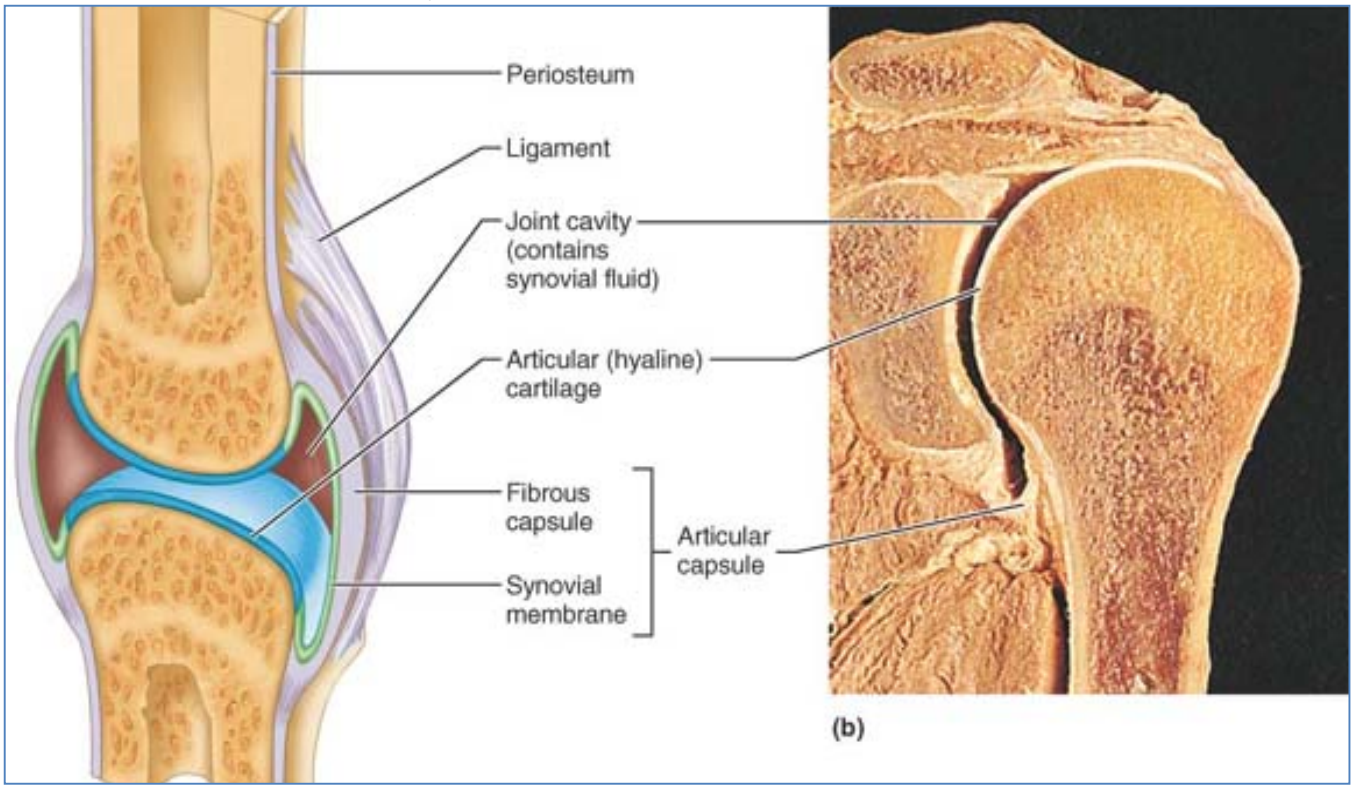
- Junction between 2 or more bones
- Not necessarily moving joints (Eg. cranial sutures)
- **3 Types:**
    - **Fibrous**
        - No movement
        - Joined by fibrous tissue
        - No joint cavity
        - Eg. Cranial Sutures
        - Eg. Syndemoses – between tibia & fibula @ ankle.



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



- **Synovial**
  - 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 H_2O content
    - Avascular - nutrients in synovial fluid diffuse to it.
    - Cells = Chondrocytes
    - Ground Substance – high H_2O 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

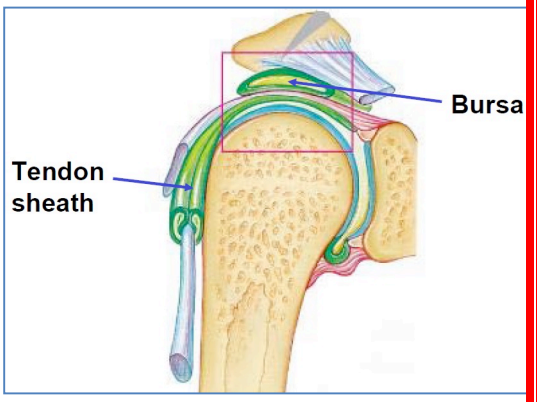


  - **Types of Synovial Joints:**
    - Plane – intertarsal joints in hand
    - Hinge – elbow/knee
    - Pivot – proximal radioulnar joint
    - Saddle – carpometacarpal joint of thumb
    - Ball & Socket – shoulder/hip
    - Condyloid – metacarpophalangeal joints

- **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

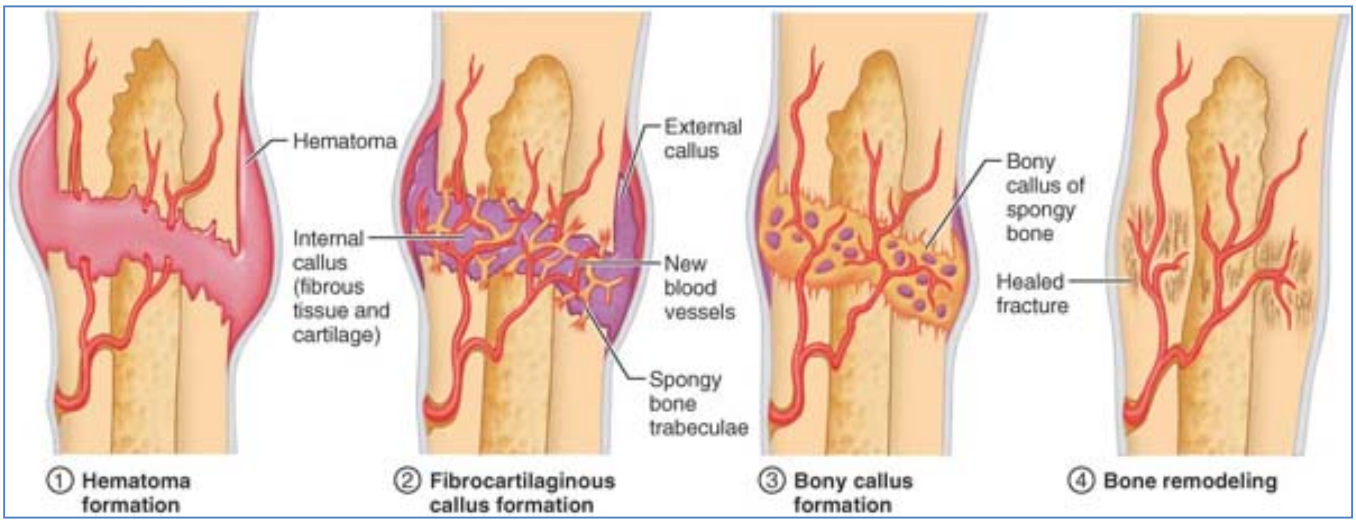
Bursae and Tendon Sheaths:

- 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**



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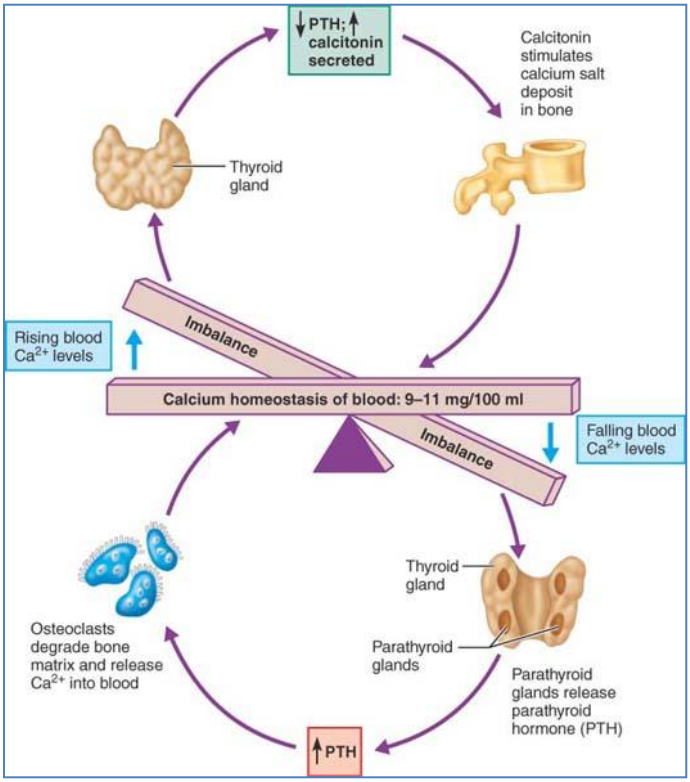

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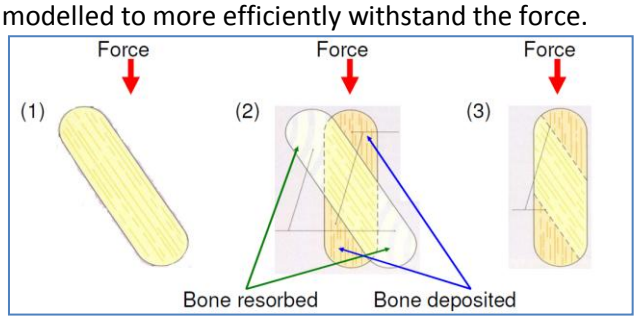
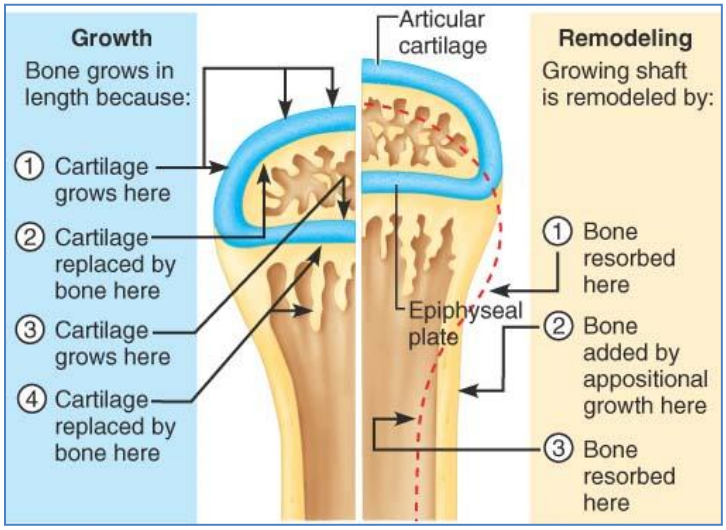
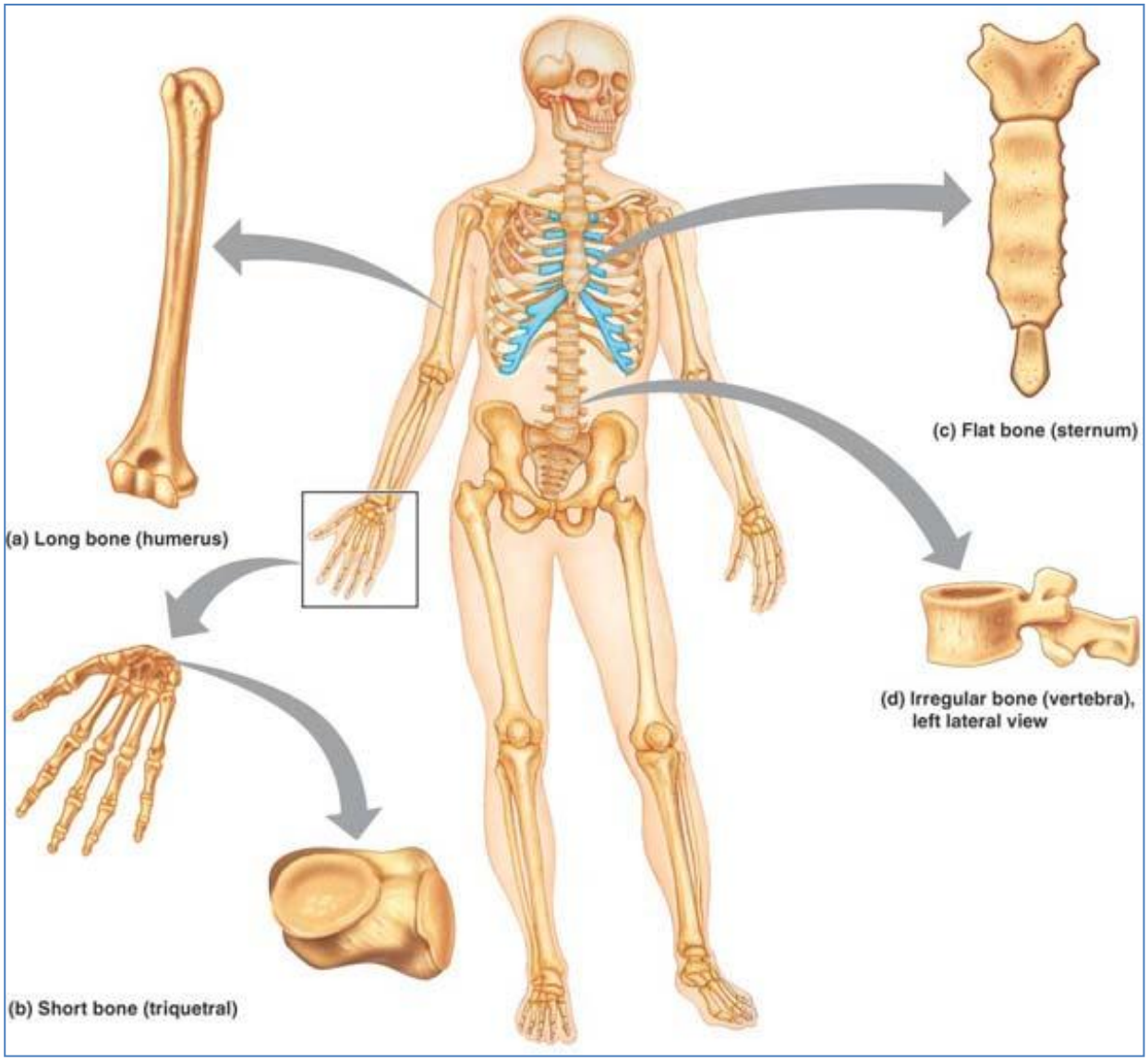


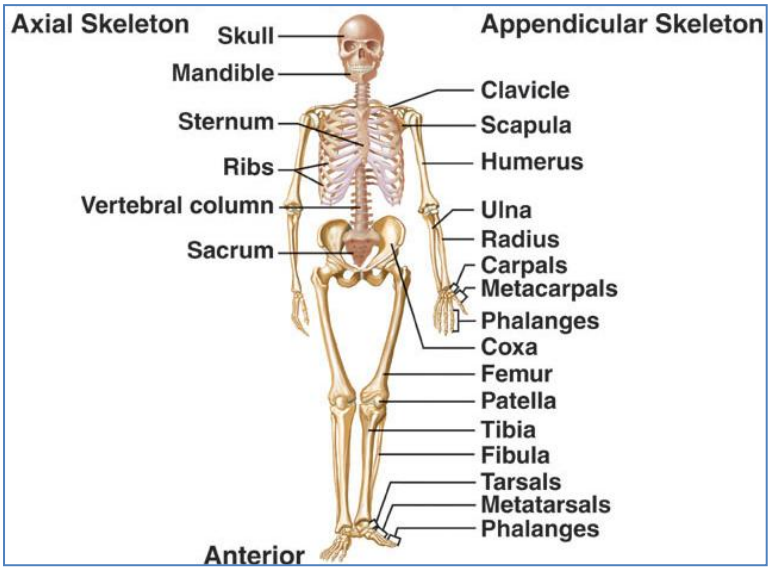
- **Eg. Long Bone Growth:**
  - **Length**
    - Apposition at epiphyseal line
    - By osteoblasts
  - **Width**
    - Apposition by osteoblasts
    - Resorption (bone removal) by osteoclasts



Classification of Bones:



Appendicular Vs. Axial Skeleton:

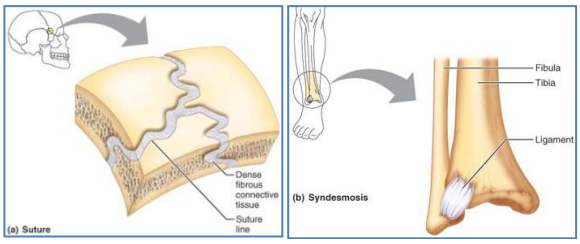


Long Bone Structure:

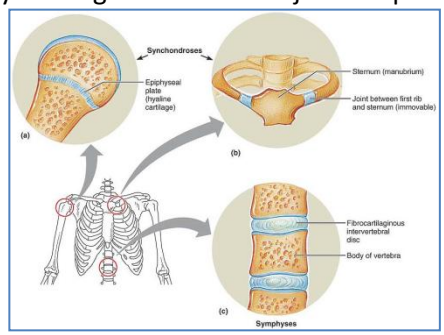
- **Diaphysis**
  - Shaft
  - Hollow
  - Strength + Lightness
  - Contains marrow (yellow in adult)
- **Epiphysis**
  - Expanded ends of bones
  - Proximal & Distal
  - Covered in **articular cartilage.**
  - Boundary defined by **epiphyseal line.**
- **Medullary (Marrow) Cavity**
  - Marrow cavity
  - Red Marrow & Yellow (fatty) marrow
  - Site of hematopoesis (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:

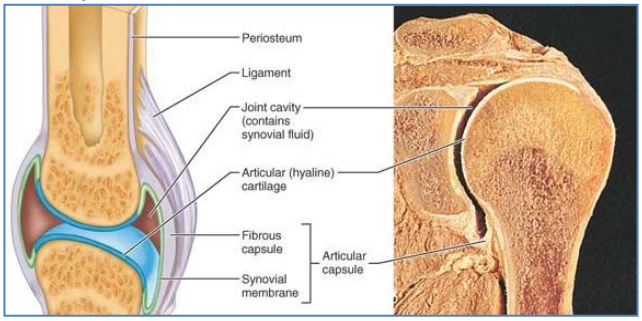
- Junction between 2 or more bones
- Not necessarily moving joints (Eg. cranial sutures)
- **3 Types:**
    - **Fibrous**
        - No movement
        - Joined by fibrous tissue
        - No joint cavity
        - Eg. Cranial Sutures
        - Eg. Syndemoses – between tibia & fibula @ ankle.



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



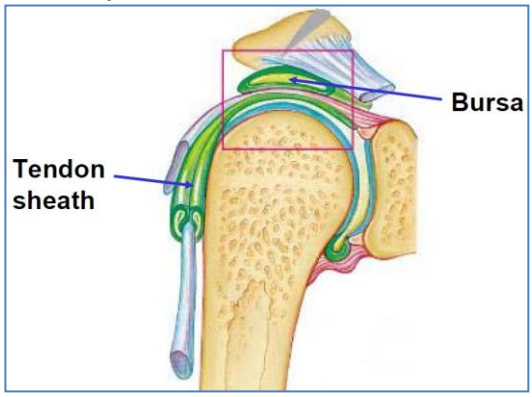
    - **Synovial**
        - **Articular (hyaline) Cartilage**
            - Covers bone ends
            - Protects bone – prevents bone-bone contact
            - Resists shock
            - Avascular - nutrients in synovial fluid diffuse to it.
            - Cells = Chondrocytes
        - **Synovial fluid**
            - 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

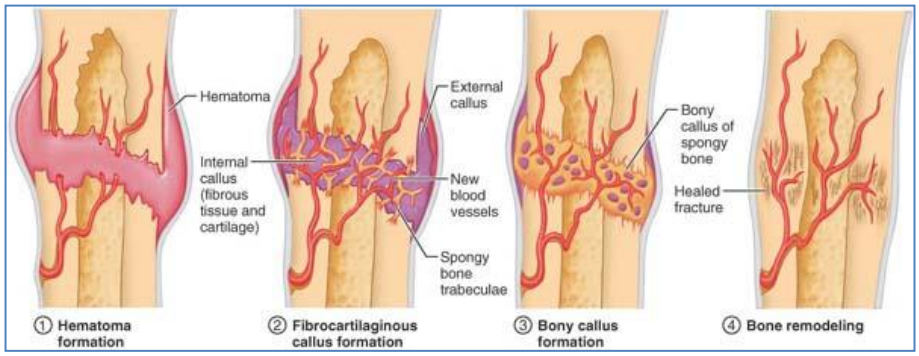
Bursae and Tendon Sheaths:

- 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

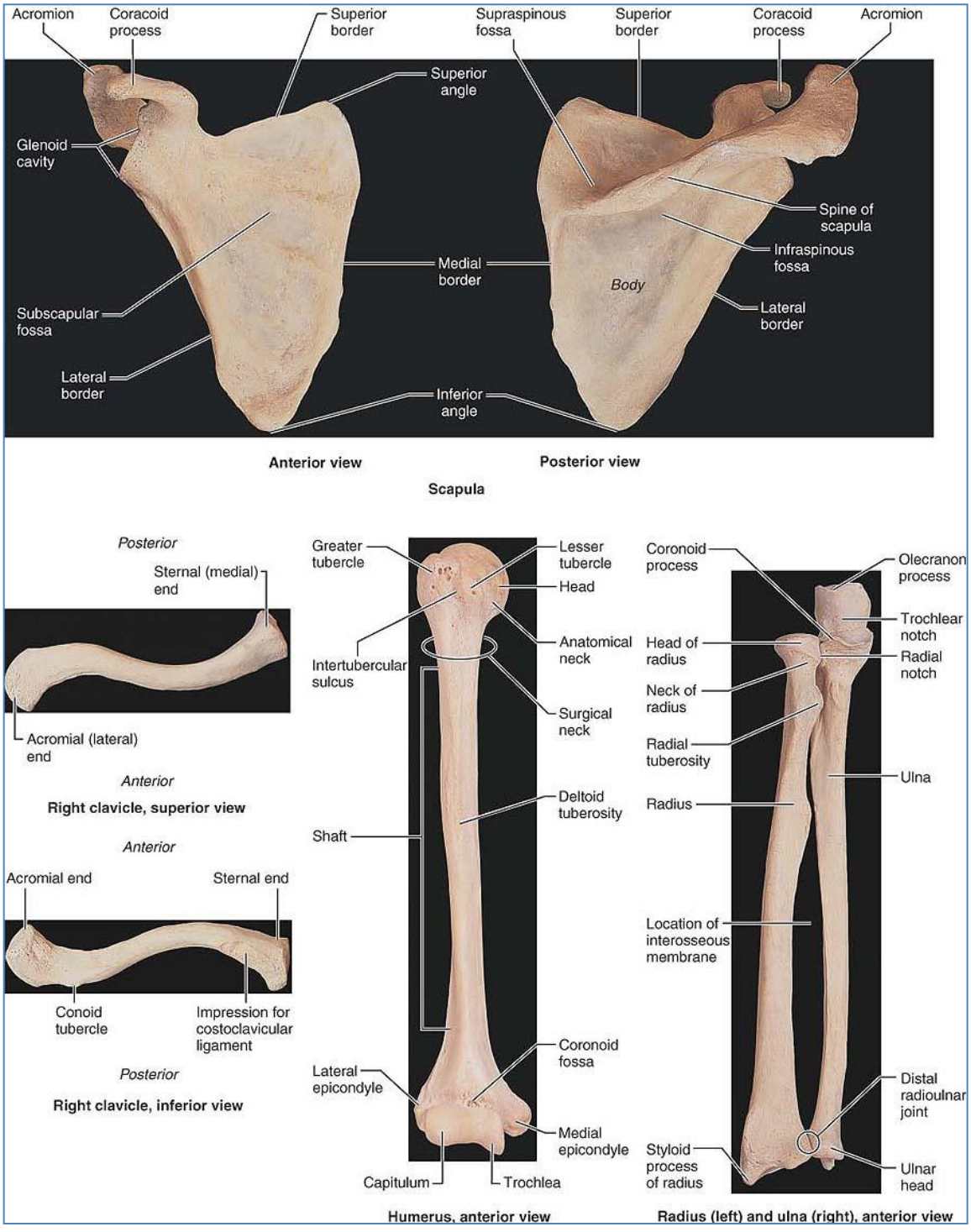
- **1. Hematoma Formation**
- **2. Fibrocartilaginous Callus Formation**
- **3. Bony Callus Formation**
- **4. Bone Remodelling**



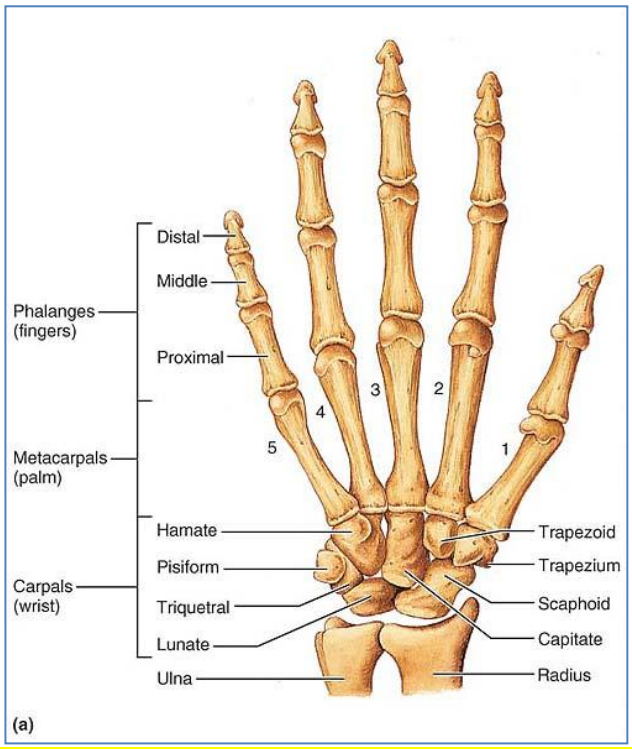
Shoulder Girdle (Pectorial Girdle):

- **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**



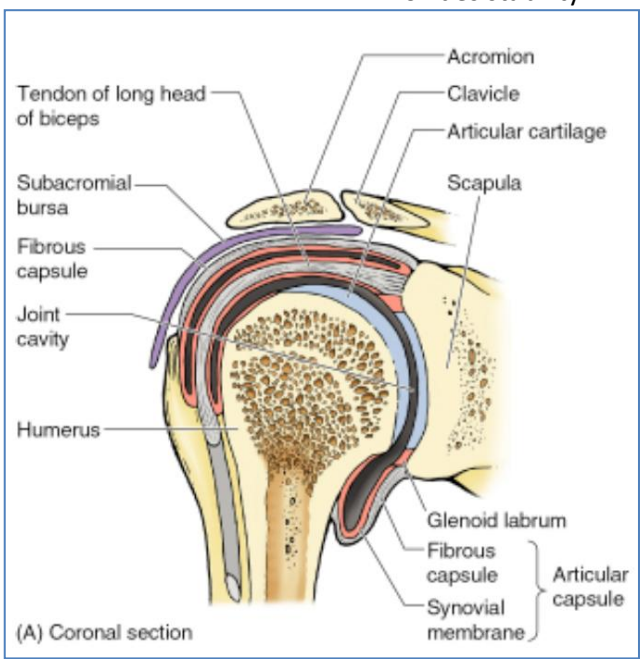
- **‘Hand’:**
  - **Carpals (“Wrist”):**
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
    - Pisiform
    - Triquetral
    - Lunate
    - Scaphoid
  - **Metacarpals (“Palm”):**
    - Metacarpals # 1-5
  - **Phalanges (“Fingers”):**
    - Distal # 1-5
    - Middle # 1-5
    - Proximal # 1-5

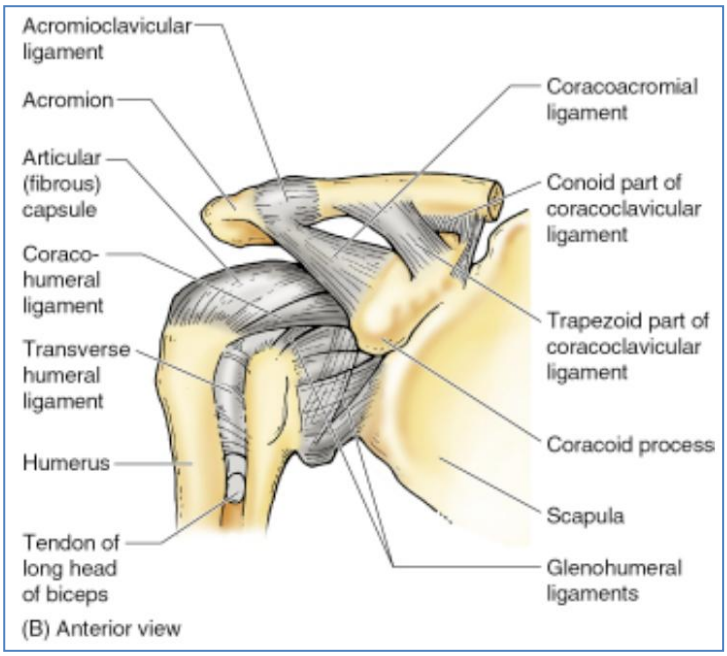


NB: Some **L**overs **T**ry **P**ositions **T**hat **T**hey **C**an’t **H**andle
Scaphoid, Lunate, Triquetrium, Pisiform, Trapezium, Trapezoid, Capitate, Hamate.

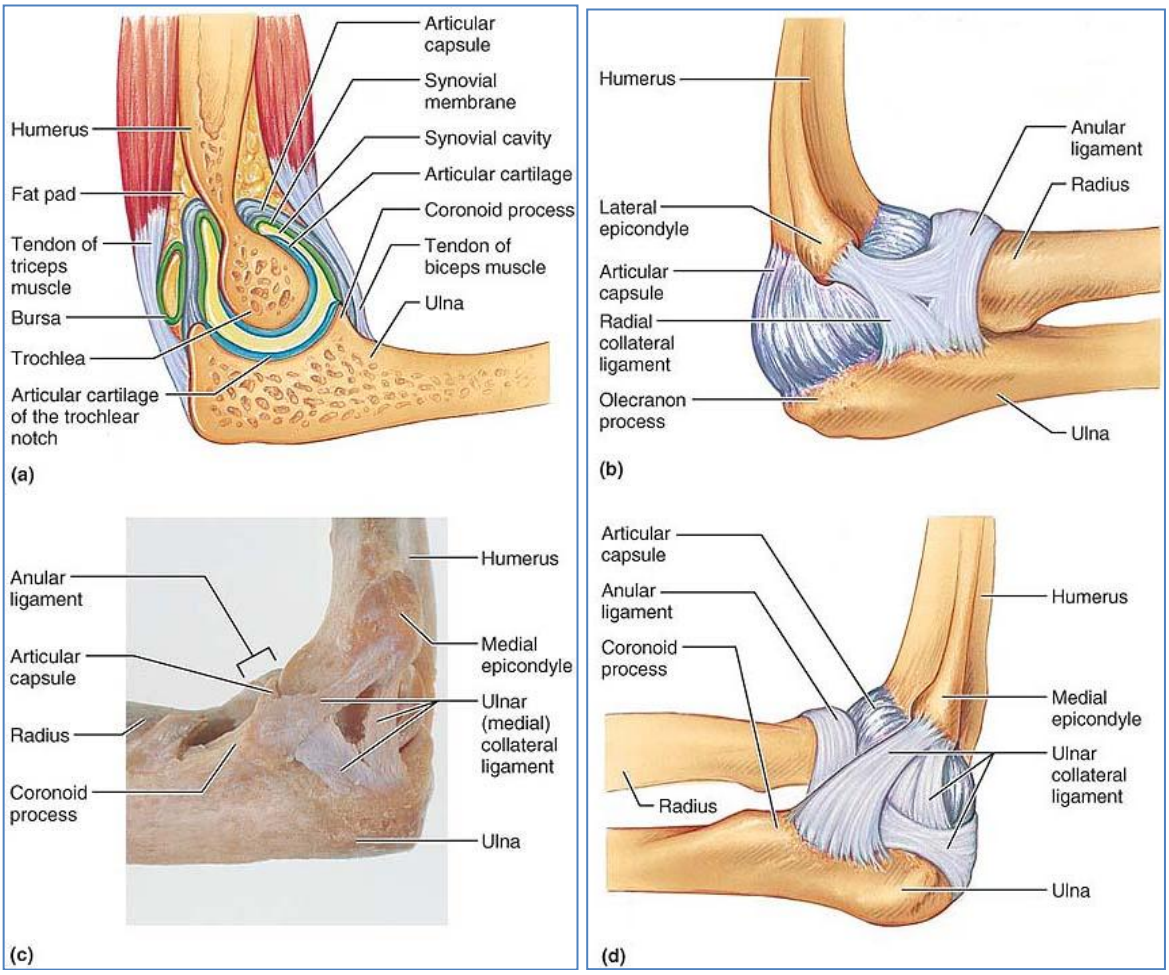
- **AcromioClavicular Joint:**
  - **Features:**
    - Joins the Clavicle to the Acromion
    - Synovial Plane
    - Has an ‘Articular Disc’(oval plate of fibrocartilage) – for congruence between bones.
  - **Bones:**
    - Clavicle
    - Acromion of Scapula
  - **Ligaments:**
    - Coracoacromial
 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





- **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



- **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 + Abduciton/Adduction = Circumduction
    - **Bones:**
      - Radius
      - Proximal Carpals
    - **Ligaments:**
      - Palmar Carpal Ligament
      - Flexor Retinaculum (Transverse Carpal Ligament) – Roof of Carpal Tunnel
      - Dorsal RadioCarpal Ligament

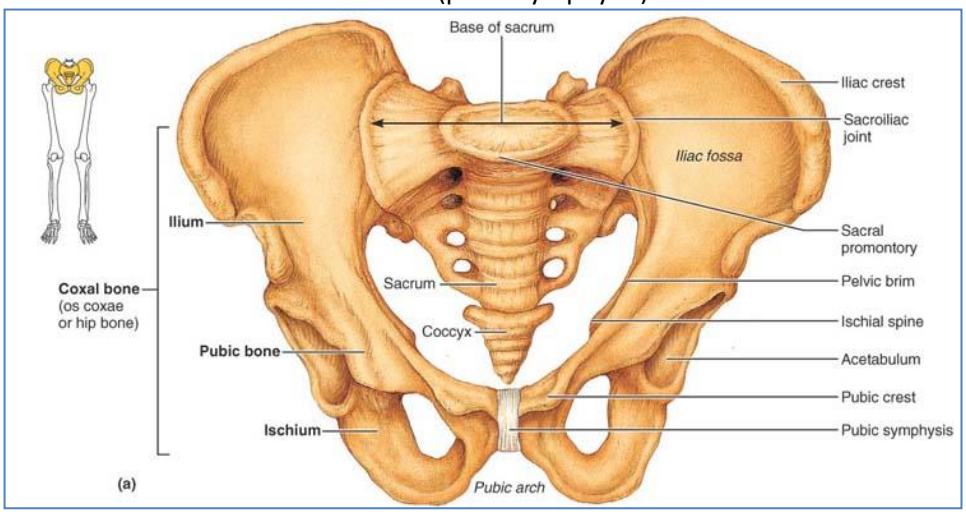
- **InterCarpal Joints:**
  - **Features:**
    - Joins Adjacent Carpals
    - Synovial Plan
  - **Bones:**
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
    - Pisiform
    - Triquetral
    - Lunate
    - Scaphoid
  - **Ligaments:**
    - The various Palmar Intercarpal Ligaments

Joint	Synovial type	Movements
Intercarpal	plane	gliding
1st Carpometacarpal	saddle	Extension, flexion, abduction, adduction, circumduction, oppositon
2nd to 5th Carpometacarpal	plane	gliding
Metacarpophalangeal	Condyloid	Extension, flexion, abduction, adduction, circumduction
Interphalangeal	Hinge	Extension, flexion

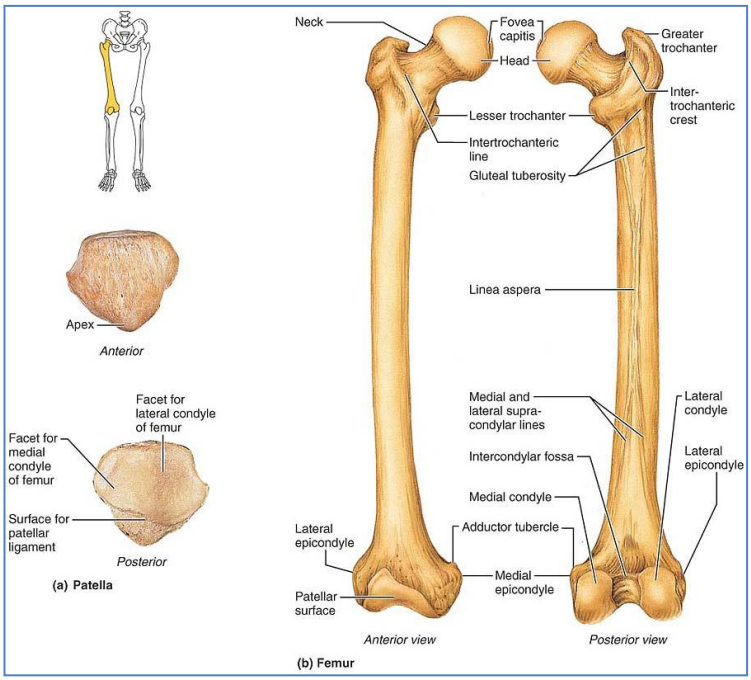
The Pelvic Girdle & The Lower Limb

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 ASIS
        - Posterior Superior Iliac Spine PSIS
        - Anterior Inferior Iliac Spine AIIS
        - Posterior Inferior Iliac Spine PIIS
        - 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)

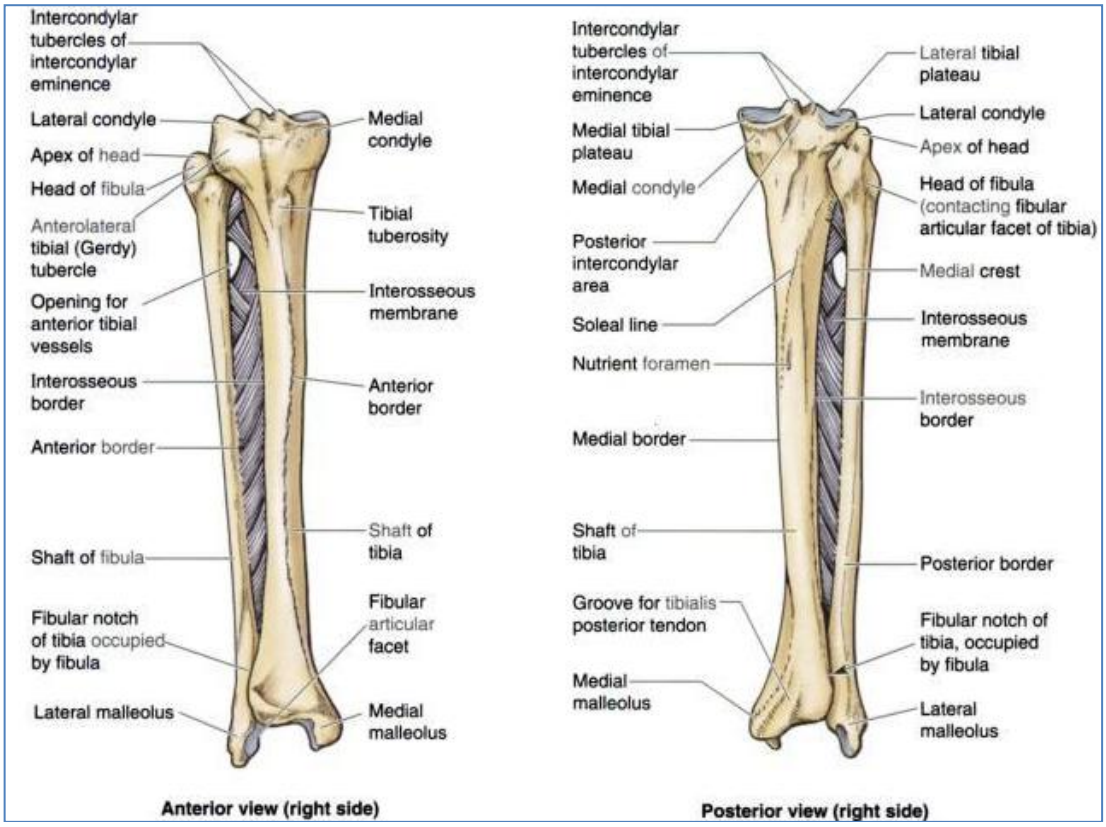


- **Femur:**
  - **Type/Features:**
    - Long bone
    - Longest & Strongest bone of the body.
    - Angle of Inclination - 125°
    - Angle of Anteversion - 10°
    - Neck of femur – prone to fracture due to lack of trabeculae.
  - **Landmarks:**
    - Head
    - Neck
    - Greater Trochanter
    - Lesser Trochanter
    - Lateral Epicondyle
    - Medial Epicondyle
    - Adductor Tubercle
    - Patellar Surface
  - **Articulations:**
    - Acetabulum of the Coxal Bones of the Hip
    - Patella
    - Tibia

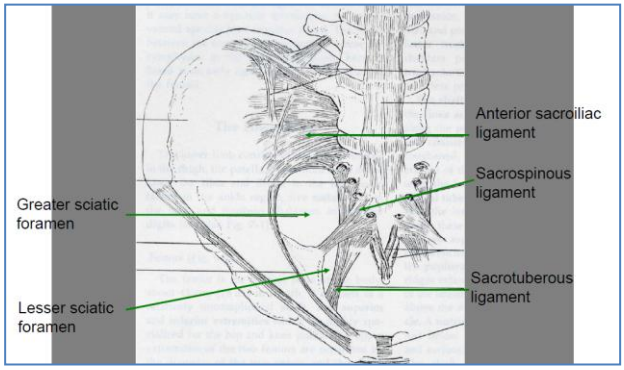


- **Patella**
  - **Type/Features:**
    - Triangular Sesamoid Bone
    - Enclosed in Quadriceps Tendon
    - Protects Knee Joint Anteriorly
    - Improves Leverage of thigh muscles across the knee.
  - **Landmarks:**
    - Lateral Facet
    - Medial Facet
    - Apex
  - **Articulations:**
    - Femur – 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
        - Fibula – Fibular Facet (proximally)
        - Trochlea of Talus Bone of Tarsals of the Foot.
        - Fibula – Fibular Notch (distally)
- **Fibula**
    - **Type/Features:**
        - Slender Long Bone
        - Attached to Tibia by *Tibiofibular Syndemosis* (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.



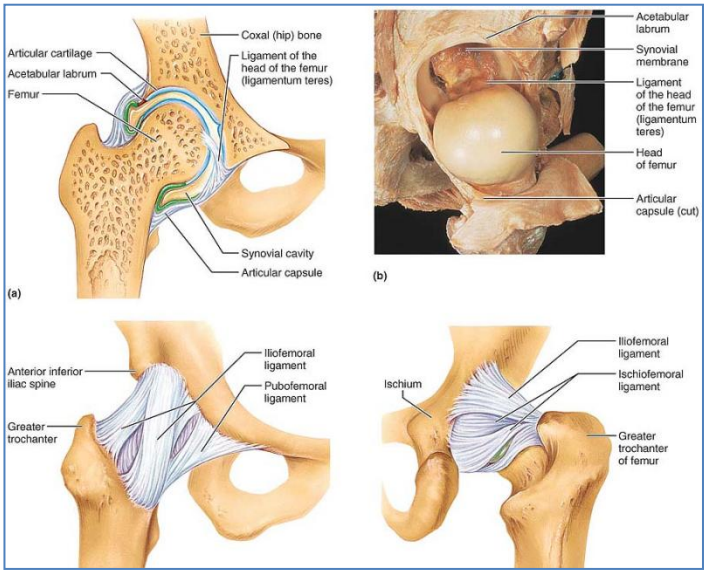
Joints:



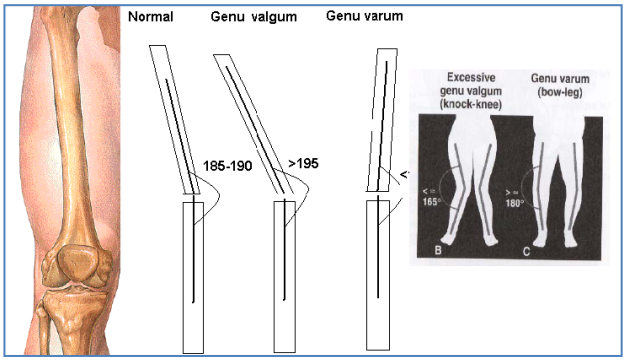
- **Sacro-Iliac:**
  - **Features:**
    - Synovial Planar Joint
    - Loosens during labour.
  - **Bones:**
    - Sacrum
    - Ilium
  - **Ligaments:**
    - Anterior Sacroiliac Ligament
    - Posterior Sacroiliac Ligament
    - Interosseous Sacroiliac Ligament

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

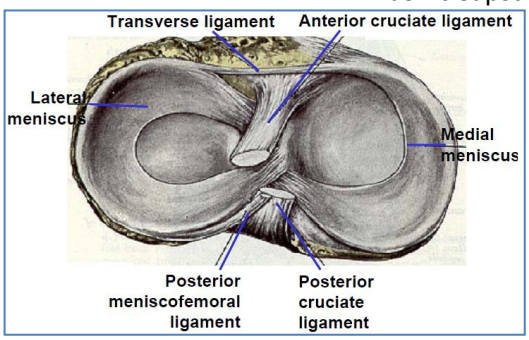
- **Hip Joints:**
  - **Features:**
    - Synovial, MultiAxial Ball & Socket
    - Acetabular Labrum (lip) of fibrocartilage – deepens socket – High Bony Congruency
    - Central fat-filled acetabular fossa.
  - **Bones:**
    - Rounded head of Femur
    - Acetabulum of Innominate Bones.
  - **Ligaments:**
    - **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

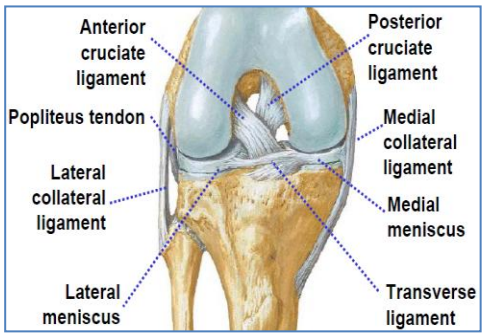


- **Knee Joint:**
  - **Features of The Knee Joint:**
    - Synovial Modified Bicondylar **Hinge** Joint
    - **Relatively Unstable:**
      - Some Gliding & Rolling
      - Some Rotation
      - Ligaments provide the stability – not Bony Congruity.
    - Poor Bony Congruity
    - **2 Parts:**
      - **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.



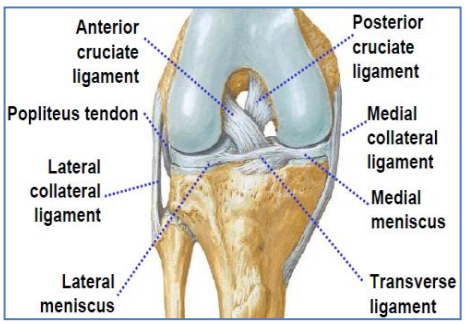
    - **Menisci:**
      - Fibrocartilage on Tibial Plateaus
      - Deepens the socket – increases congruity
      - Shock absorption
      - Peripheral Aspects are Vasculated – Central Aspects aren't → heal very slowly
      - **Lateral:**
        - More freely movable than Medial Meniscus due to attachments
        - **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



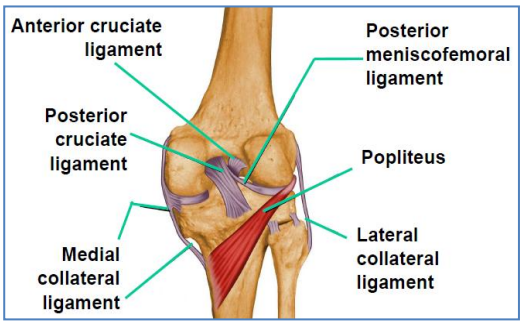


  - **Bones:**
    - Femur
    - Patella
    - Tibia

- **Ligaments:**
  - Fibrous Capsule
    - Thick on Medial & Lateral aspects
    - 'Sleeve' around joint.
  - Extracapsular:
    - Patellar Ligament – Very Stong
    - 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)

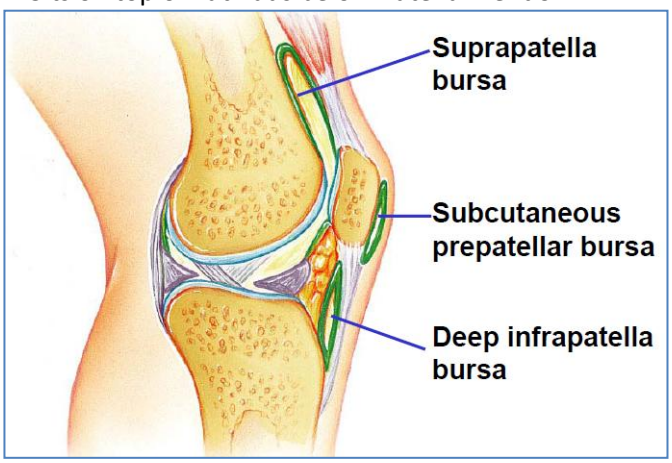


Anterior



Posterior

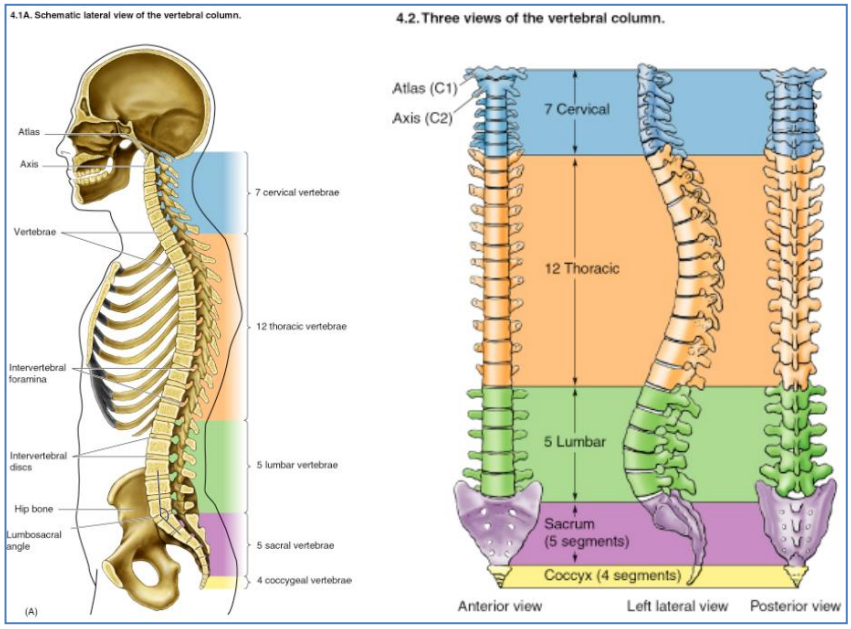
- **Bursae:**
  - **SupraPatella Bursa**
    - Continuous with Snyovial Joint Cavity
    - Sits underneath Quads Tendon
  - **Subcutaneous PrePatellar Bursa**
    - Anterior to Patella
    - For kneeling
  - **Deep Infrapatella Bursa**
    - Sits on top of Fat Pads below Patellar Tendon



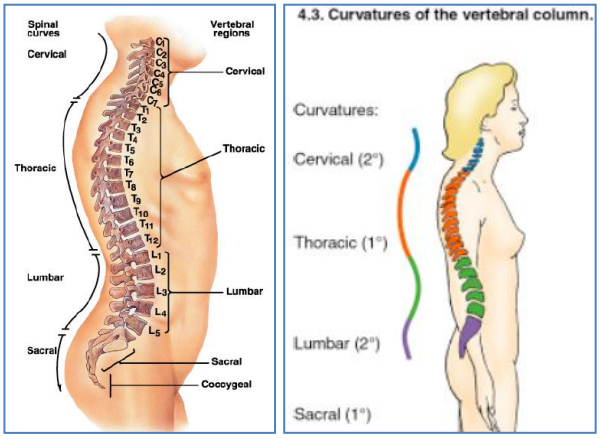
The Axial Skeleton

Bones:

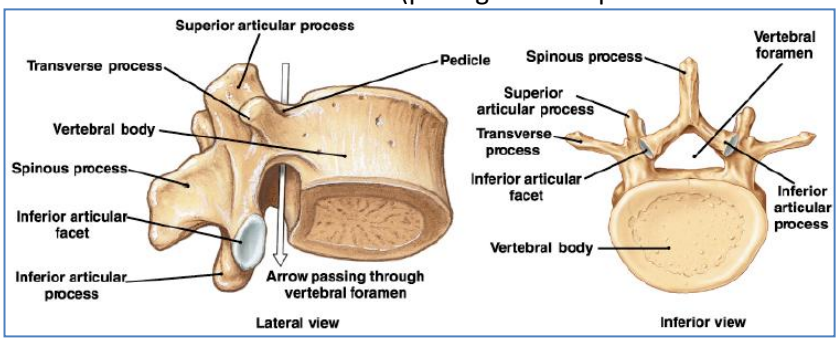
- **Vertebral Column:**
  - **General Info:**
    - 33 Vertebrae
    - 5 Regions:
      - 7x Cervical
      - 12x Thoracic
      - 5x Lumbar
      - 5x Sacral (fused by adulthood)
      - 4x Coccygeal
    - Bones increase in size towards the bottom. (due to increased load/weight)
    - Protects Spinal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



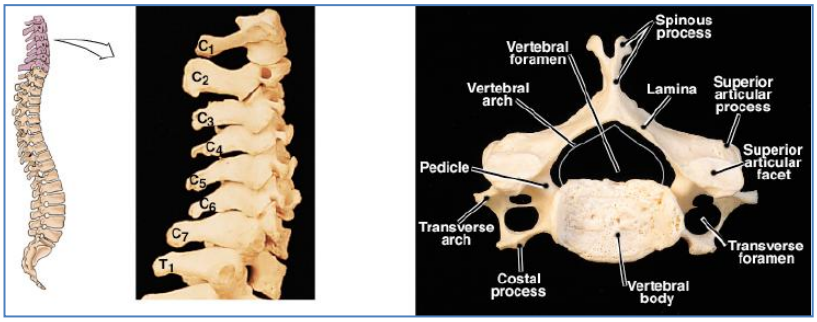
  - **Curvatures:**
    - **2x Primary:** (Concave Anteriorly)
      - Ie. Thoracic
      - & Sacral
    - **2x Secondary** (Concave Posteriorly)
      - Ie. Cervical
      - & Lumbar
    - **Abnormalities:**
      - **Kyphosis:** Excess 1^0 curvature
      - **Lordosis:** Excess 2^0 curvature
      - **Scoliosis:** Lateral Deviation



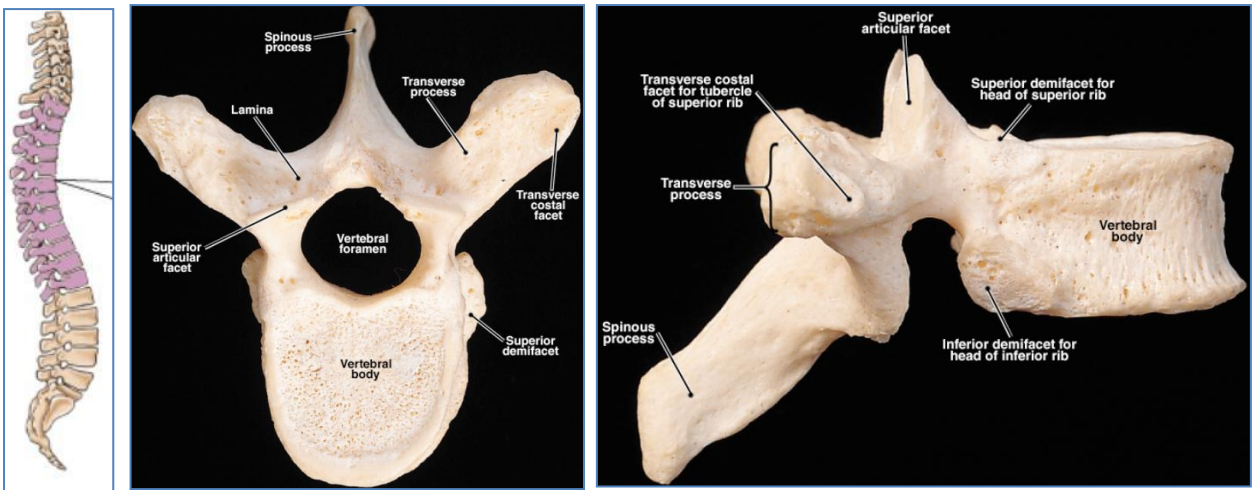
- **Typical Vertebrae:**
    - Body
    - Vertebral Arch
    - Vertebral Foramen (canal)
    - Transverse Processes
    - Spinous Processes
    - Articular Processes
        - Superior
        - Inferior
    - Intervertebral Foramen (passage of the spinal nerve root between vertebrae)



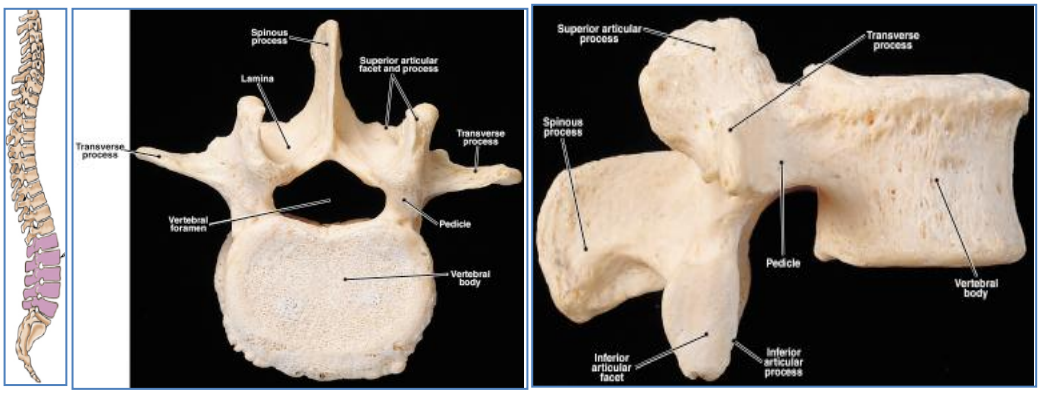
- **7x Cervical:** Distinguishing Features:
    - Small Body
    - Very Large Vertebral Foramen
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries
    - Dual Spinous Processes



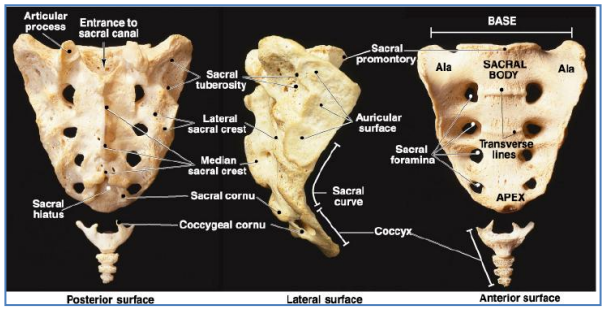
- **12x Thoracic:** Distinguishing Features:
    - Medium Sized Body
    - Thick Lamina
    - Single Spinous Process
    - Costal Facet on Transverse Processes & Body – for Ribs



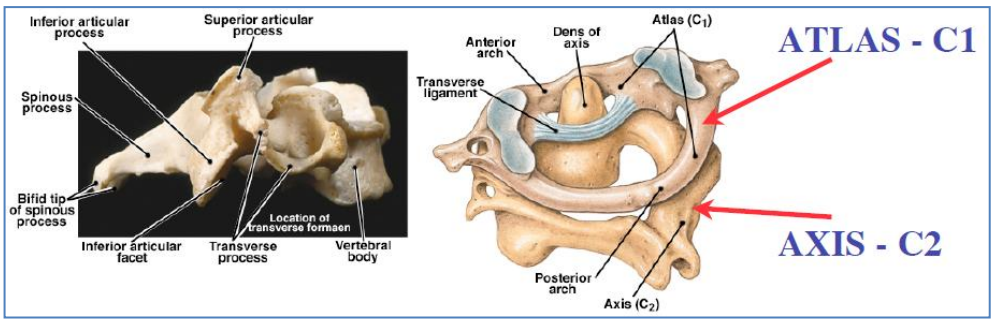
- **5x Lumbar:** Distinguishing Features:
  - Very Large Body
  - Smaller Vertebral Foramen
  - No Costal Facets
  - Chode-like Spinous Processes



- **5x Sacrum:** Distinguishing Features:
  - Obvious
  - Don't bother with landmarks of this
- **4x Coccyx:** Distinguishing Features:
  - Obvious
  - Don't bother with landmarks of this



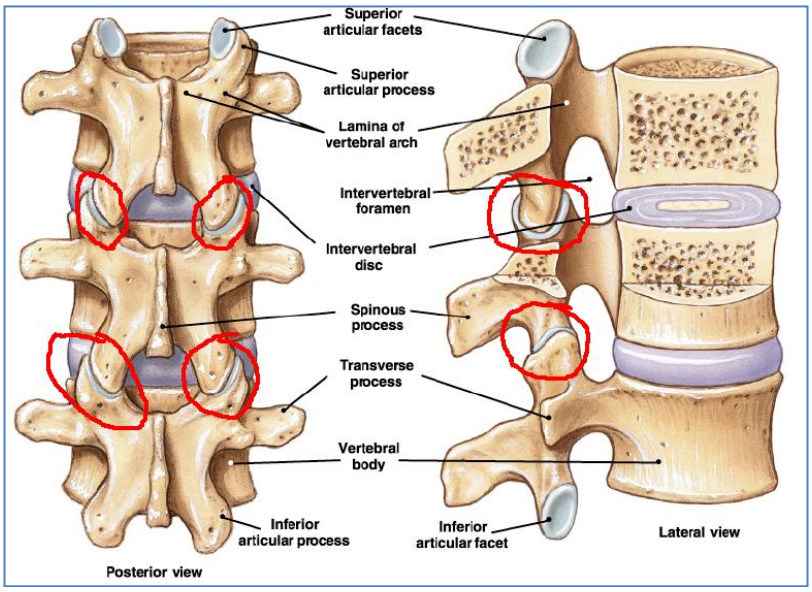
- **<u>Special "Atypical" Vertebrae:</u>**
  - **C1 - Atlas:**
    - No Body
    - Just a ring of bone
      - Anterior Arch
      - Posterior Arch
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries
    - Transverse Ligament – for Dons of Axis
    - Skull Sits on top of this bone
  - **C2 - Axis:**
    - Small body with a protuberance: The "Dens of Axis"
    - Wide Lamina & Vertebral Foramen
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries



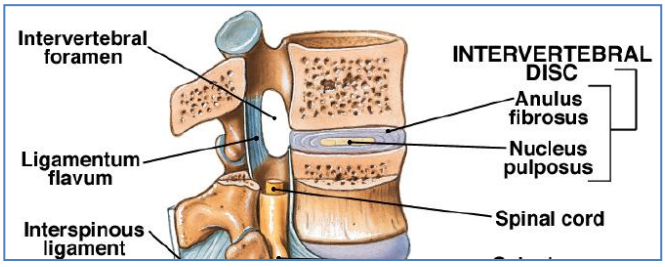
- **Joints:**
  - **Atlanto-Occipital Joint:**
    - Synovial Egg & Spoon Joint
    - Between the Skull & The Atlas
    - Allows you to nod (the 'yes' joint)

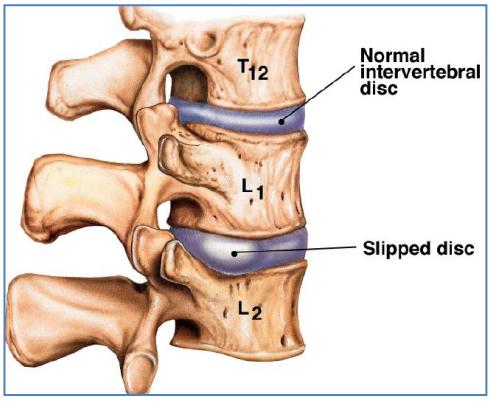
  - **Atlanto-Axial Joint:**
    - 2 Parts:
      - Synovial Pivot –
        - Dens of Axis & Transverse Ligament of Atlas
      - Synovial Planar –
        - Superior Articular Surface of Axis & Inferior Articular Surface of Atlas.
    - Allows the head to turn (the 'no' joint)

  - **Zygopophyseal (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.

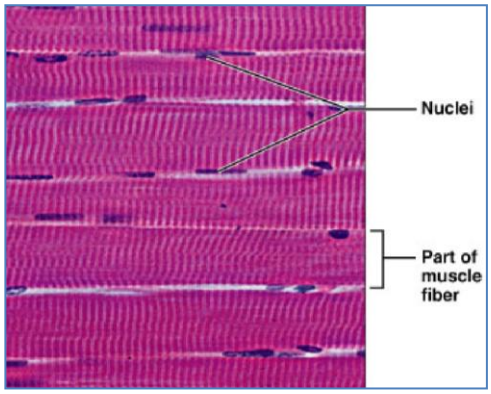




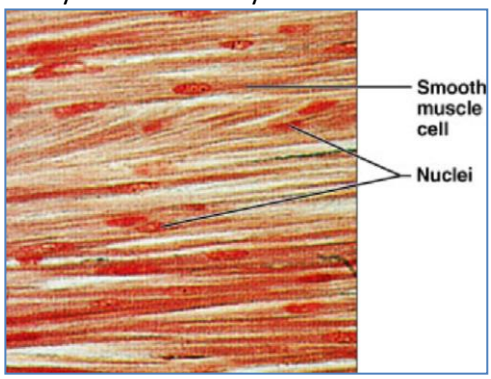
A&P
Muscle Anatomy & Physiology

Muscle Tissue:

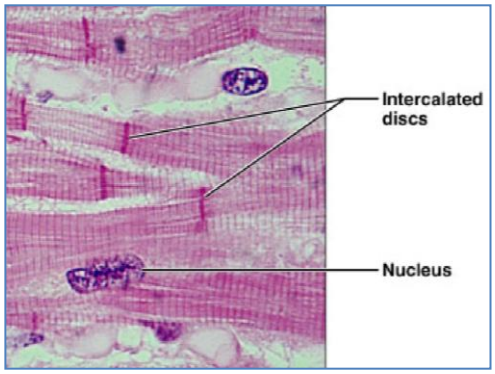
- **3 Types**
  - **Skeletal**
    - Attaches to bone for movement (voluntary)
    - Long, Cylindrical
    - Multinucleated
    - Obvious striations →sarcomeres.



  - **Smooth**
    - 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

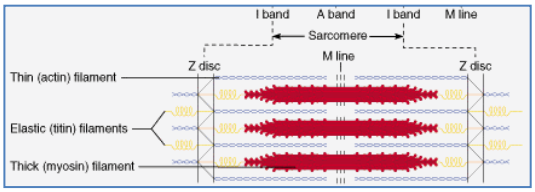


  - **Cardiac**
    - Makes up the heart.
    - Long, **Branched**, Cylindrical
    - Striations → sarcomeres
    - Usually single-nucleated
    - Intercalated discs – cell membranes of 2 adjacent cells bound mechanically (desmosomes), chemically & electrically (gap junctions). Essentially makes the entire heart one single muscle.
    - Involuntary – controlled by autonomic nervous system

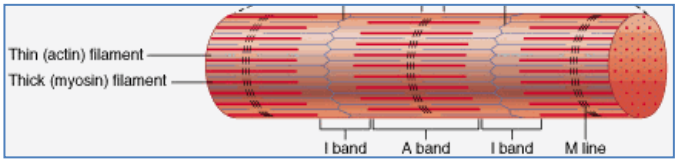


Revision of Skeletal Muscle Structure:

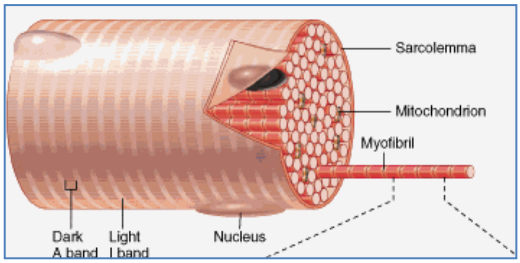
- **Myofilaments**
  - Contractile *Proteins*:
    - **Actin** (Thin)
    - **Myosin** (Thick)
  - **Z-Disc** – anchors sarcomeres together.
    - Ensures whole cell contraction.

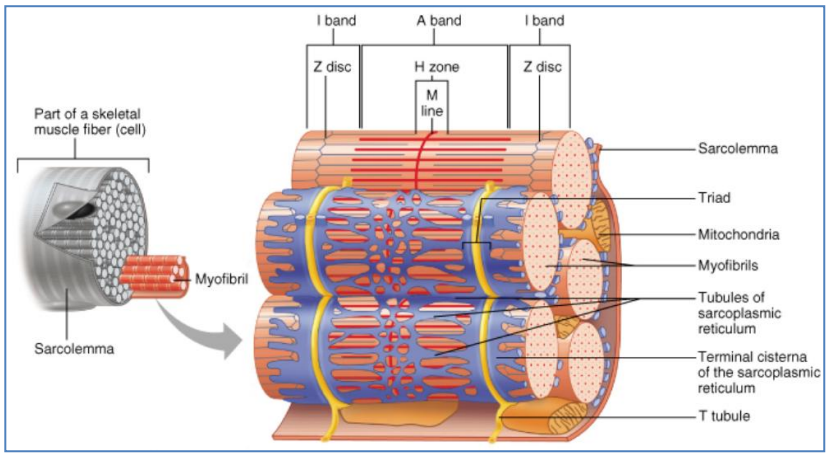


- **Myofibrils**
  - Contractile *Organelles*:
  - **Sarcomeres** →striped appearance
    - Z-Disc → Z-Disc
    - Mid I-Band → Mid I-Band

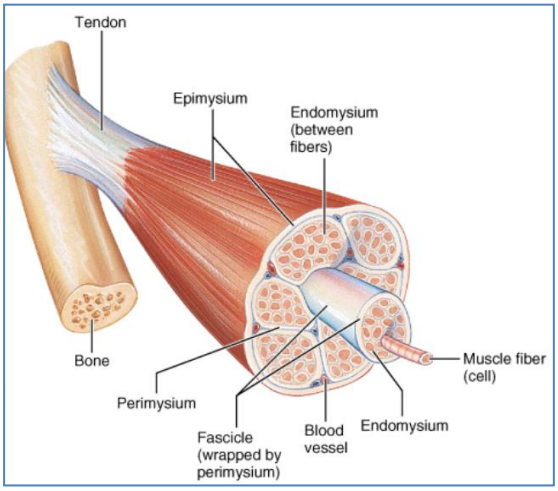


- **Muscle Fibres (cells)**
  - Contractile *Cells*
  - **Sarcolemma** (plasma membrane)
    - **Transverse ('T') Tubules**
      - Perpendicular Invaginations of the sarcolemma (PM)
      - Runs between paired terminal cisterna of Sarcoplasmic Reticulum
      - Conducts impulses from sarcolemma deep 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
- **Endomysium**
  - Connective Tissue
  - Wraps single muscle fibres (cells)



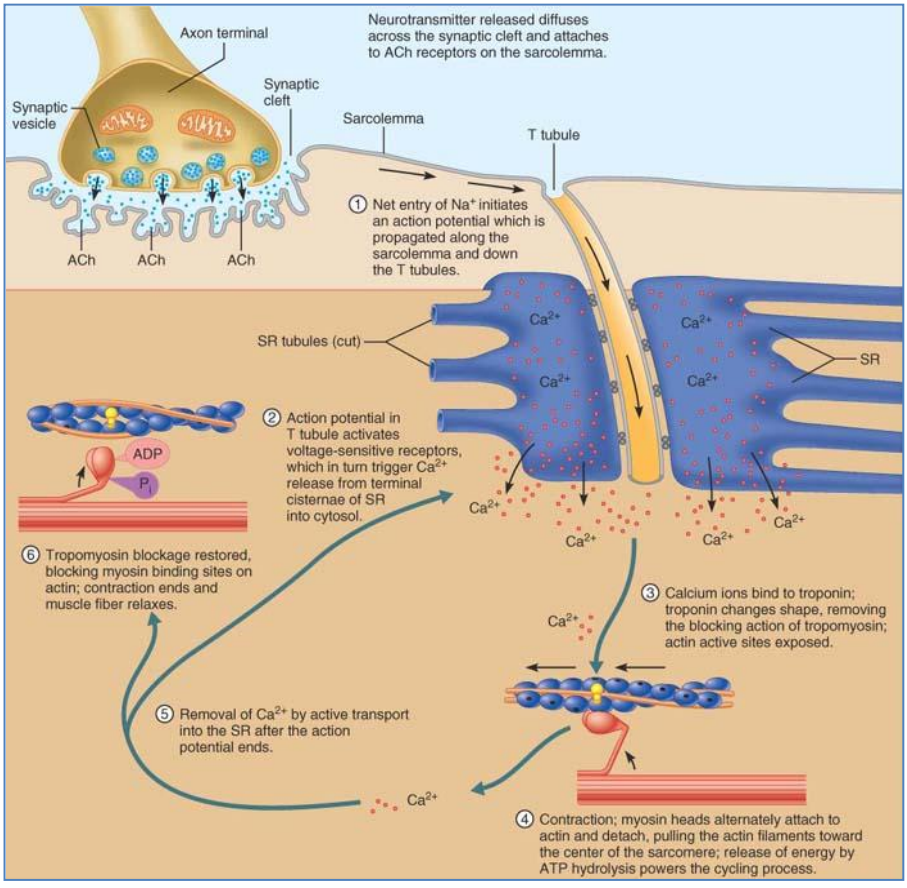


- **Muscle Fascicles**
  - Bundles of muscle fibres (cells)
- **Perimysium**
  - Connective Tissue
  - Wraps Fascicles
- **Single Muscle**
  - Muscle as a whole – eg. The bicep.
- **Epimysium**
  - Connective Tissue
  - Wraps whole muscle.
- **Tendons**
  - A fusing together of all connective tissue layers.
  - Connects muscle to bone



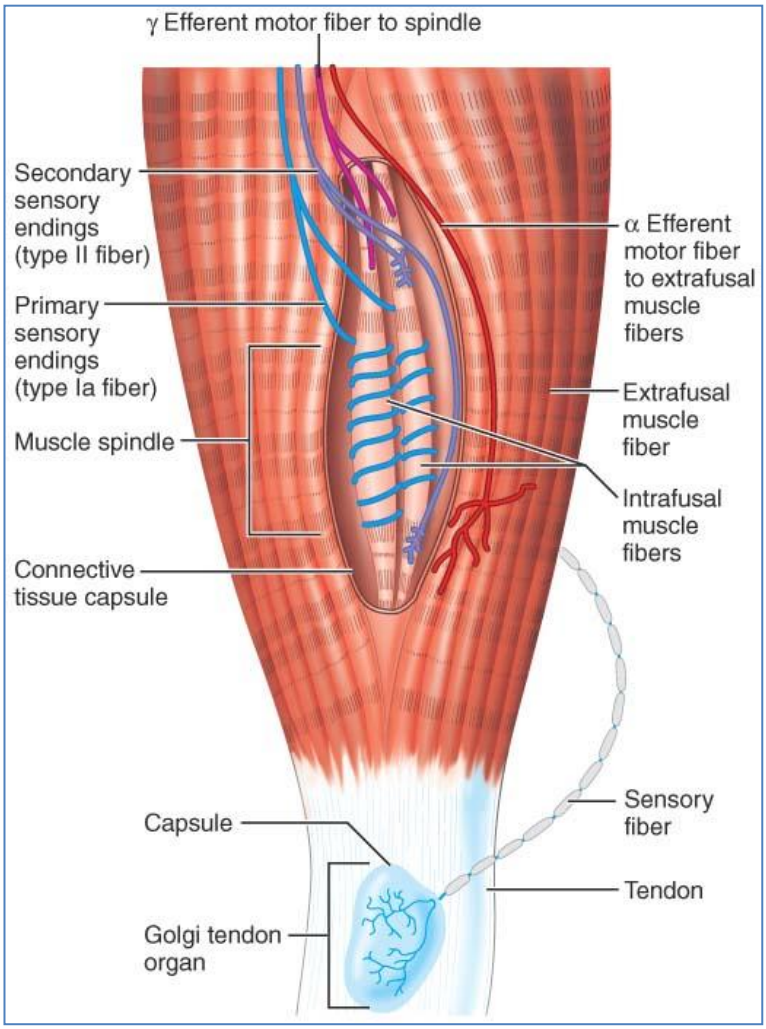
<u>Events @ Neuromuscular Junction:</u>

- Each axon results in several neuromuscular junctions with single muscle fibres.
- **Events:**
  - **Nerve impulse** reaches axon terminal
  - Voltage-gated **Ca channels open**.
  - **Ca** diffuses **into axon terminal**
  - Causes **vesicles of ACh** to be **exocytosed** into synaptic cleft.
  - **ACh binds to receptors** on sarcolemma
  - Initiates **action potential** along **muscle** cell **membrane**.
  - **ACh** is swiftly **broken down** by **ACh-esterase** →allows quick successive stimuli.
  - **Action potential** propagates **along sarcolemma** & **down T-Tubules**.
  - Action potential causes **terminal cisternae** to **release Ca^+** into the sarcoplasm.
  - **Ca^+ binds** to **troponin** → **removes tropomyosin**.
  - **Myosin heads attach** & pull **thin filaments** towards centre of sarcomere.
  - **Ca^+** actively **reabsorbed** by Sarcoplasmic Reticulum
  - **Troponin-Tropomyosin** Complex is **re-established**
  - **Cross-Bridging ceases**



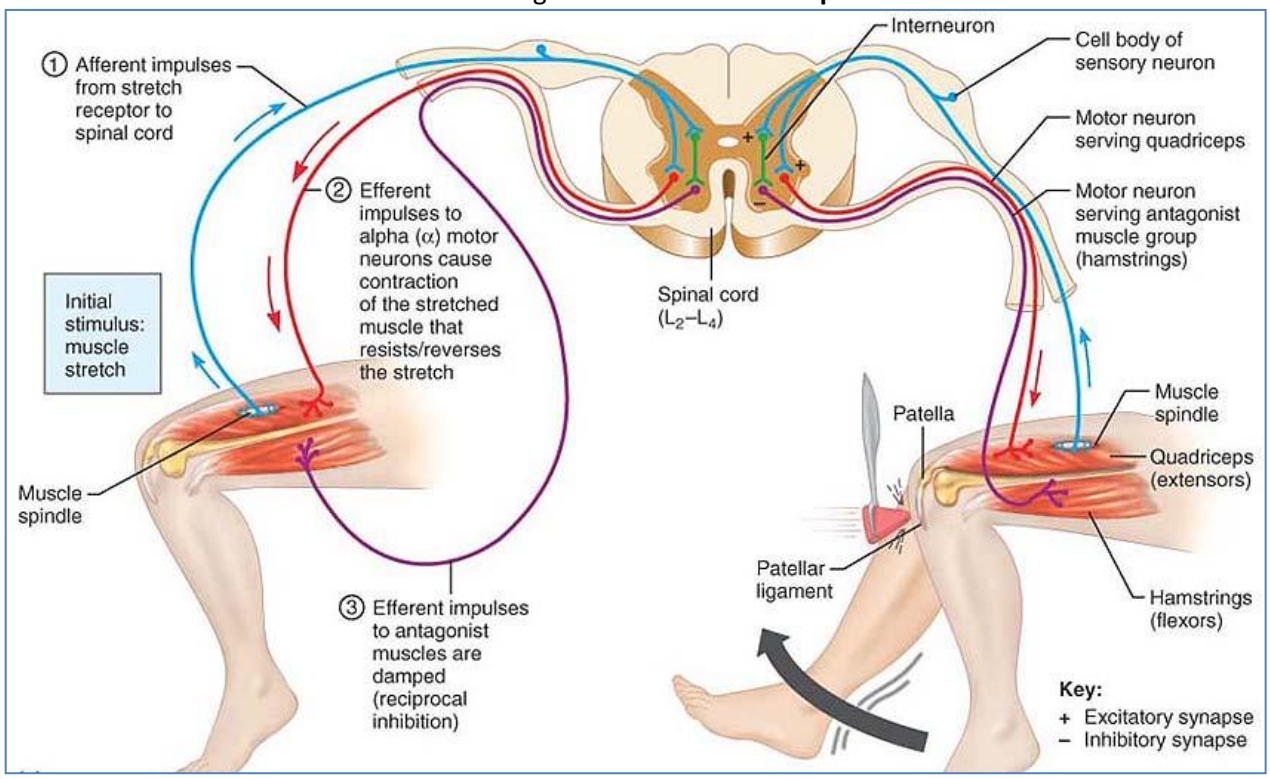
Muscle Sensory Feedback

- Muscles need to 'know what they are doing'
  - **Tension**...and....
  - **Length** of the muscle.
- **How? – Through "Proprioception"** (via proprioceptors)
  - Awareness of body positioning in space.
  - Mediated by Cerebral Cortex & Cerebellum
- **Proprioceptors:** (Muscle Spindles & Golgi Tendon Organs)

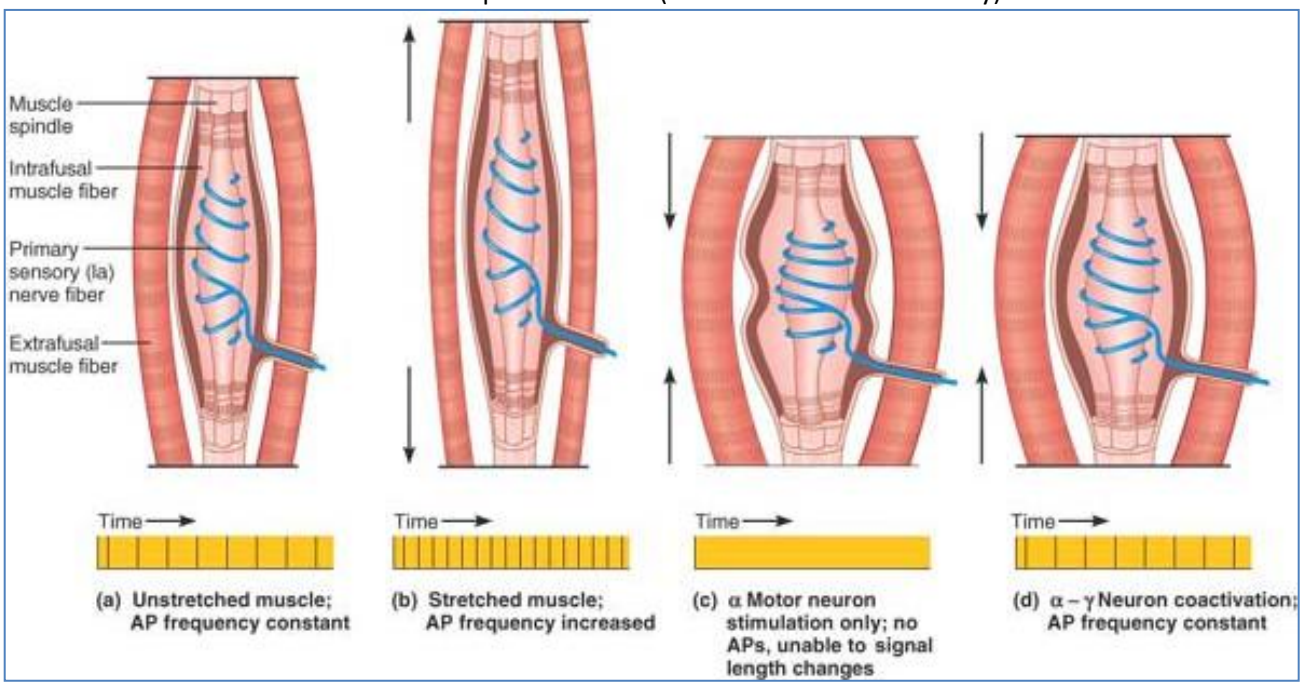


  - **Muscle Spindles:**
    - Encapsulated Proprio-Mechano-Receptors
    - Located inside muscle amongst normal (extrafusal) muscle fibres.
    - **Intrafusal Muscle Fibres** ("inside spindle")
      - **Receptive Central Region:**
        - Receptive
        - Non-contractile →Lack myofilaments
        - Wrapped by **primary** afferent endings of large **type Ia** sensory fibres:
          - Monitor **rate** & degree of **stretch**.
      - **Receptive Spindle Ends:**
        - Receptive
        - Wrapped by **secondary** afferent endings of small **type II** sensory fibres:
          - Monitor degree of **stretch** only.
      - **Distal Contractile Spindle Ends:**
        - Contractile →Contain myofilaments
        - Innervated by **gamma (γ) efferent fibres** – originate in ventral horn.
        - Maintain **spindle sensitivity.**

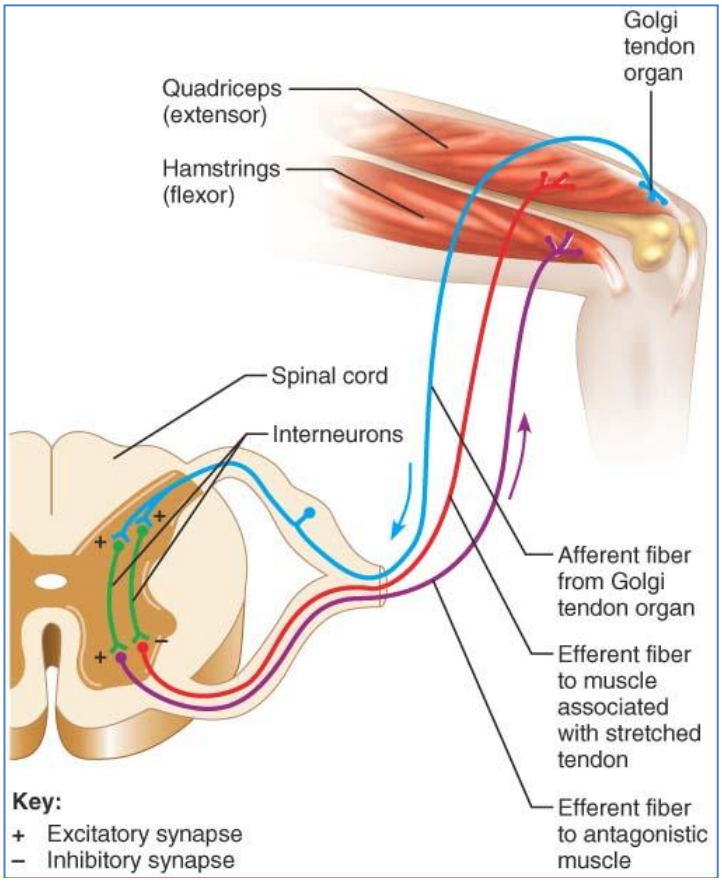
- **The Stretch Reflex:**
  1. Spindle activated by stretch
  2. Types Ia & II sensory fibres transmit impulses to spinal cord.
  3. Sensory fibres synapse with **α-Motor-Neurons** in spinal cord
  4. Transmits action potential to muscle
  5. Contracts extrafusal fibres of the stretched muscle
  6. Prevents further stretching of muscle
  7. Also inhibits antagonistic muscles → **Reciprocal Inhibition**



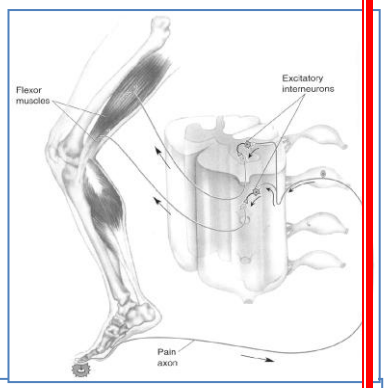
- **Adjusting Muscle Spindle Sensitivity:**
  - Muscle spindles require a certain tension to work properly.
  - If intrafusal fibres didn't contract with the extrafusal fibres during muscle contraction, the spindles would go slack & cease generating action potentials.
  - **α-γ Coactivation** prevents this by sending voluntary contractile action potentials to the intrafusal fibres as well as the extrafusal fibres.
  - Maintains spindle tension (and therefore its sensitivity)



- **Golgi Tendon Organs:**
  - Encapsulated Proprio-Mechano-Receptors
  - Innervated by **type Ib afferent fibres**
  - In tendons connecting to bone
  - Monitor muscle *tension*
  - Inhibits contraction of muscle when tension is too great - **Golgi Tendon Reflex:**
    - When tension reaches a threshold, Golgi tendon organs are activated.
    - Afferent impulses transmitted to spinal cord
    - Contracting muscle is relaxed + Antagonist muscle is contracted.



- **Cerebral Cortex & Cerebellum**
  - Integrates Afferent Input
  - Fine-tunes motor outputs
  - Subconscious level

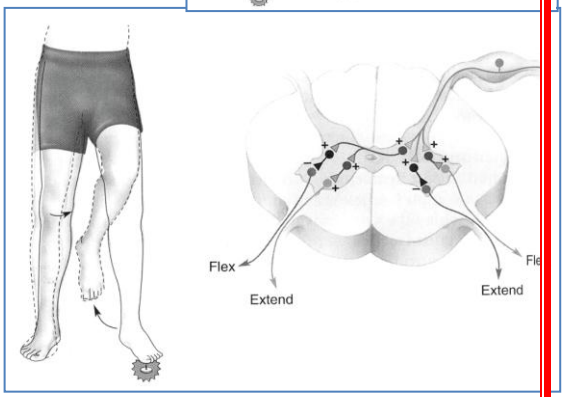


Flexor Reflex:

- Painful cutaneous stimuli of the limbs causes withdrawal from the stimulus.
- Polysynaptic – contracts & relaxes multiple different muscles.

Crossed Extensor Reflex:

- Painful cutaneous stimuli of a limb causes withdrawal of that limb and extension of the opposite limb.
- Information crosses over to opposite side of spinal cord → excites extensor muscles of opposite limb.

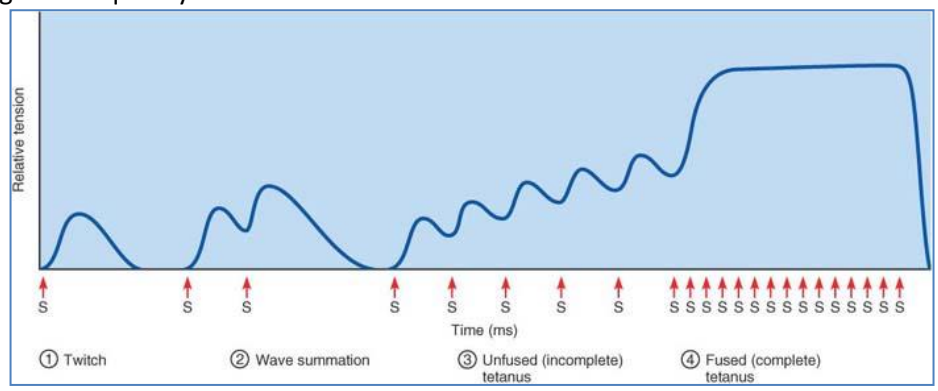


Muscle Tone:

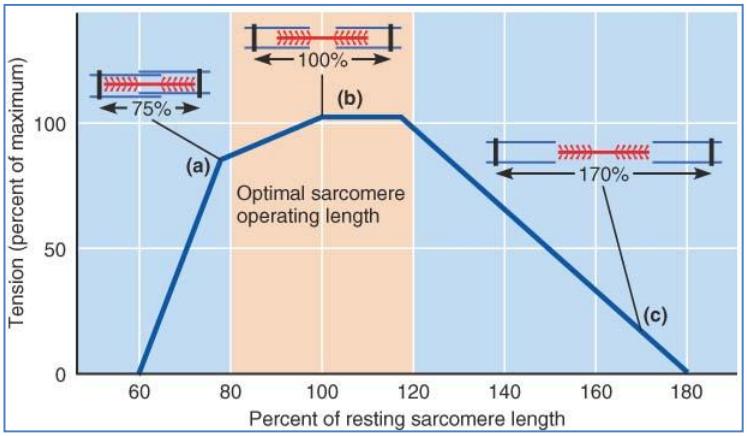
- Sustained partial contraction exhibited in 'relaxed' muscles.
  - In response to stretch receptors
- Keeps muscle poised & ready
- Keeps muscle healthy
- Maintains posture and stabilises joints.

Determinants of Contractile Force:

- **Number of Muscle Fibres Stimulated:**
  - The more motor units recruited, the greater the force.
  - The more muscle fibres recruited, the greater the force.
- **Size of Muscle Fibres Stimulated:**
  - Proportional to *cross-sectional area*
  - The larger the entire muscle→greater the force
  - The larger the muscle fibre →greater the force.
  - Muscle building causes *hypertrophy* of muscle fibres (cells).
- **Frequency of Stimulation:**
  - Wave summation of twitches
  - Cytosolic Ca^{2+} rises – contractile force increases
  - Highest frequency: **Tetanus.**

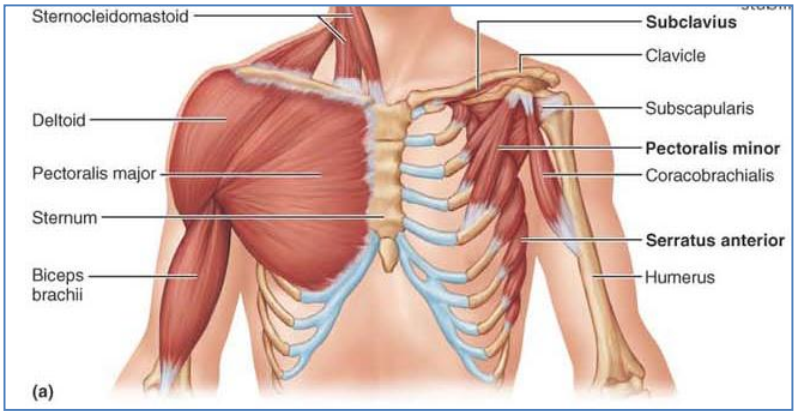


- **Degree of Muscle Stretch:**
  - Optimal: when all myosin heads can form cross-bridges.

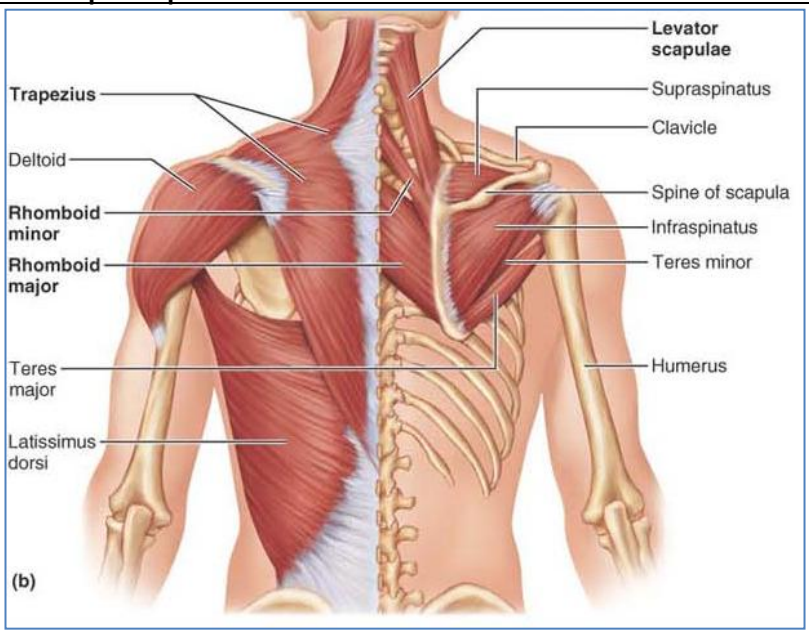


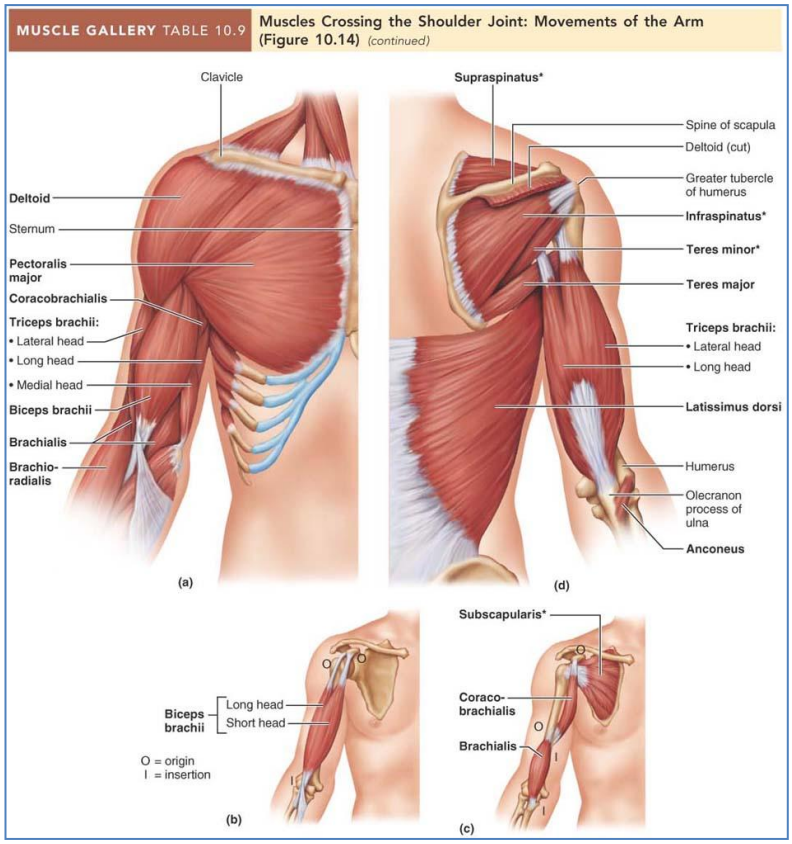
- **Muscle Fibre Type:**
  - **White:**
    - Anaerobic
    - Larger cross-sectional area
    - Higher force generators
  - **Red**
    - Aerobic
    - Many mitochondria
    - Less force generated

Anterior View: Deep & Superficial Muscles of The Pectoral Girdle & The Glenohumeral Joint

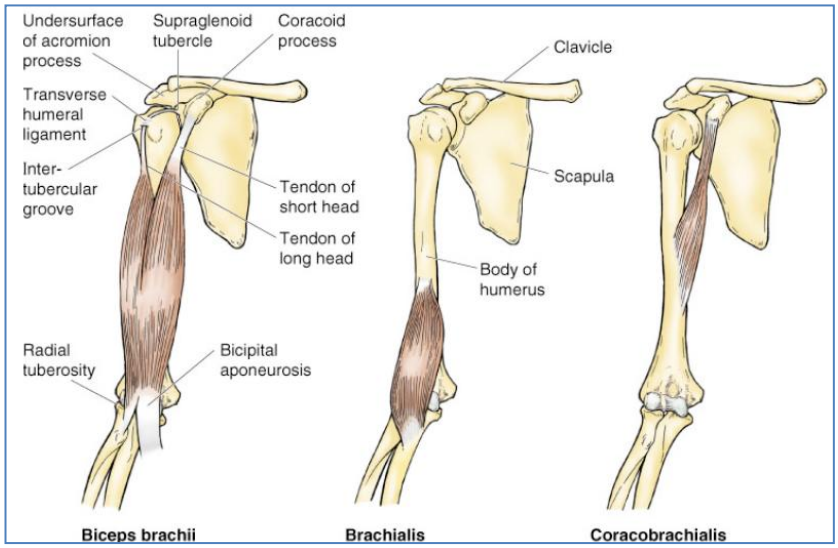


Posterior View: Deep & Superficial Movers of The Pectoral Girdle & The Glenohumeral Joint

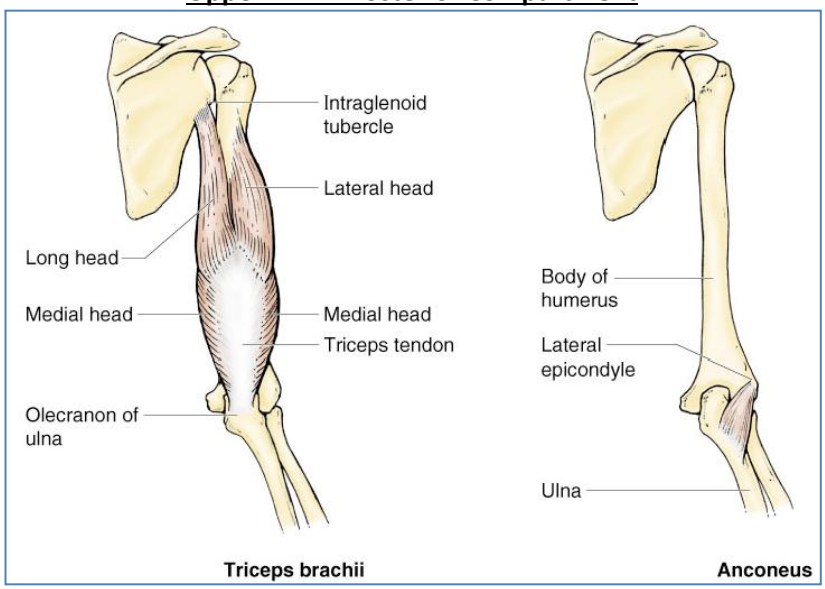


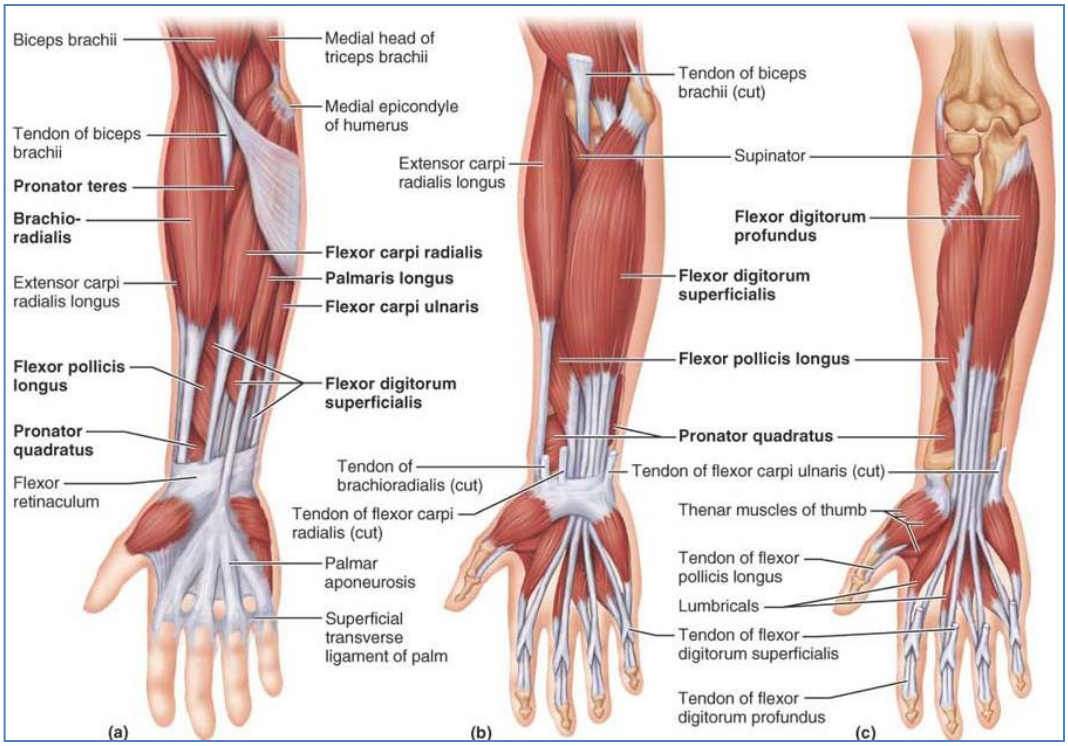


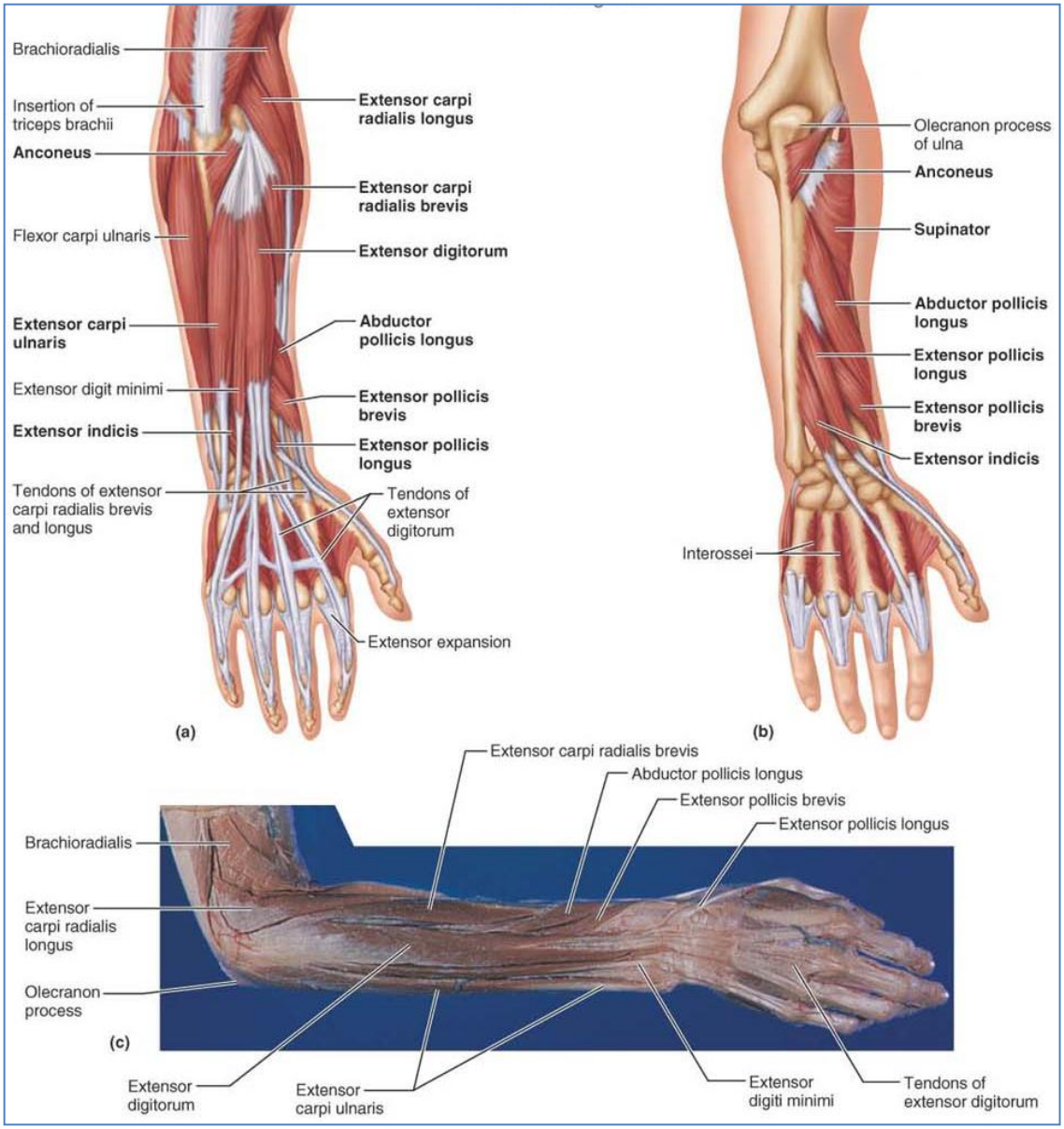
Upper Arm – Anterior Compartment

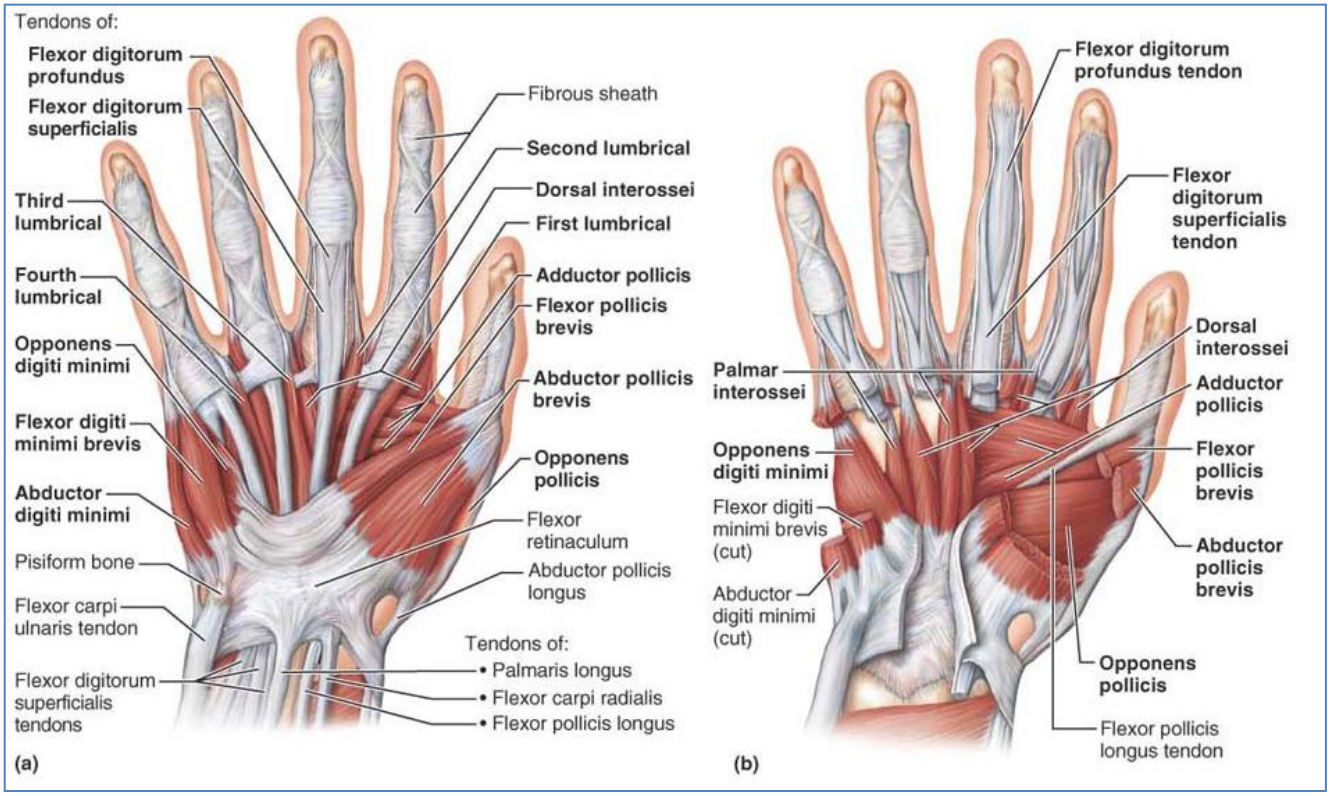


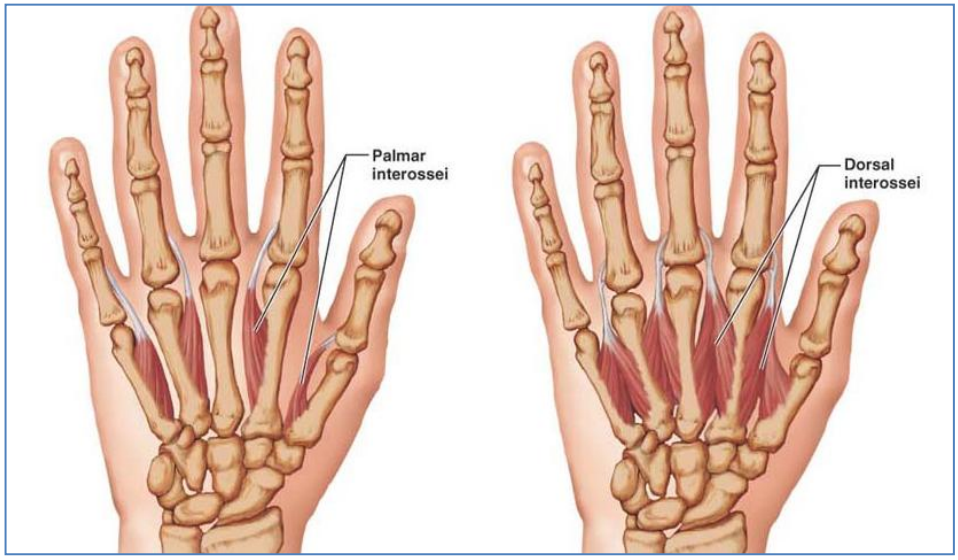
Upper Arm – Posterior Compartment

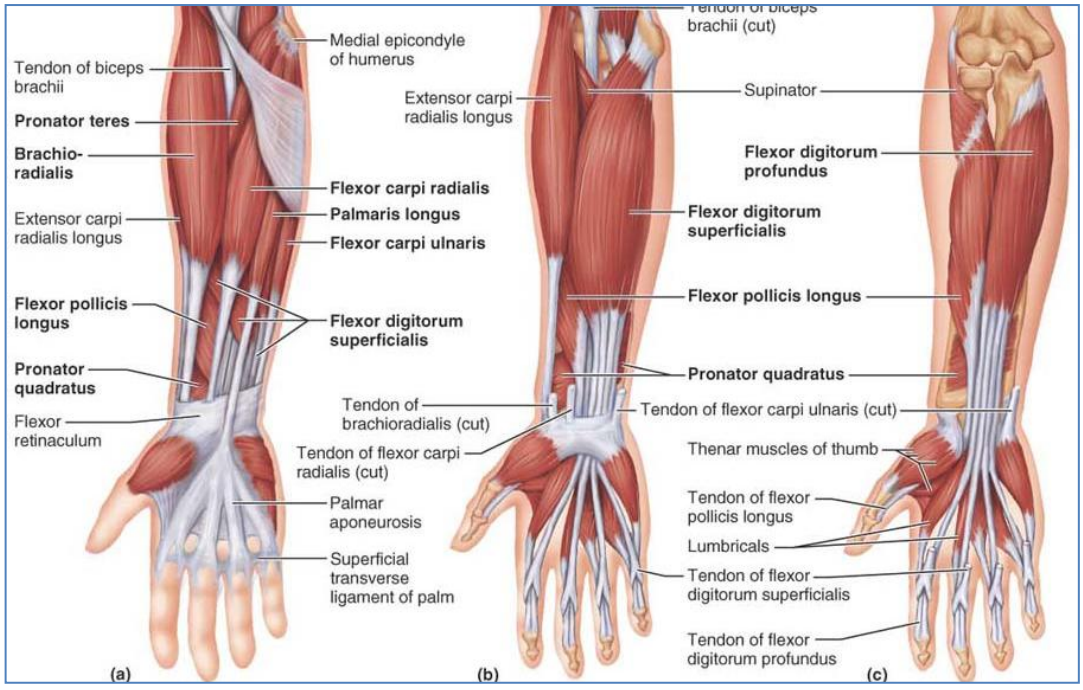


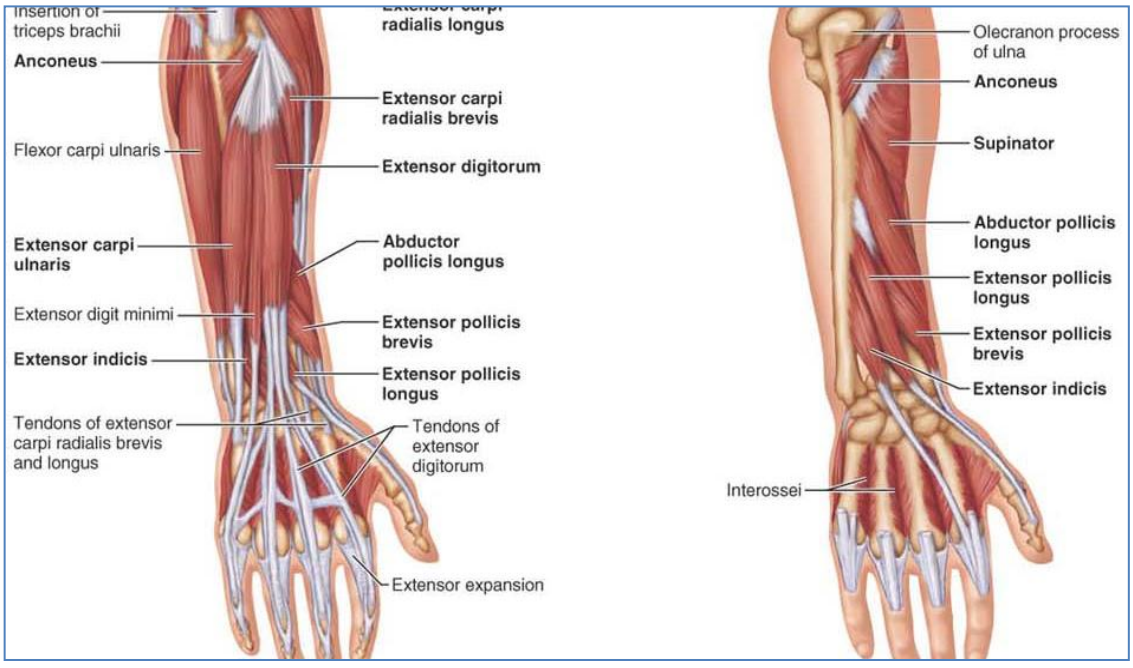




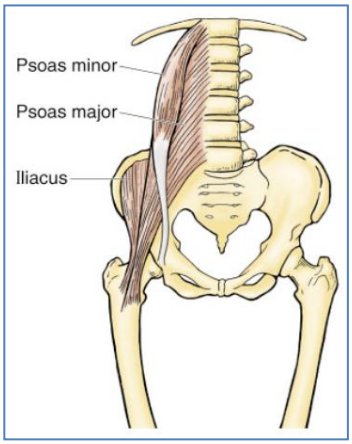






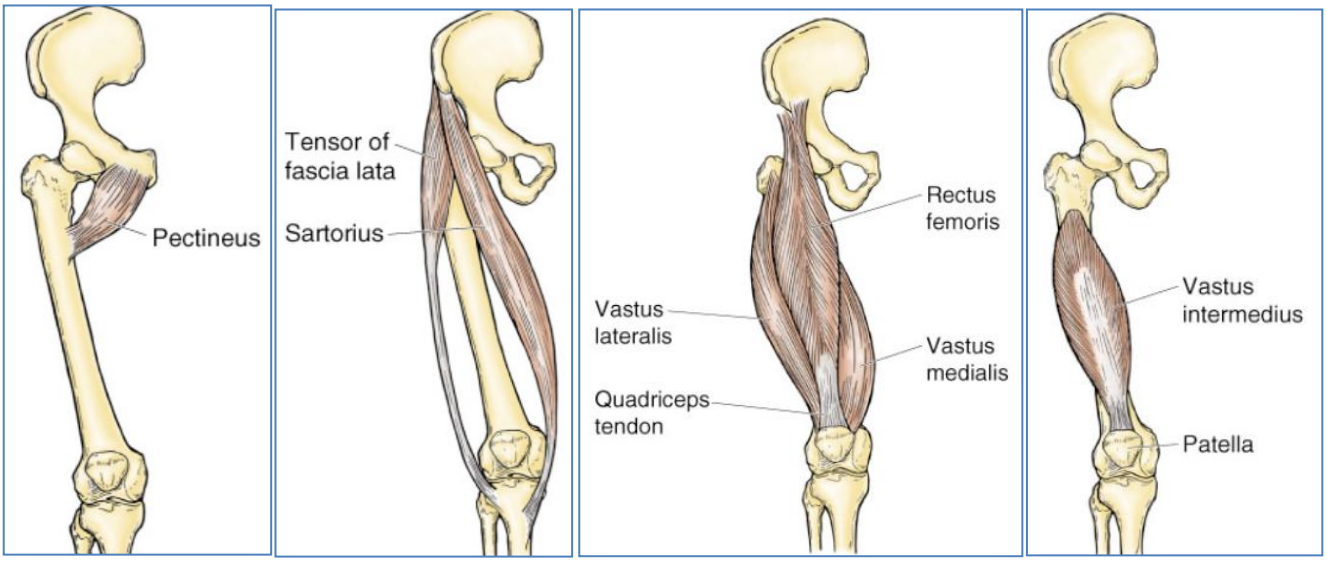


Iliac Region

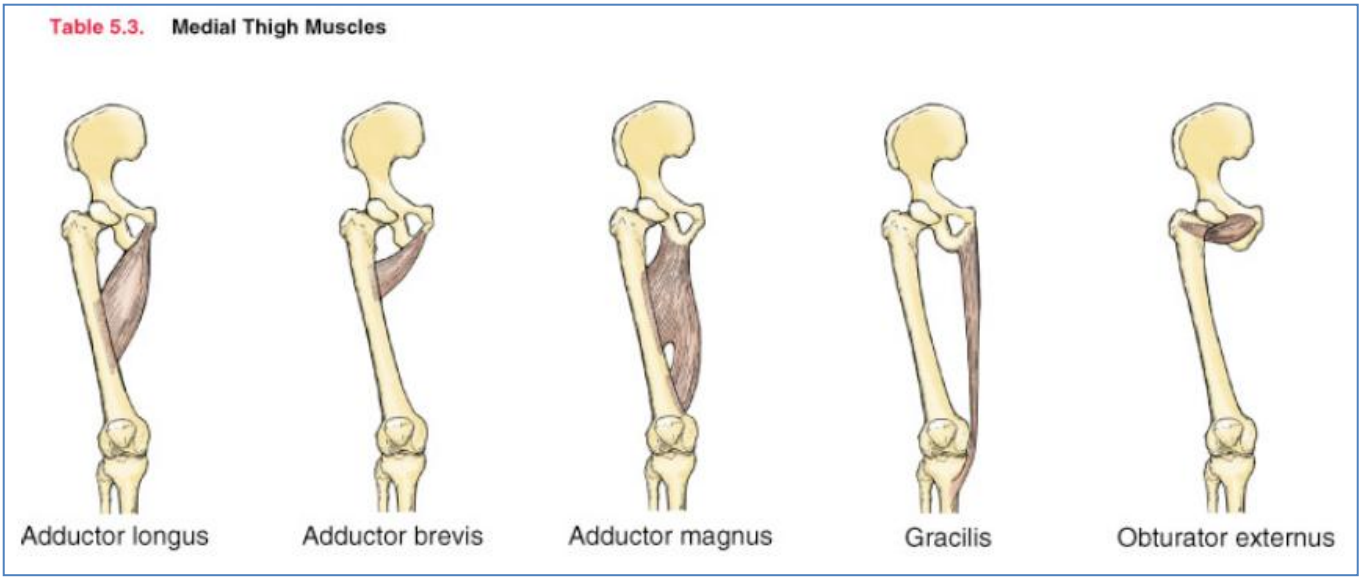


Iliopsoas: Iliacus, Psoas Major, Psoas Minor

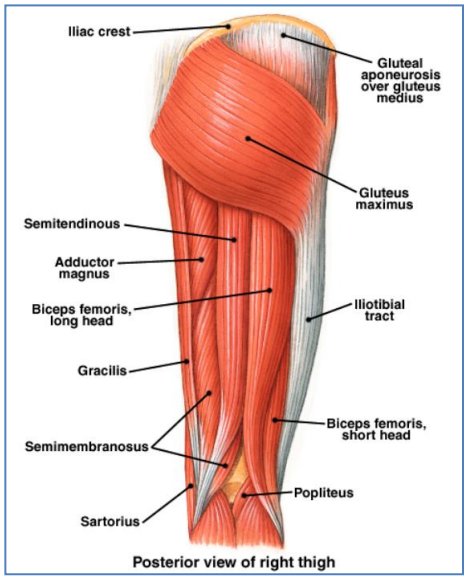
Thigh: Anterior:



Thigh Medial:

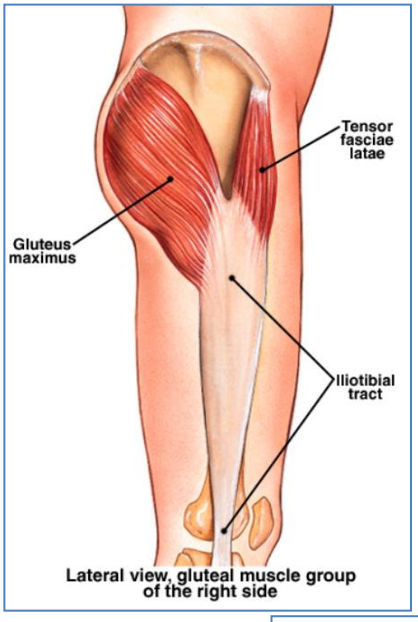


Thigh Posterior:

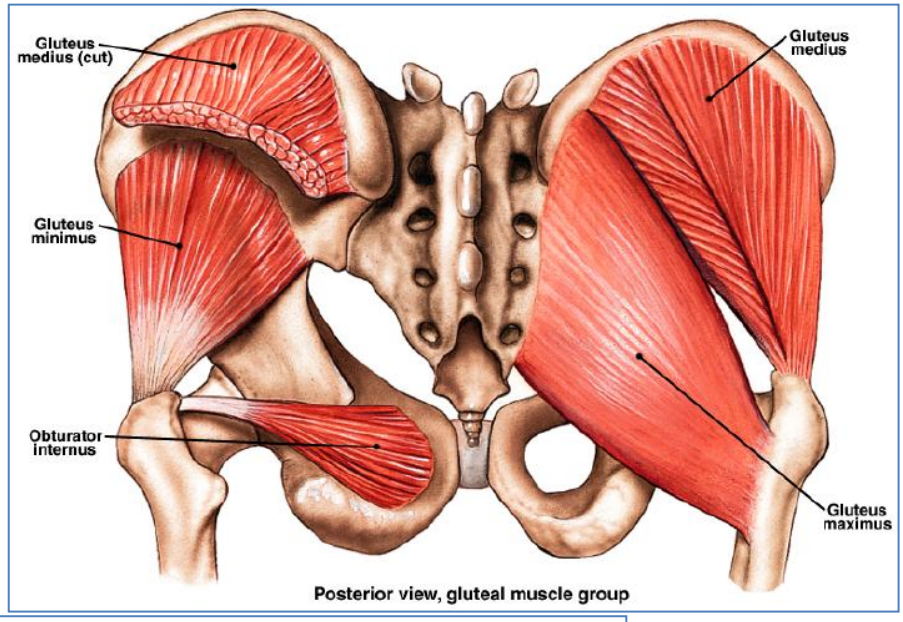


Posterior view of right thigh

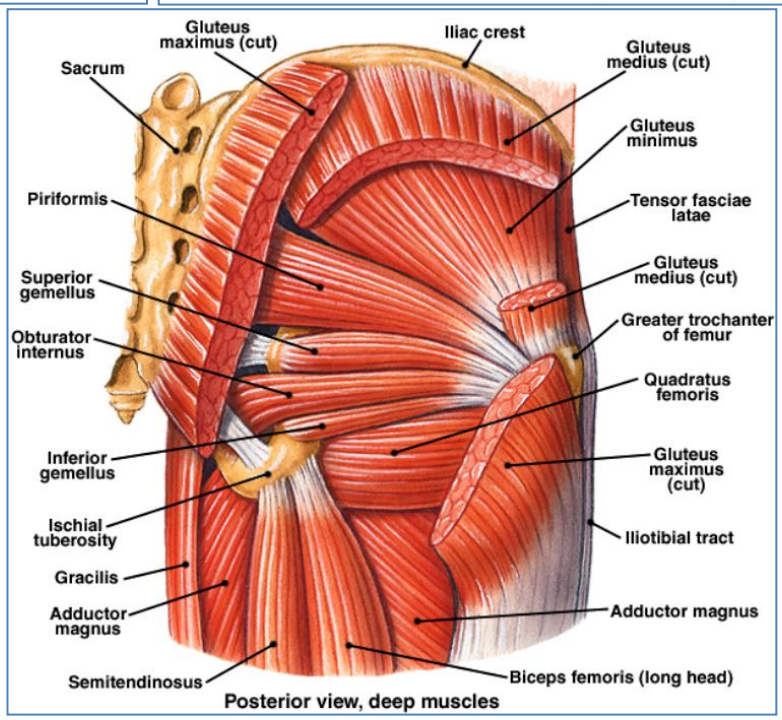
Gluteal Region



Lateral view, gluteal muscle group of the right side



Posterior view, gluteal muscle group



Posterior view, deep muscles

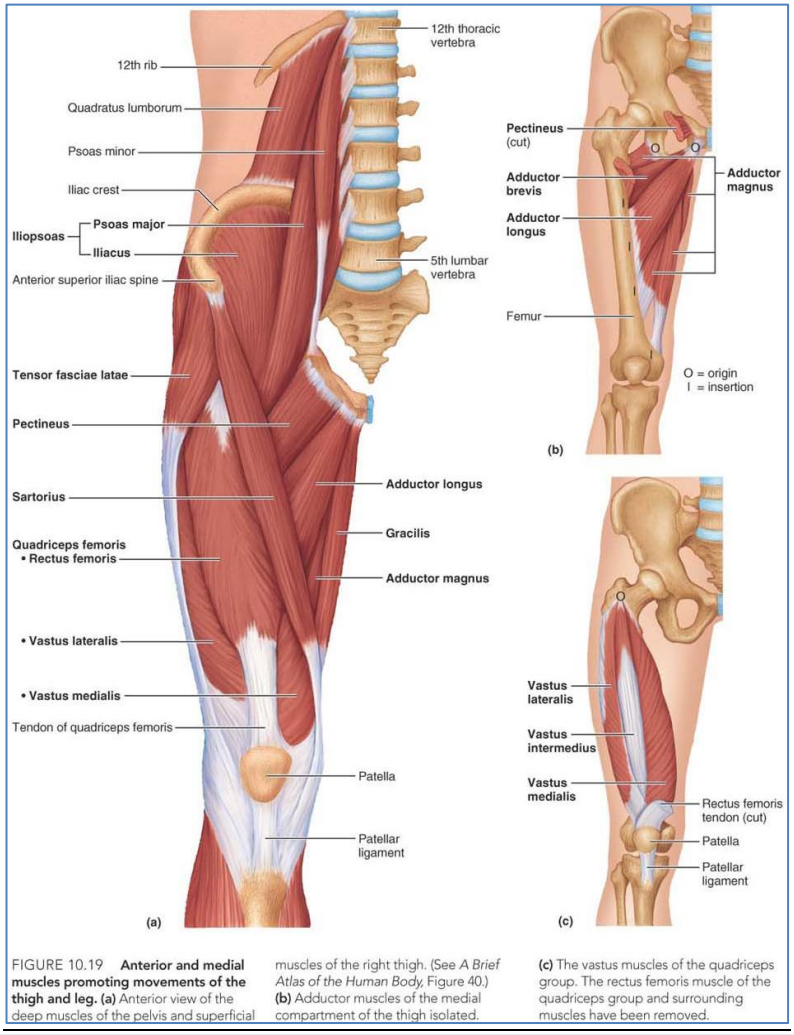


FIGURE 10.19 **Anterior and medial muscles promoting movements of the thigh and leg. (a)** Anterior view of the deep muscles of the pelvis and superficial muscles of the right thigh. (See *A Brief Atlas of the Human Body*, Figure 40.) **(b)** Adductor muscles of the medial compartment of the thigh isolated. **(c)** The vastus muscles of the quadriceps group. The rectus femoris muscle of the quadriceps group and surrounding muscles have been removed.

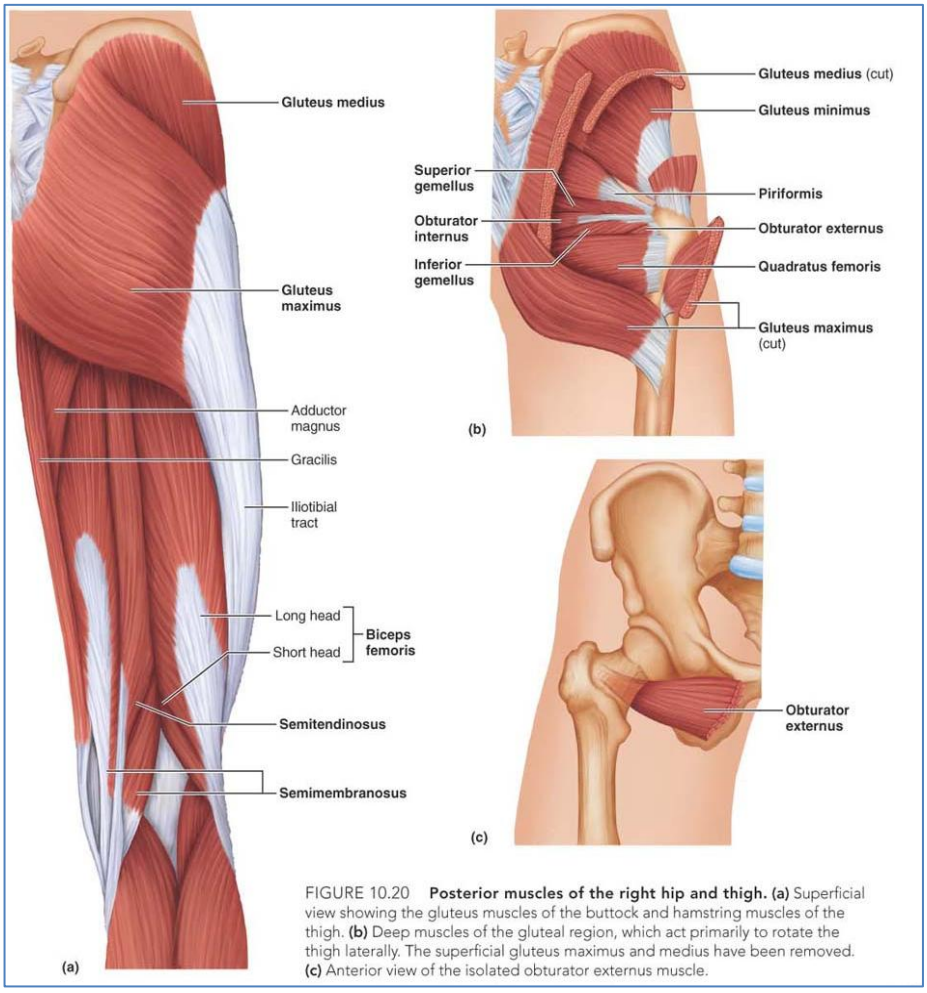
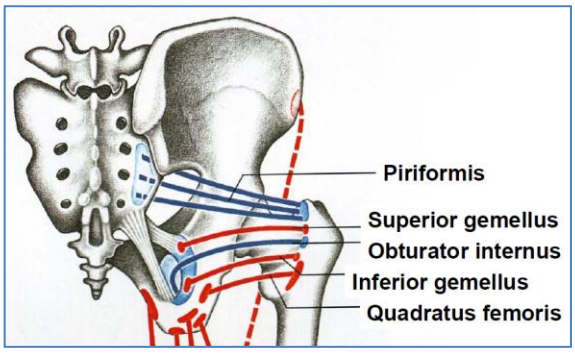
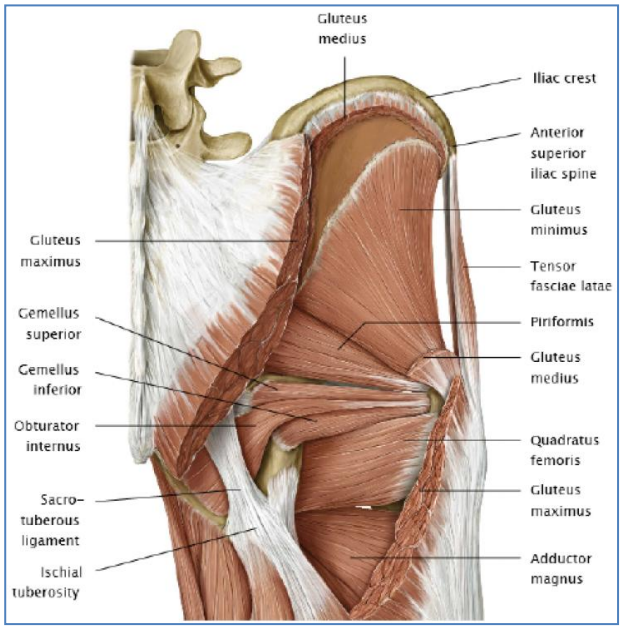


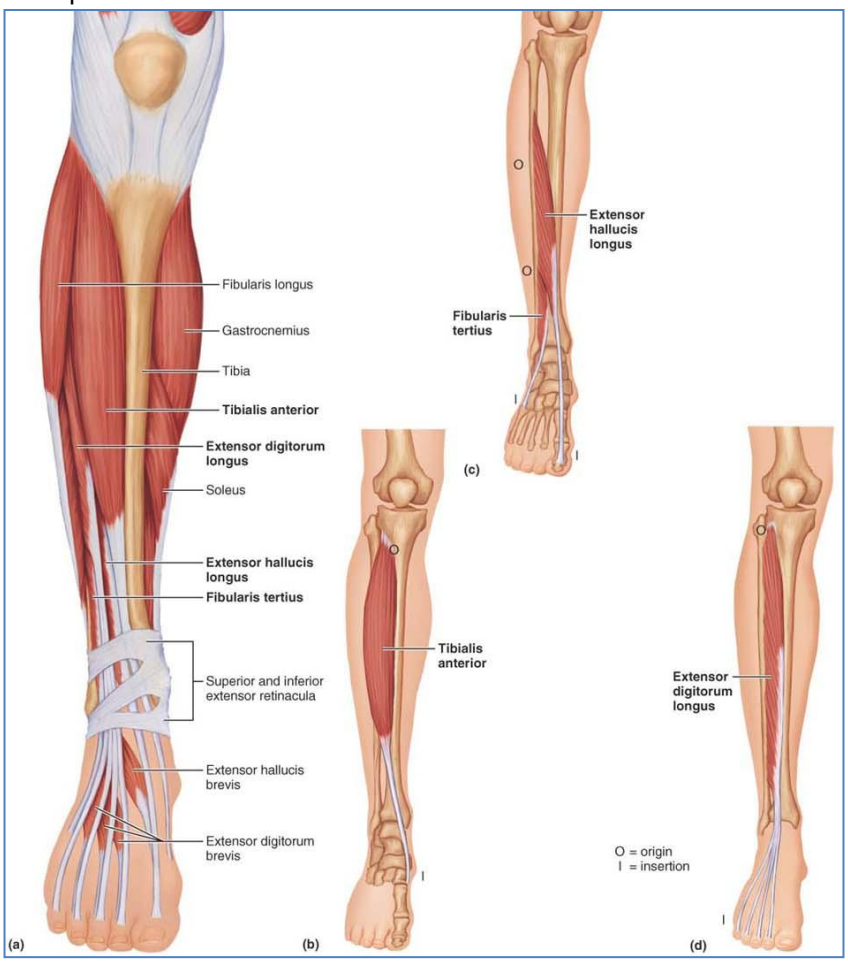
FIGURE 10.20 **Posterior muscles of the right hip and thigh. (a)** Superficial view showing the gluteus muscles of the buttock and hamstring muscles of the thigh. **(b)** Deep muscles of the gluteal region, which act primarily to rotate the thigh laterally. The superficial gluteus maximus and medius have been removed. **(c)** Anterior view of the isolated obturator externus muscle.

Lateral Rotators: Origins & Insertions: Posterior Aspect





- **Anterior Compartment of Leg:**
  - **Tibialis Anterior:**
    - Dorsiflexion
    - Deep Fibular Nerve
  - **Extensor Hallucis Longus:**
    - Extension of Big Toe
  - **Extensor Digitorum Longus:**
    - Extension of Phalanges 2→5
  - **Fibularis Tertius:**
    - Dorsiflexion
    - Deep Fibular Nerve



- **Lateral Compartment of Leg:**
  - **Fibularis Longus**
  - **Fibularis Brevis**

MUSCLE GALLERY TABLE 10.15 *(continued)*

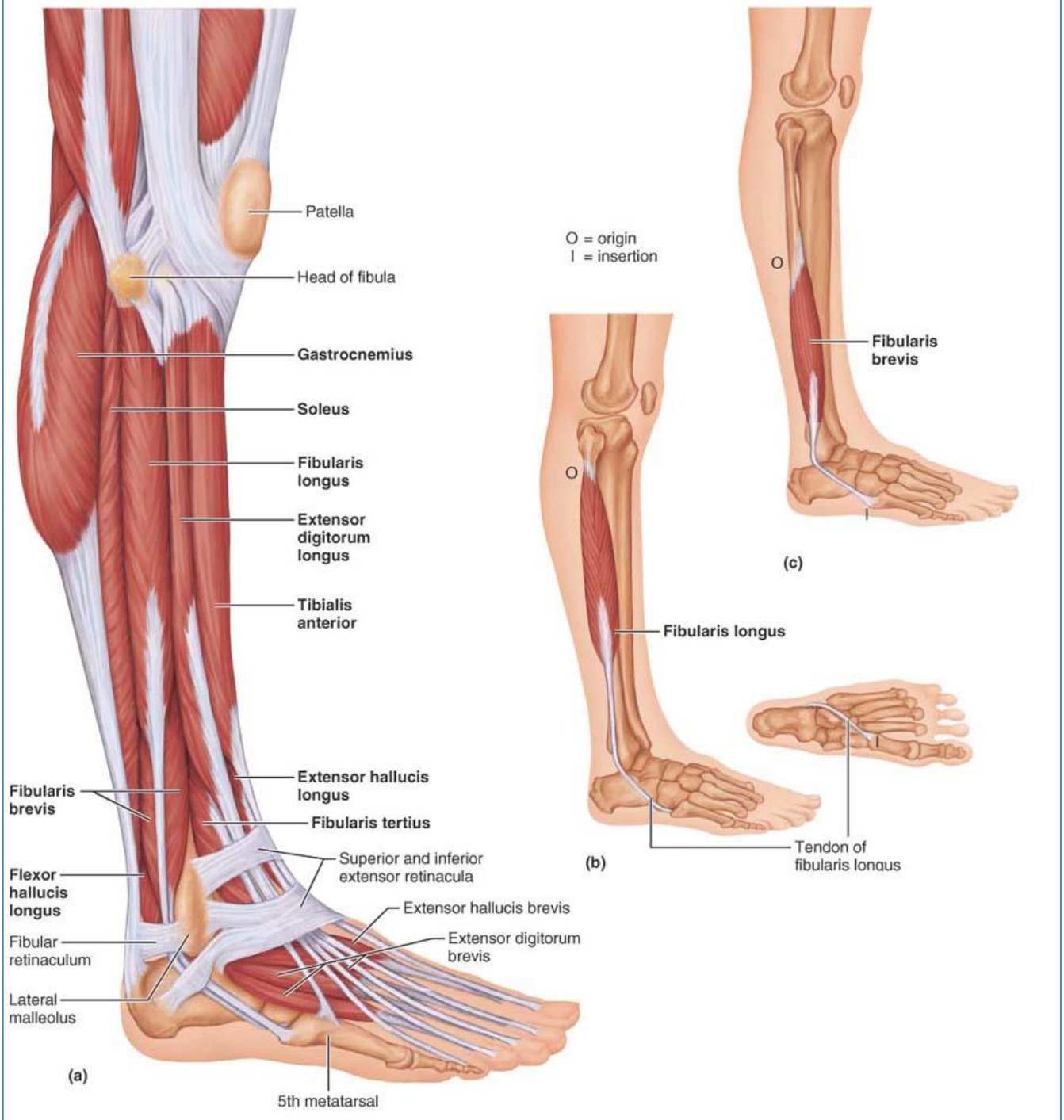


FIGURE 10.22 **Muscles of the lateral compartment of the right leg.** **(a)** Superficial view of lateral aspect of the leg, illustrating positions of lateral compartment muscles (fibularis longus and brevis) relative to anterior and posterior leg muscles. **(b)** Isolated view of fibularis longus; inset illustrates the insertion of the fibularis longus on the plantar surface of the foot. **(c)** Isolated view of the fibularis brevis muscle. (See *A Brief Atlas of the Human Body*, Figure 42.)

- **Posterior Compartment of Leg:**
  - **Triceps Surae:**
    - **Gastrocnemius Medial Head:**
    - **Gastrocnemius Lateral Head:**
    - **Soleus:**
  - **Plantaris:**
  - **Tibialis Posterior:**
  - **Flexor Digitorum Longus:**
  - **Flexor Hallucis Longus:**

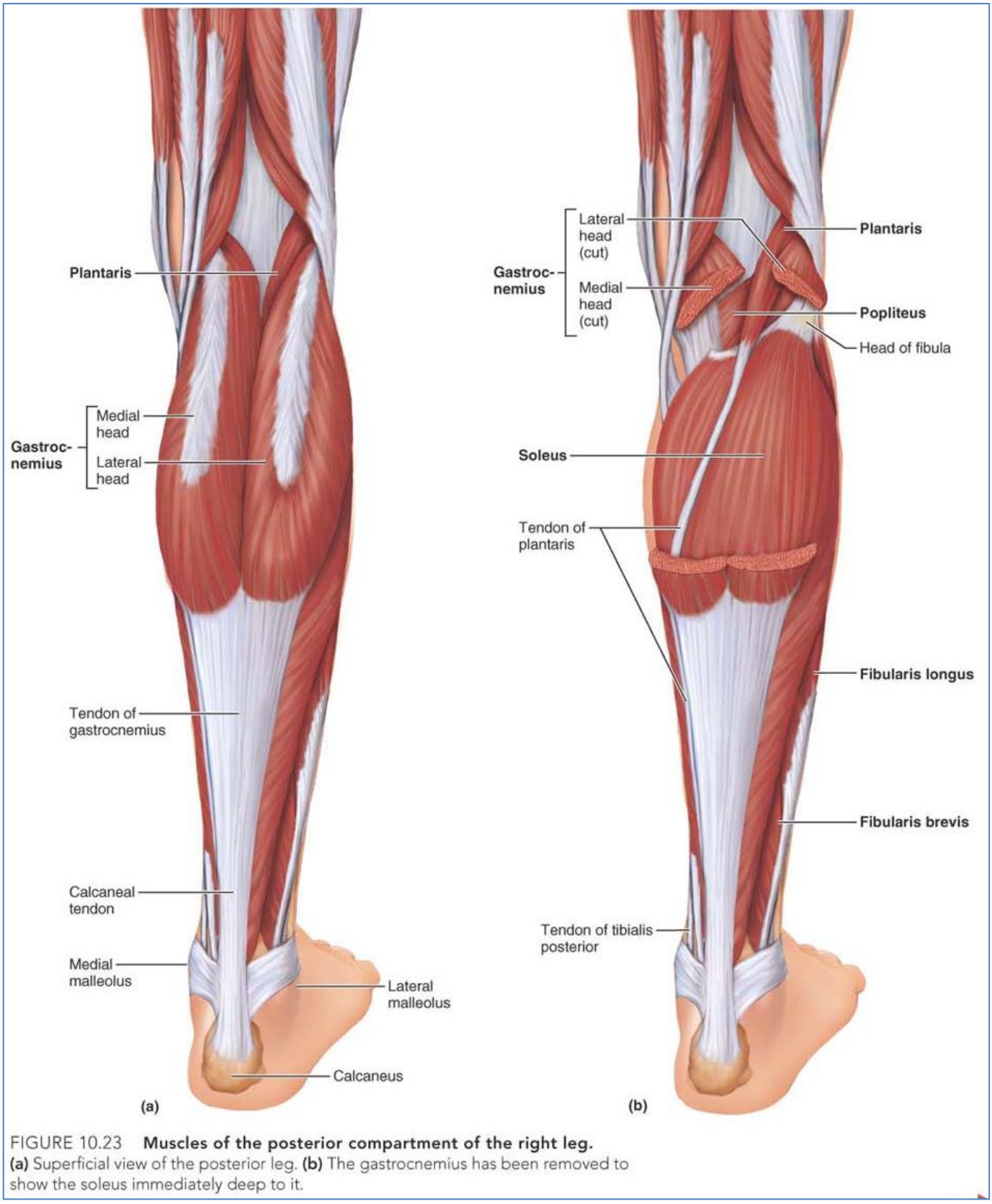


FIGURE 10.23 **Muscles of the posterior compartment of the right leg.**
(a) Superficial view of the posterior leg. **(b)** The gastrocnemius has been removed to show the soleus immediately deep to it.

MUSCLE GALLERY TABLE 10.15 **Muscles of the Leg: Movements of the Ankle and Toes (Figures 10.21 to 10.23)** *(continued)*

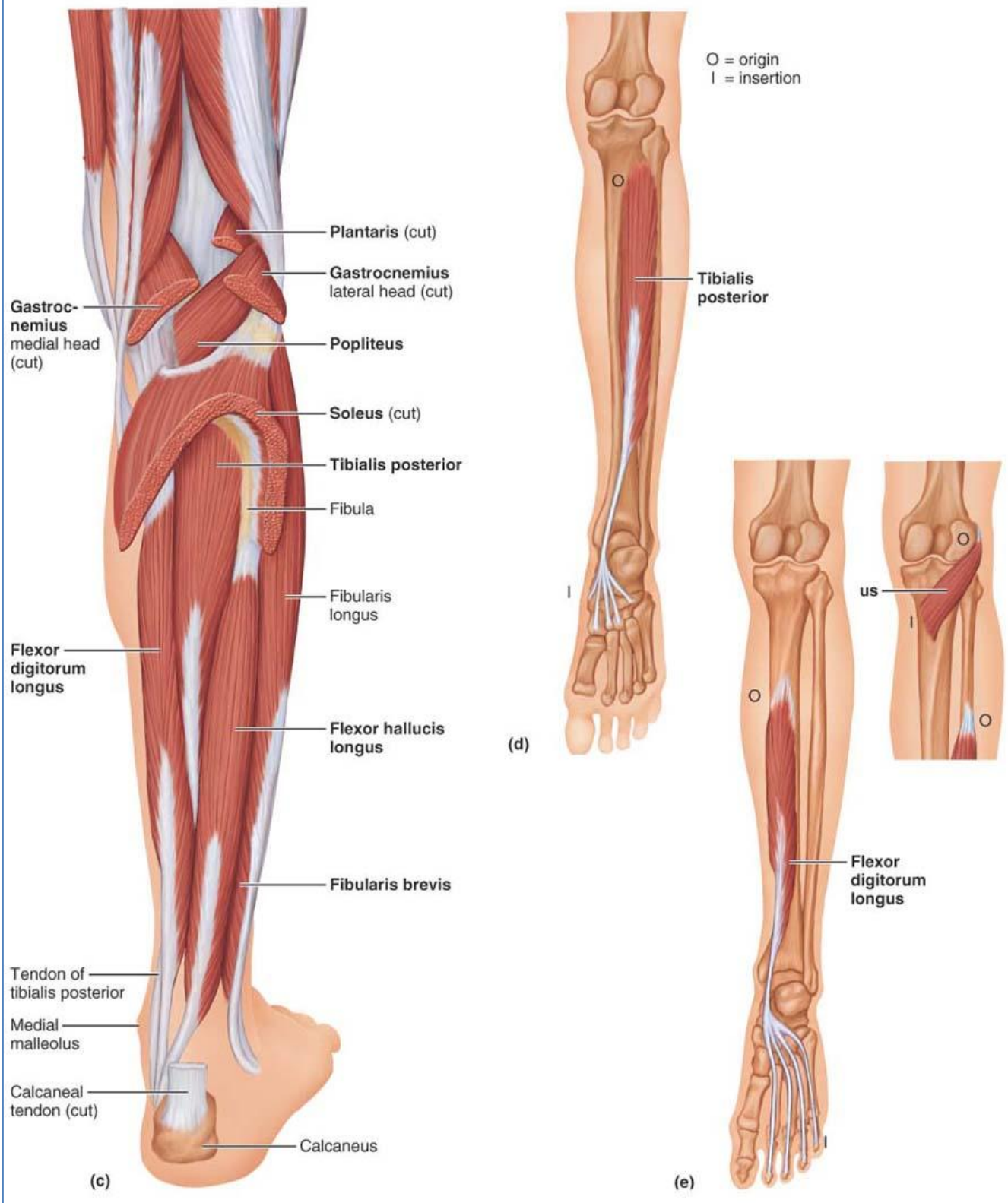
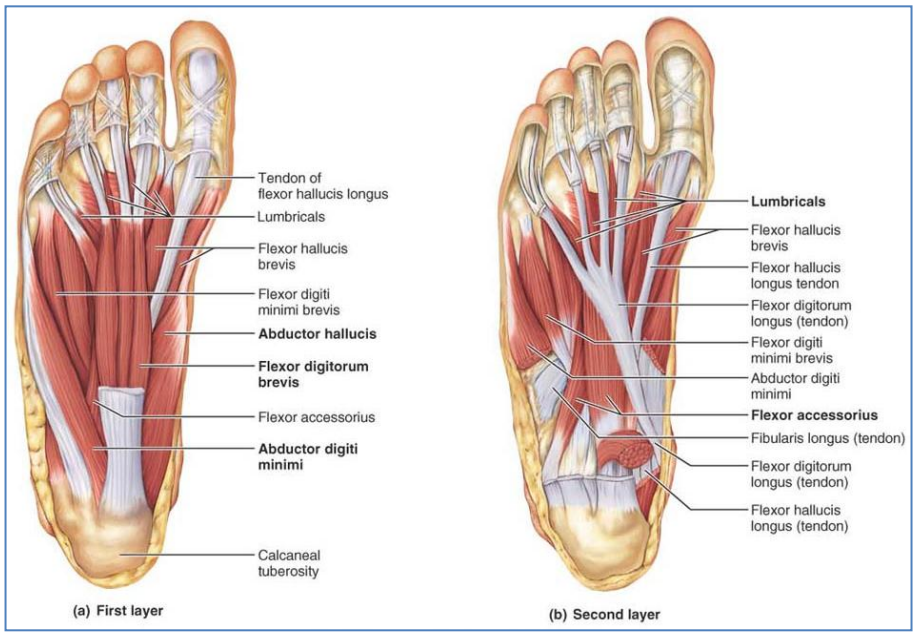
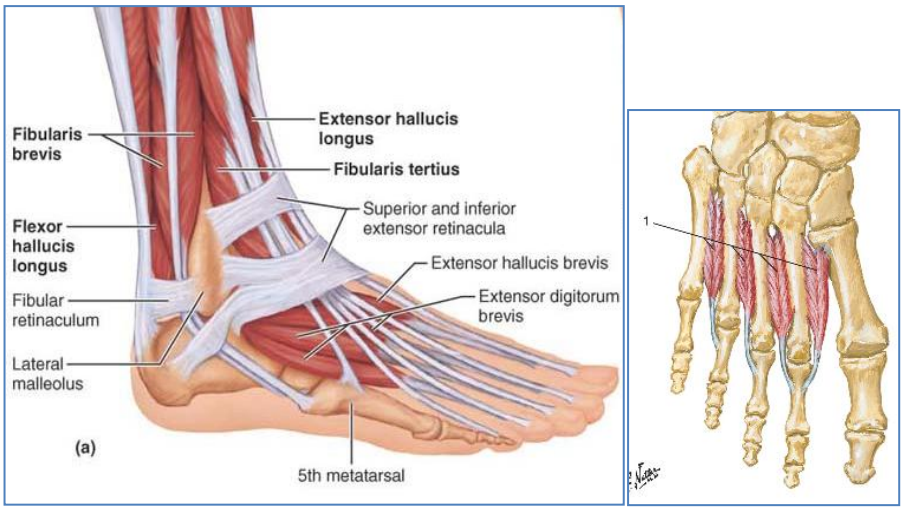


FIGURE 10.23 *(continued)* **Muscles of the posterior compartment of the right leg. (c)** The triceps surae has been removed to show the deep muscles of the posterior compartment. **(d–f)** Individual deep muscles are shown in isolation.

- **Intrinsic Muscles of the Foot:**
  - **Plantar Aspect:**
    - **First Layer:**
      - **Abductor Hallucis**
      - **Flexor Digitorum Brevis**
      - **Abductor Digiti Minimi**
    - **Second Layer:**
      - **Flexor Hallucis Brevis**
      - **Quadratus Plantae**
      - **Flexor Digiti Minimi Brevis**
      - **Lumbricals**
    - **Third Layer:**
      - **Adductor Hallucis – Transverse Head**
      - **Adductor Hallucis – Oblique Head**
    - **Fourth Layer:**
      - **Plantar Interossei** – Abduct Toes

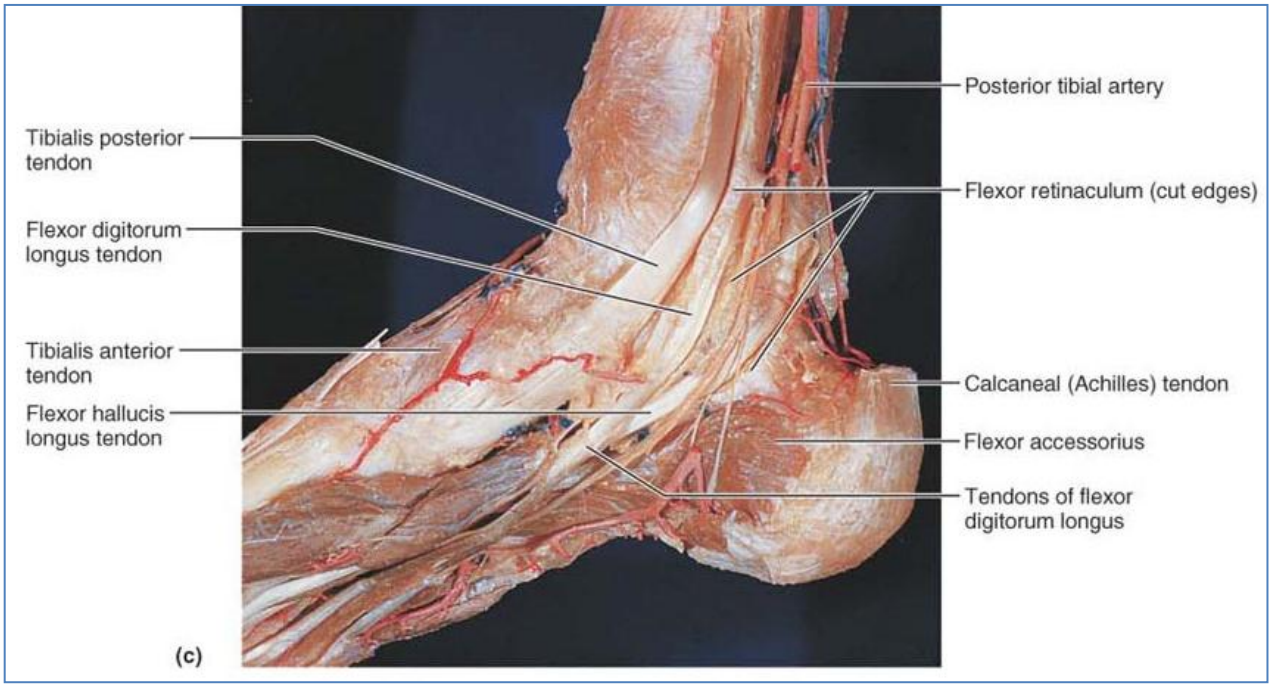


  - **Dorsal Aspect:**
    - **First Layer:**
      - **Extensor Hallucis Brevis**
      - **Extensor Digitorum Brevis**
    - **Second Layer:**
      - **Dorsal Interossei –** Abduct Toes



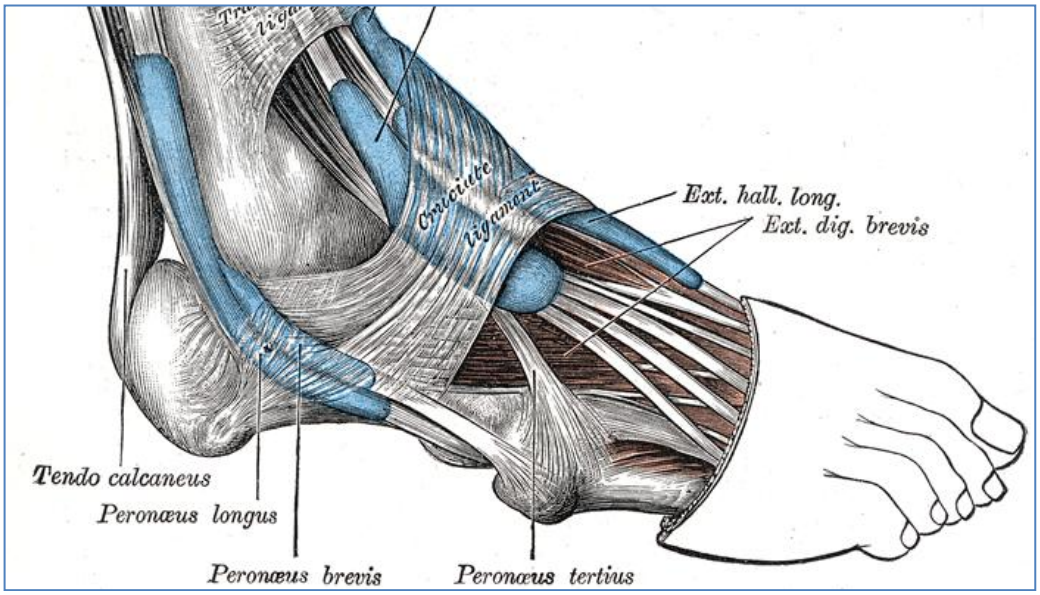
Structures Passing Medial Malleolus:

- **Tom - Tibialis Posterior**
- **Dick - Flexor Digitorum Longus**
- **And - Posterior Tibial Artery**
- **Naughty - Tibial Nerve**
- **Harry - Flexor Hallucis Longus**

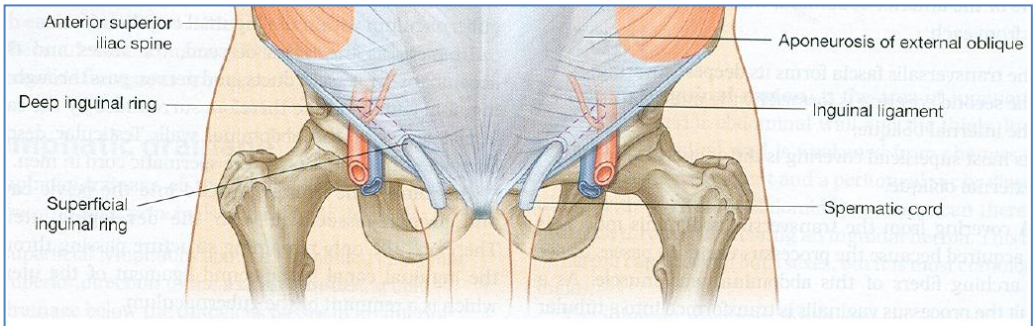


Structures Passing Lateral Malleolus:

- **Fibularis Longus**
- **Fibularis Brevis**



Inguinal Canal:

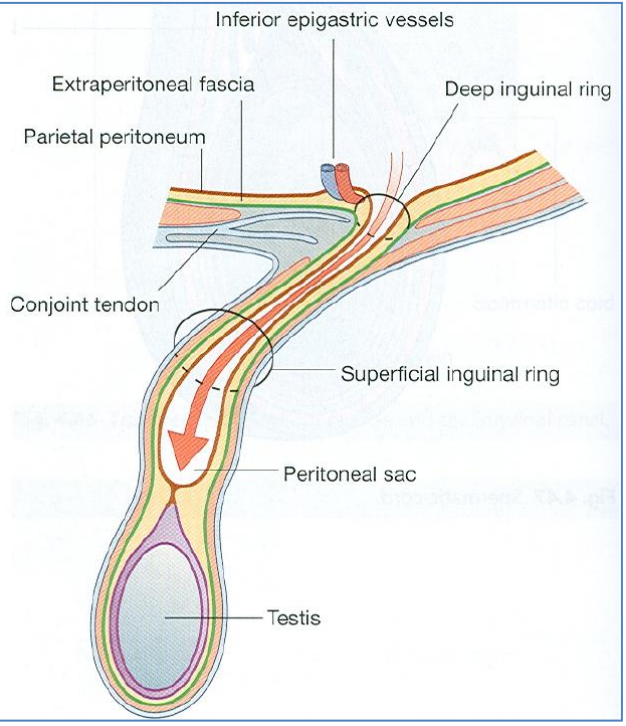


superficial inguinal ring in external oblique aponeurosis.
deep inguinal ring in transversalis fascia to the

Indirect inguinal hernia

Enters deep inguinal ring to pass out of the abdomen within spermatic cord

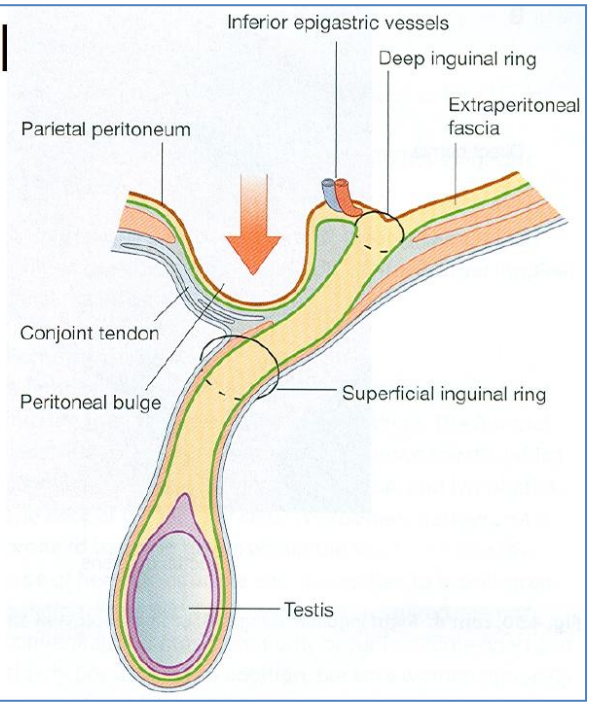
Presents as a swelling in the scrotum



Direct inguinal hernia

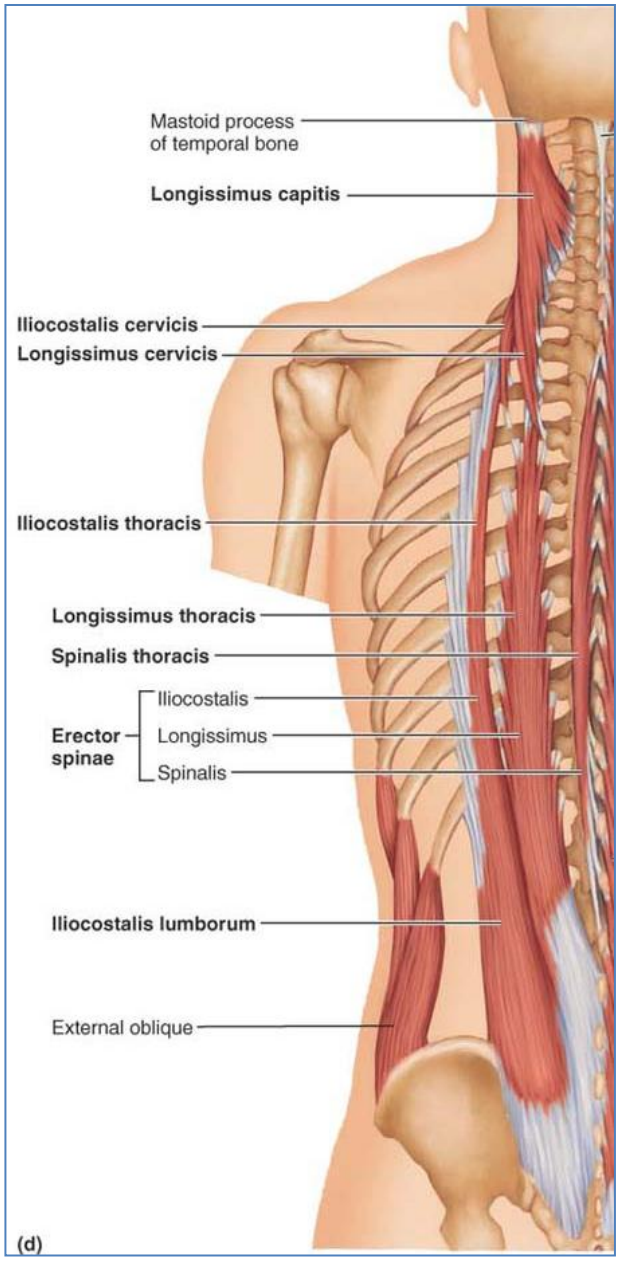
Passes through a weakness in the anterior abdominal wall lateral to the inferior epigastric vessels

Presents as a swelling in the groin

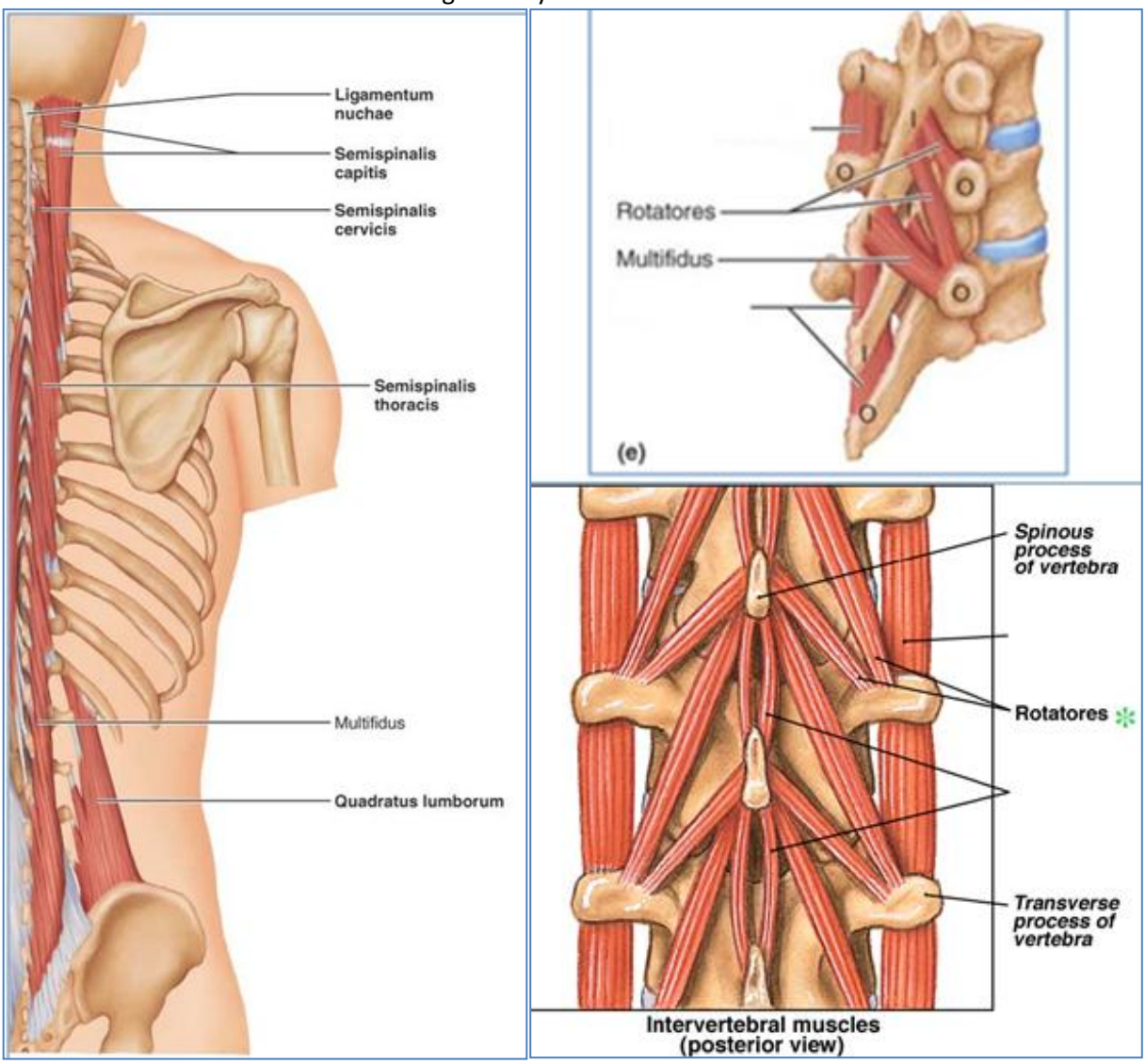


Deep Back Muscles:

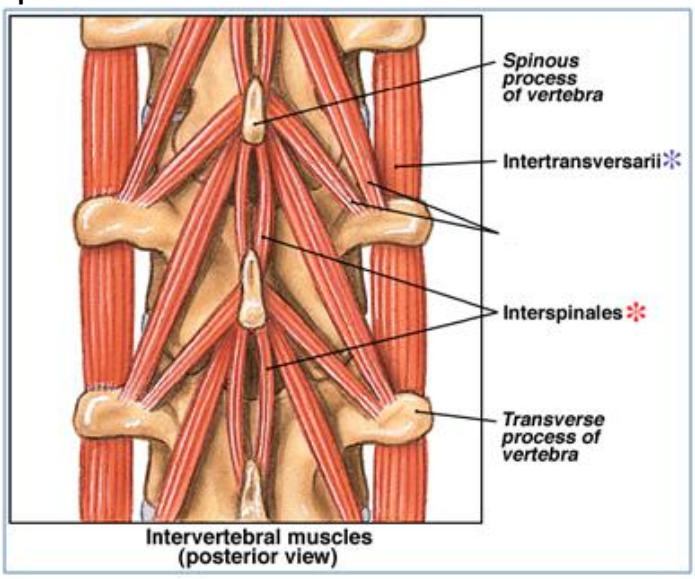
- **Erector Spinae:** Most Superficial Group
  (**I L**ove **S**ex)
  - **Iliocostalis:** (Lumborum/Thoracis/Cervicis)
    - Lateral-most
    - O – Iliac Crest
    - I – Lumbar & Thoracic Ribs + Transverse Processes of Cervical Vertebrae
  - **Longissimus:** (Thoracis/Cervicis/Capitus)
    - Between Iliocostalis & Spinalis
    - O – Transverse Processes of Lumbar, Thoracic & Cervical Vertebrae
    - I – Ribs Superior to Origin, Or, Transverse Processes of Thoracic or Cervical Vertebrae
  - **Spinalis:** (Thoracis/Cervicis/Capius)
    - Medial-most
    - O – Spines of Upper-Lumbar & Lower-Lumbar Vertebrae
    - I – Spinous Processes of Upper Thoracic & Cervical Vertebrae



- **TransversoSpinalis:** Intermediate Group
  (**S**ex **M**e **R**ight)
  - **Semispinalis**
  - **Multifidus**
  - **Rotatores**
    - In Thoracic Region Only



- **Deep Group:** Deepest Group
  (**I Tr**ied **In**door **S**ex)
  - **InterTransversalis**
  - **InterSpinales**



Muscle Biology & Contraction

Types of Muscle:

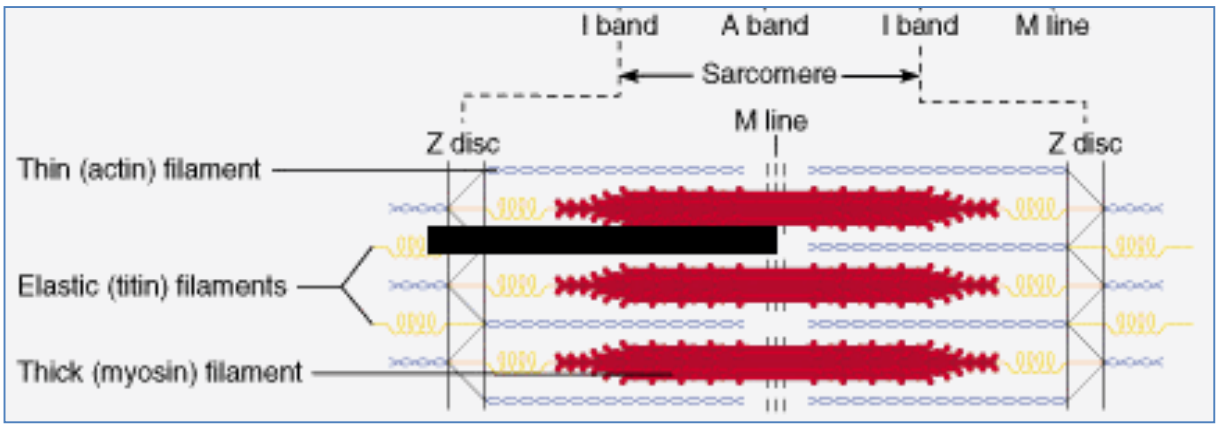
- **Skeletal**
- **Cardiac**
- **Smooth**

Functions of Muscle:

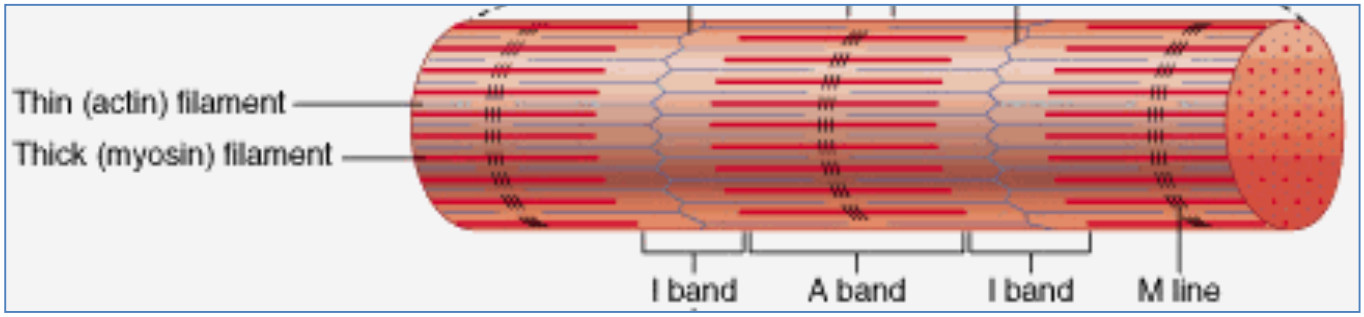
- **To Push, Not Pull** (except genitals + tongue)
- **Skeletal Movement**
- **Circulation of Blood**
- **Motility of GI Tract Contents**
- **Secretion of Glands**
- **Structural Support**

Revision of Skeletal Muscle Structure:

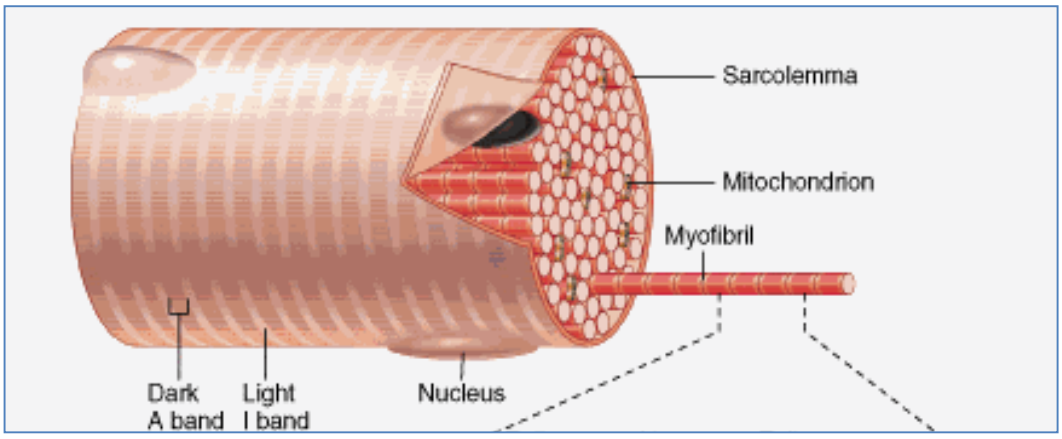
- **Myofilaments**
  - Contractile *Proteins*:
    - **Actin** (Thin)
    - **Myosin** (Thick)
  - **Z-Disc** – anchors sarcomeres together.
    - Ensures whole cell contraction.

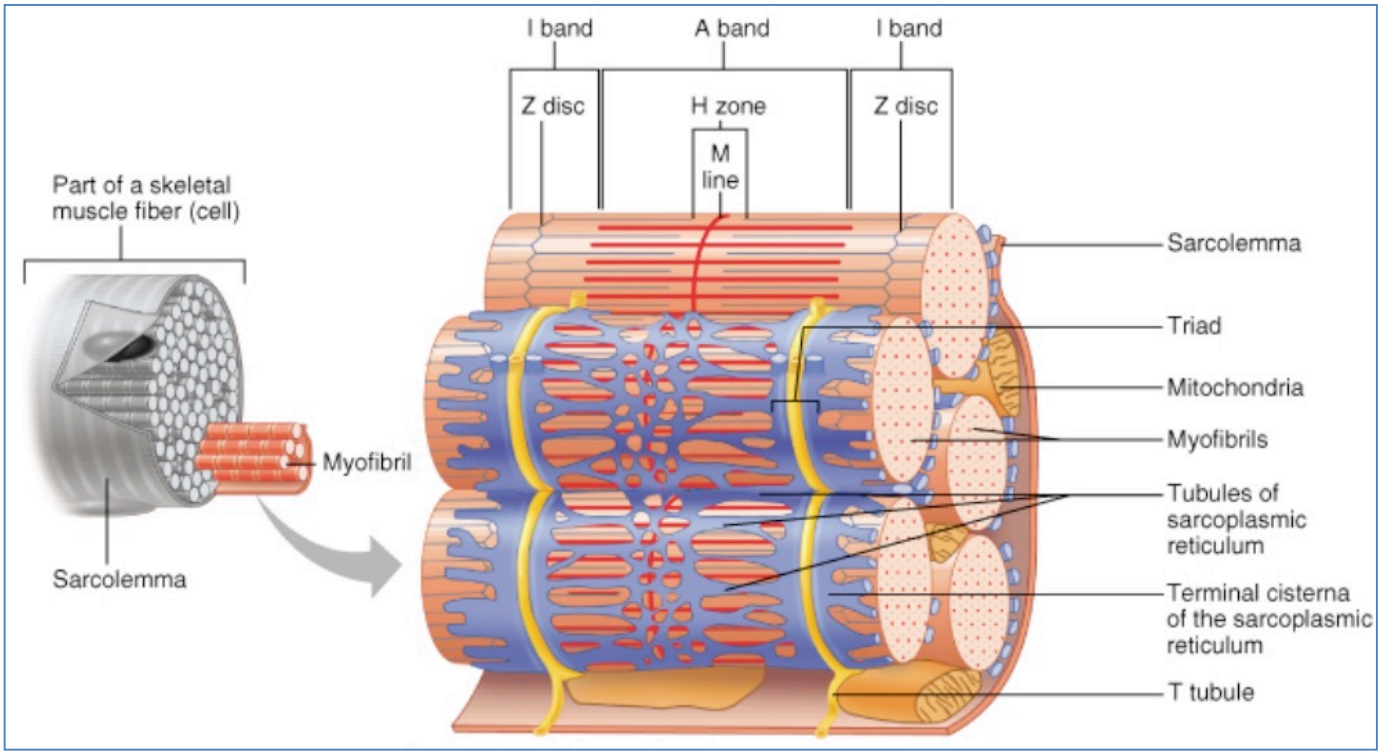


- **Myofibrils**
  - Contractile *Organelles*:
  - **Sarcomeres** → striped appearance
    - Z-Disc → Z-Disc
    - Mid I-Band → Mid I-Band

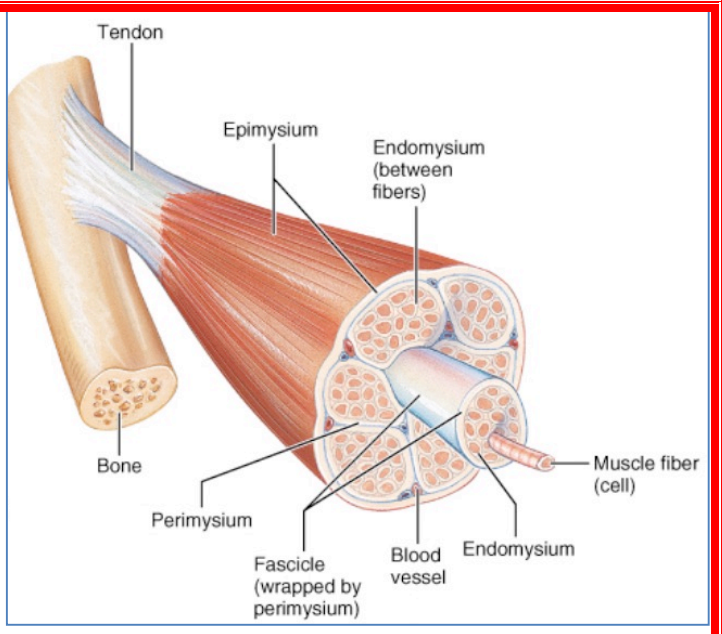


- **Muscle Fibres (cells)**
  - Contractile *Cells*
  - **Sarcolemma** (plasma membrane)
    - **Transverse ('T') Tubules**
      - Perpendicular Invaginations of the sarcolemma (PM)
      - Runs between paired terminal cisterna of Sarcoplasmic Reticulum
      - Conducts impulses from sarcolemma deep 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
- **Endomysium**
  - Connective Tissue
  - Wraps single muscle fibres (cells)



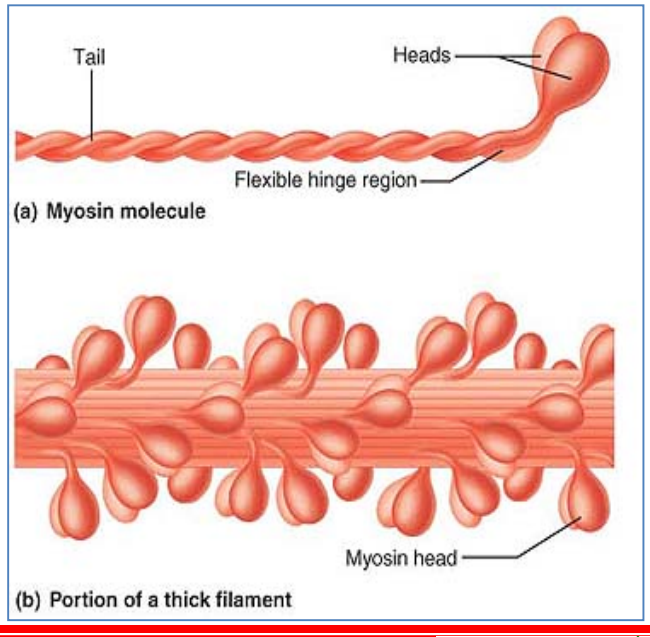


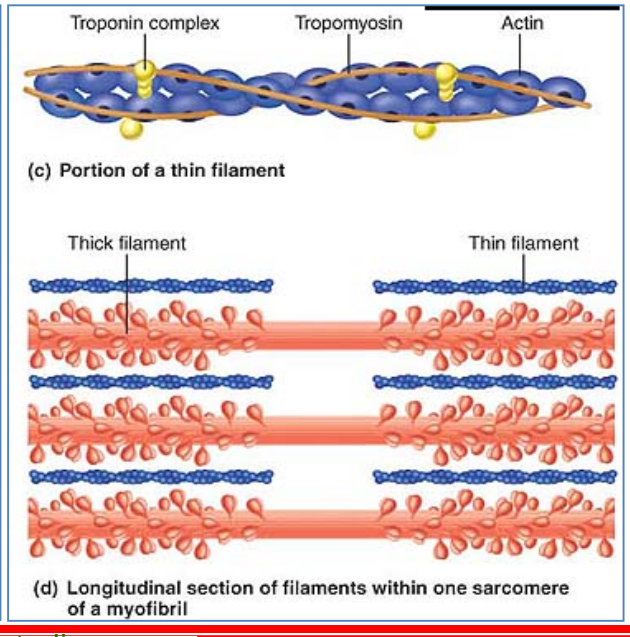
- **Muscle Fascicles**
  - Bundles of muscle fibres (cells)
- **Perimysium**
  - Connective Tissue
  - Wraps Fascicles
- **Single Muscle**
  - Muscle as a whole – eg. The bicep.
- **Epimysium**
  - Connective Tissue
  - Wraps whole muscle.
- **Tendons**
  - A fusing together of all connective tissue layers.
  - Connects muscle to bone



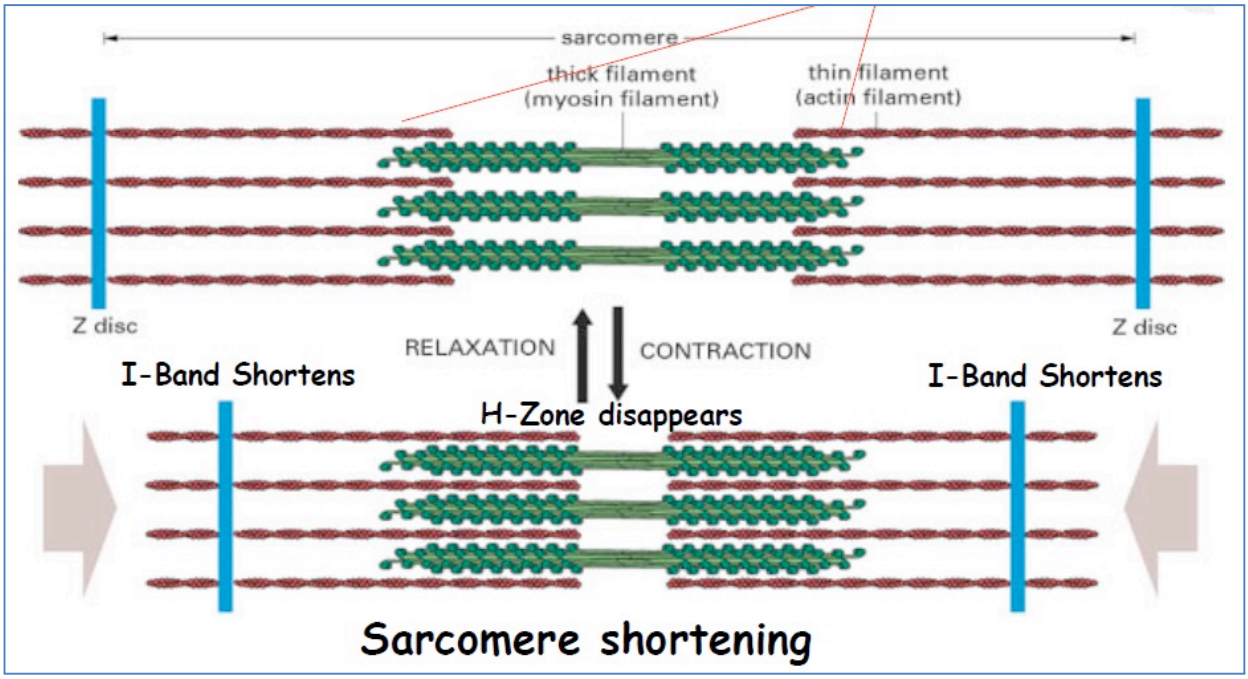
Sliding Filament Theory:

- **Sarcomere** is the functional unit of muscles.
- **Myo-Filaments** (Actin & Myosin) slide past each other
  - **Actin** (Thin)
    - **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)
    - **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.



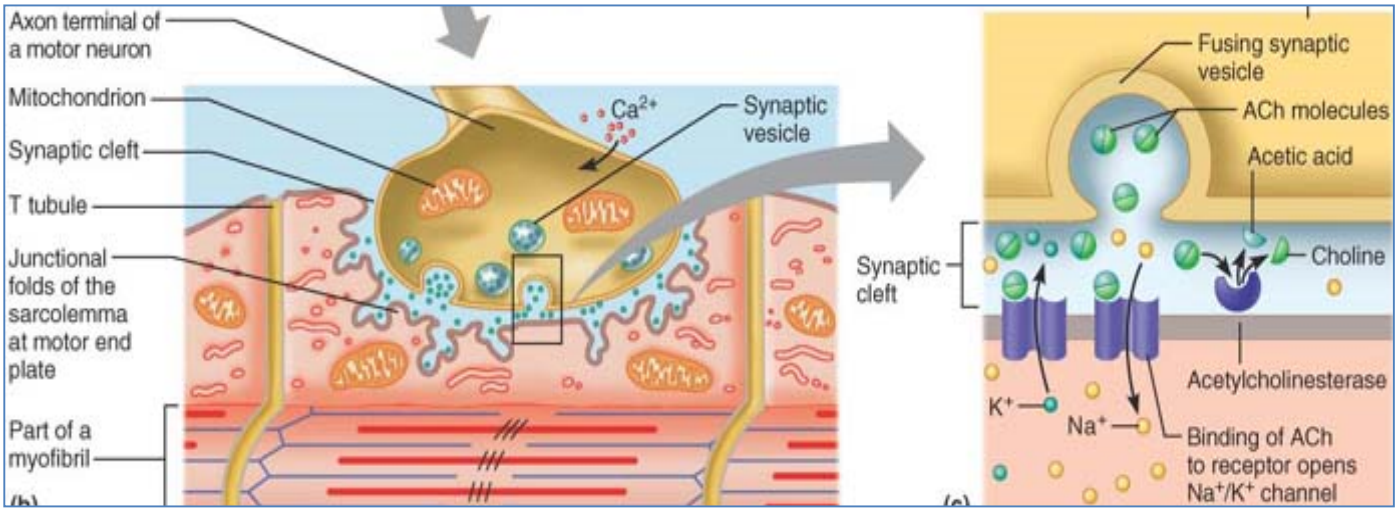


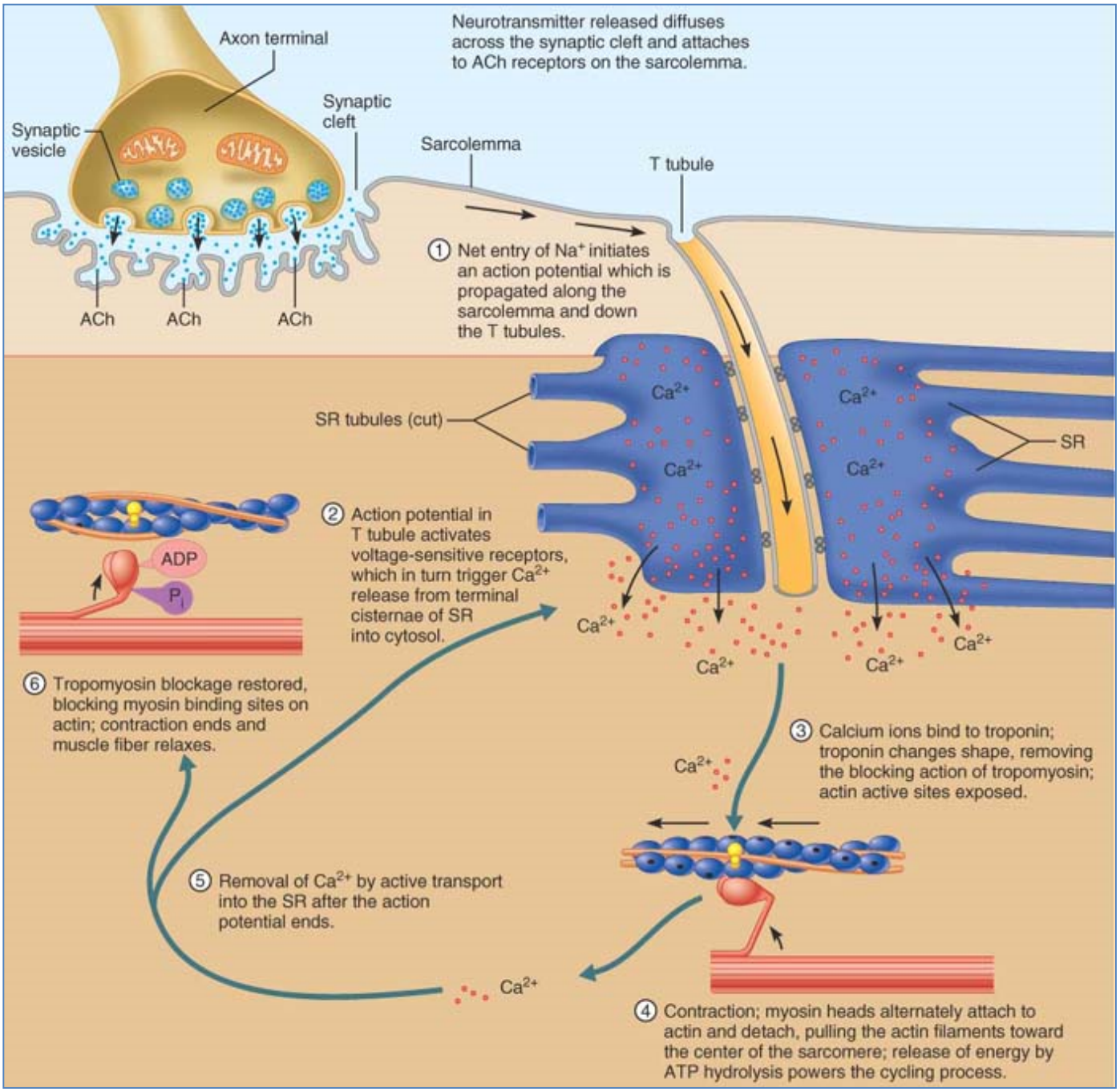
- **When relaxed**
  - Thick & thin filaments only overlap at the ends of the A.Band.
- **When stimulated**
  - (by nervous system)
  - Myosin heads latch to myosin binding sites on actin
  - Form **cross bridges**
    - Formed & broken many times in a contraction
    - Act like tiny ratchets
    - Generate tension
    - Propel thin filaments toward centre of sarcomere.



Events @ Neuromuscular Junction:

- A somatic neuron's axon divides profusely as it enters the muscle it serves.
- Each axon results in several neuromuscular junctions with single muscle fibres.
- Each muscle fibre has only one neuromuscular junction - @ approx midway along its length.
- **Events:**
  - **Nerve impulse** reaches axon terminal
  - Voltage-gated **Ca channels open**.
  - **Ca** diffuses **into axon terminal**
  - Causes **vesicles of ACh** to be **exocytosed** into synaptic cleft.
  - **ACh binds to receptors** on sarcolemma
  - Initiates **action potential** along **muscle** cell **membrane**.
  - **ACh** is swiftly **broken down** by **ACh-esterase** → allows quick successive stimuli.
  - **Action potential** propagates **along sarcolemma** & **down T-Tubules**.
  - Action potential causes **terminal cisternae** to **release Ca^+** into the sarcoplasm.
  - **Ca^+ binds** to **troponin** → **removes tropomyosin**.
  - **Myosin heads attach** & pull **thin filaments** towards centre of sarcomere.
  - **Ca^+** actively **reabsorbed** by Sarcoplasmic Reticulum
  - **Troponin-Tropomyosin** Complex is **re-established**
  - **Cross-Bridging ceases**



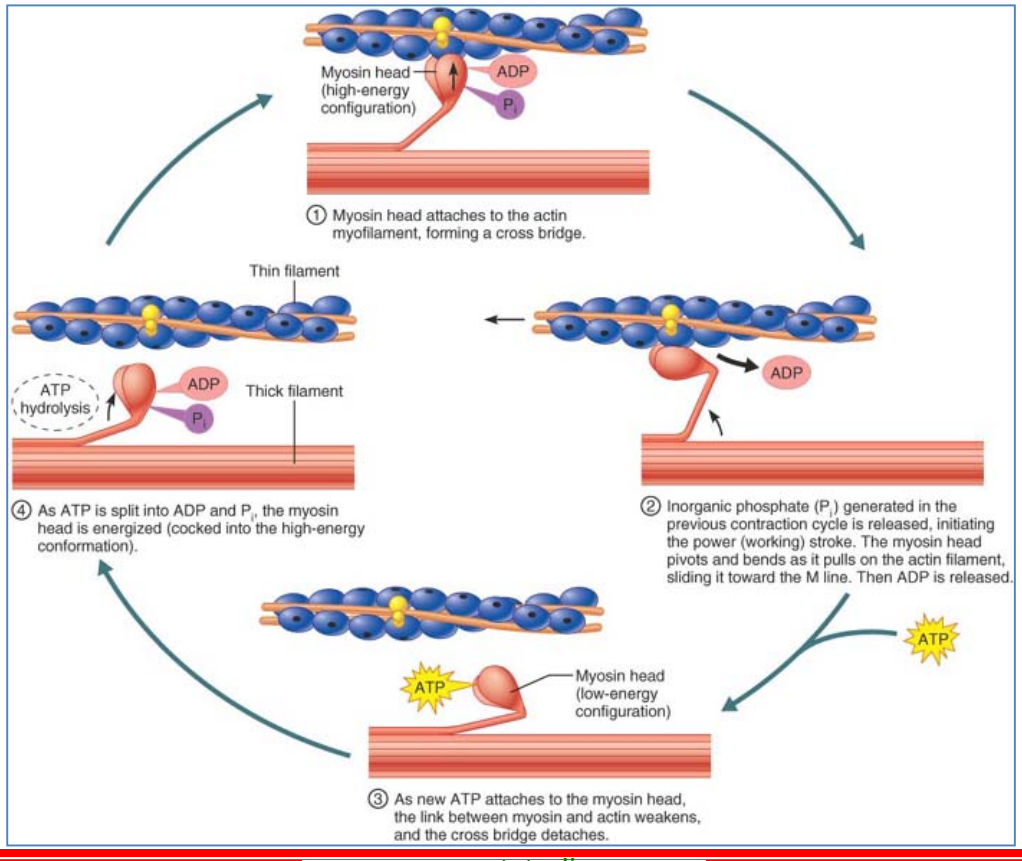


Stages of Sliding Filament Theory:

- NB: This cycle may repeat a few hundred times/second.
- Cycle is repeated over & over in the presence of Calcium and ATP.
- **Rest (No crossbridges)**
  - Low intracellular Calcium levels.
  - Myosin-binding sites are physically blocked by tropomyosin.
  - Muscle is relaxed
  - Actin & myosin uncoupled
  - Ca^{2+} stored in sarcoplasmic reticulum

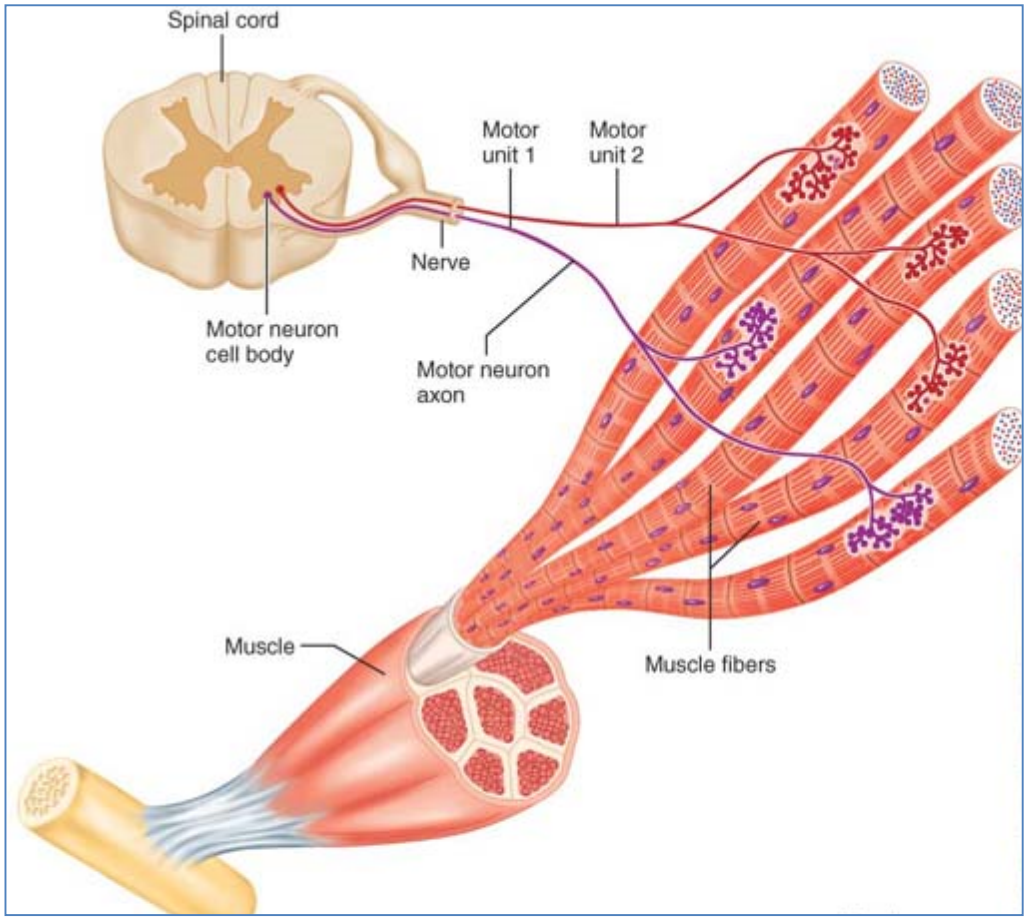
1. **Excitation-CrossBridge Formation (Ach → Ca^{2+})**
   a. Nerve impulse
   b. Ca^{2+} released from Sarcoplasmic Reticulum
   c. Ca^{2+} binds troponin → tropomyosin releases binding sites on actin.
   d. Conformational change exposes myosin binding sites
   e. Myosin-Actin cross-bridges are formed ('Charged')
   f. Formation of actomyosin
2. **Power-Stroke (Sliding, shortening & tension)**
   a. As myosin head binds to actin, P_i is released (exothermically)
   b. Myosin head changes from its high-energy shape to its bent, low-energy shape.
   c. Myosin pivots about 70^O.
   d. Muscle shortens
   e. Force developed
3. **Cross-Bridge Detatchment(Breaking of old bond + New ATP**
   a. New ATP binds to myosin head
   b. Actin-myosin cross bridge dissociates
4. **"Cocking" of Myosin Head**
   a. ATPase in myosin head hydrolyses ATP → ADP + P_i
   b. Harnesses the potential energy for the next Cross-Bridge formation.
   c. Myosin head changes to its prestrike, high-energy (cocked) position.

- **(Active [*requires ATP*] Ca^{2+} re-uptake by Sarcoplasmic Reticulum)**
  - Nerve impulse ceases
  - Ca^{2+} removed by Sarcoplasmic Reticulum's **ATP-Ca^{2+} Pump.**
  - Muscle returns to resting state



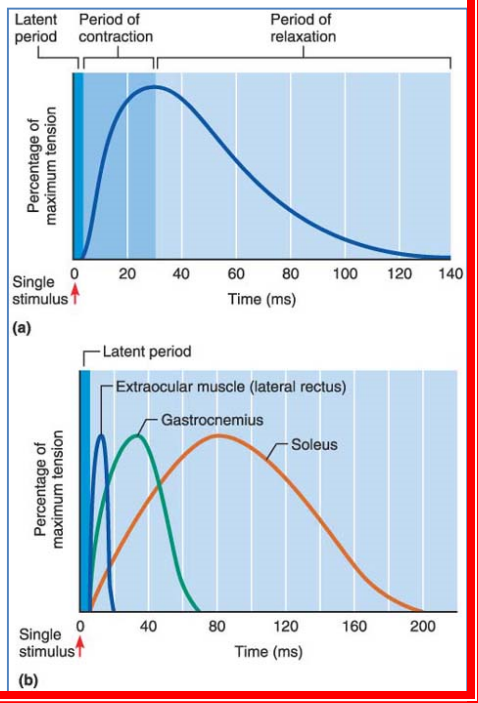
The Motor Unit:

- = A motor neuron and all the muscle fibres it supplies.
- The number of fibres per motor unit may be anywhere from 4 – a few hundred.
- Fine control muscles (fingers & eyes) have small motor units. (ie. Many nerves/entire muscle)
- Large, weight-bearing muscles have large motor units. (ie. Few nerves/entire muscle)
- Purpose of motor units is to be able to create different strengths of contraction in a muscle.



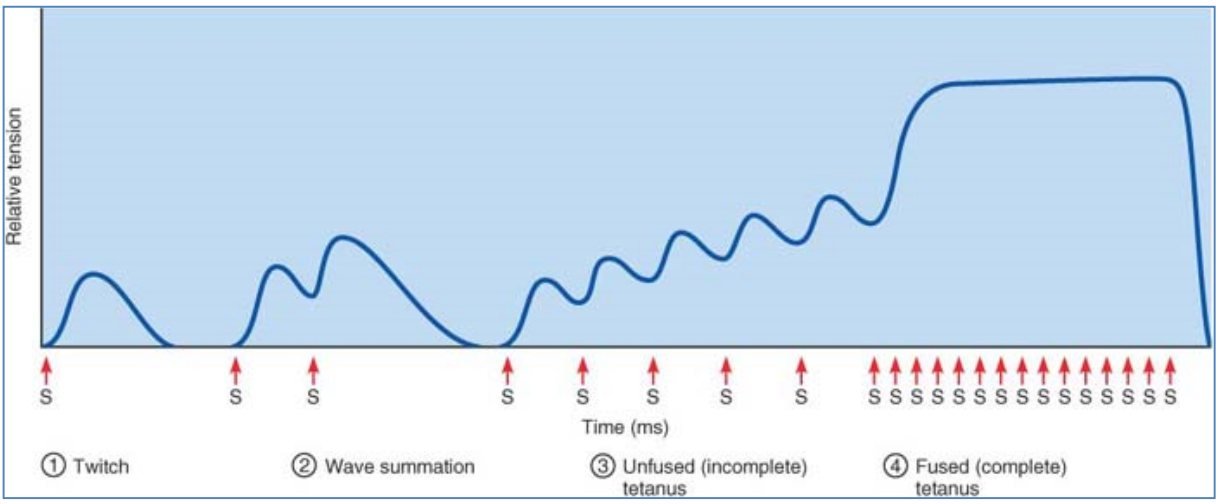
The Muscle Twitch:

- = The response of a motor unit to a single action potential of its motor neuron.
- Muscle fibres contract quickly and then relax.
- Twitch contractions of some muscles are rapid & short (eyes) while others are slow and contract for longer.
- **3 Periods:**
  - **Latent Period:**
    - First few milliseconds between stimulation and actually generating tension
    - The time when coupling is occurring
  - **Period of Contraction:**
    - When cross bridges are active
    - From onset to peak tension
    - Lasts 10-100ms
  - **Period of Relaxation:**
    - Ca^{+} reuptake into SR
    - Muscle tension decreases to zero.

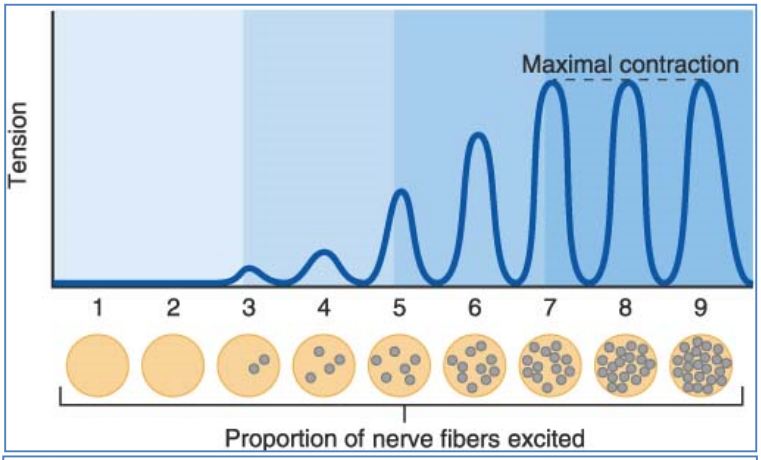


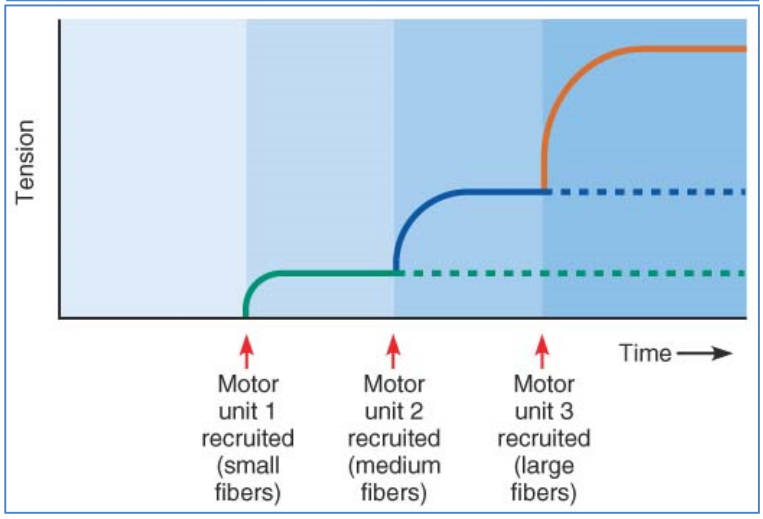
Graded Muscle Responses:

- Healthy muscle contractions are smooth & vary in strength in different situations.
- These variations are known as 'Graded Muscle Responses'.
- Muscle contraction can be 'graded' in **2 ways:**
    - **Stimulation Frequency:**
        - For **smoothness** of contraction.
        - Increasing the firing rate of motor neurons
        - Quick successive stimuli can cause summation of twitches.



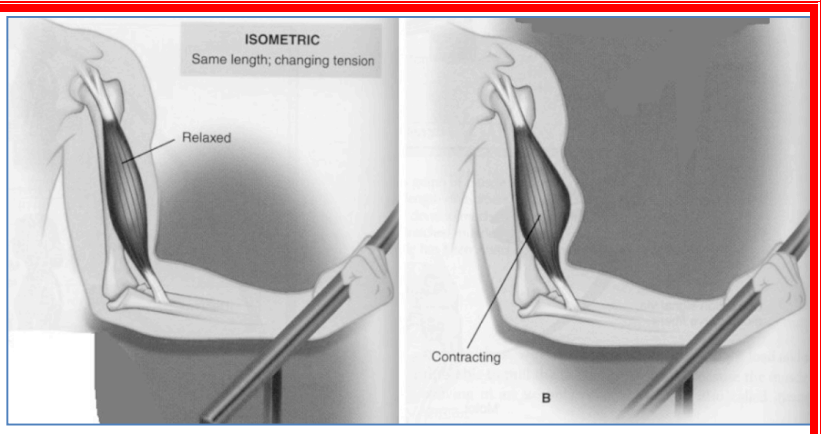
- **Stronger Stimuli (Motor Unit Recruitment):**
    - For **strength** of contraction.
    - Controlled by **multiple motor unit summation**
    - Neural activation of an increasingly large number of motor units serving the muscle.



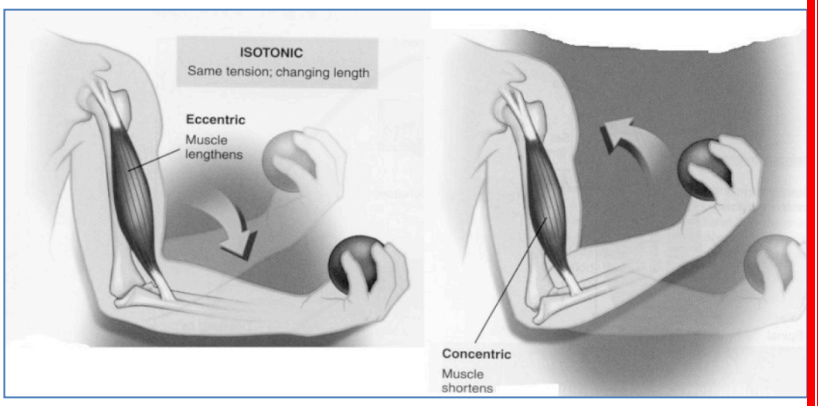


Types of Muscle Activation:

- **Isometric**
  - Constant Force
  - Unchanged muscle length
  - Ie. Static compression



- **Isotonic**
  - Constant Force (tone)
  - Constant Tension (tone)
  - Changes in muscle length:
  - **Concentric**
    - Shortening Muscle
    - Eg. Bicep curl (on the way up)
  - **Eccentric**
    - Elongating Muscle
    - Eg. Bicep curl (on the way down)



Muscle Attatchments:

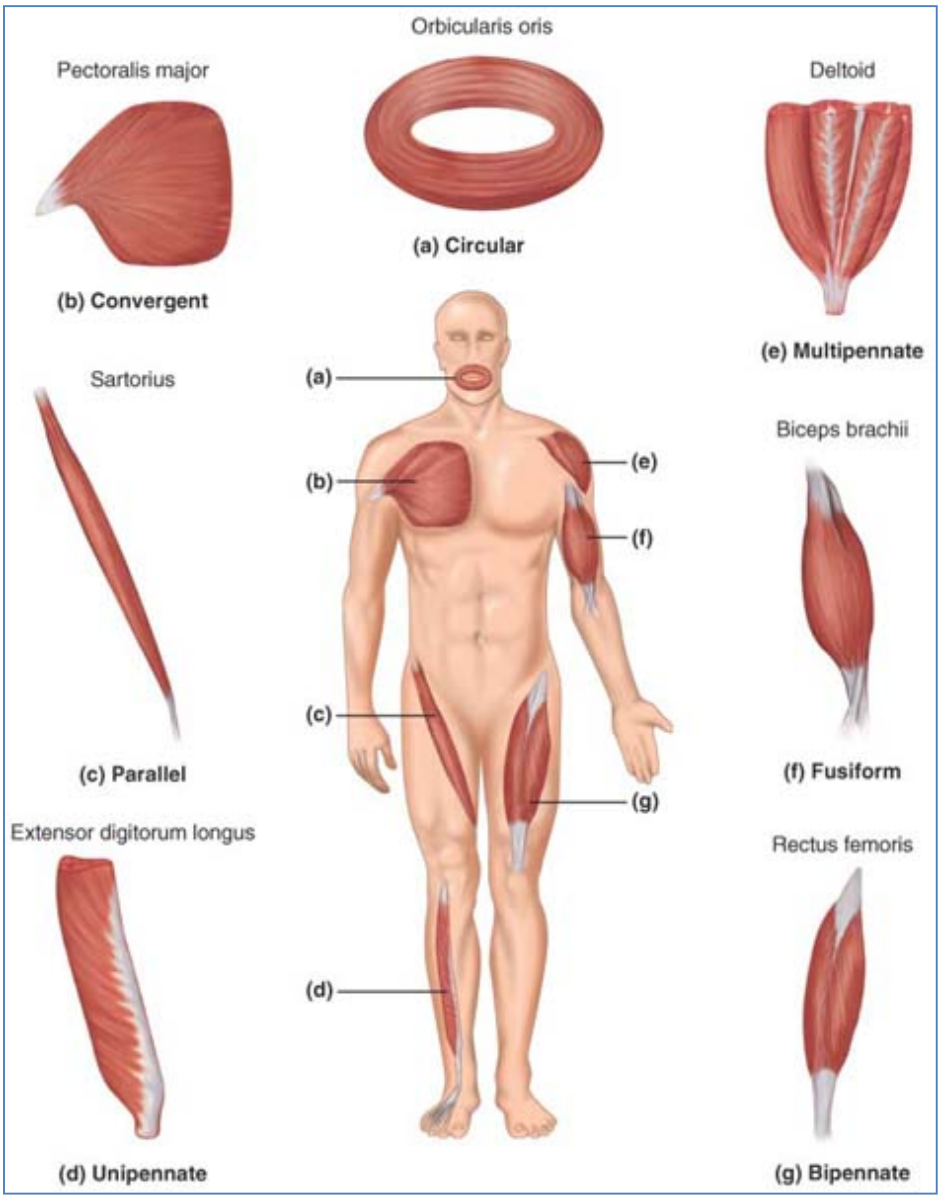
- **Direct**
  - Muscle joins to insertion directly
  - More powerful but more fragile
  - Requires a large space
- **Indirect**
  - Muscle joints to insertion via tendon
  - Requires less space – good for dexterity in fingers

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)



Components of Levers:

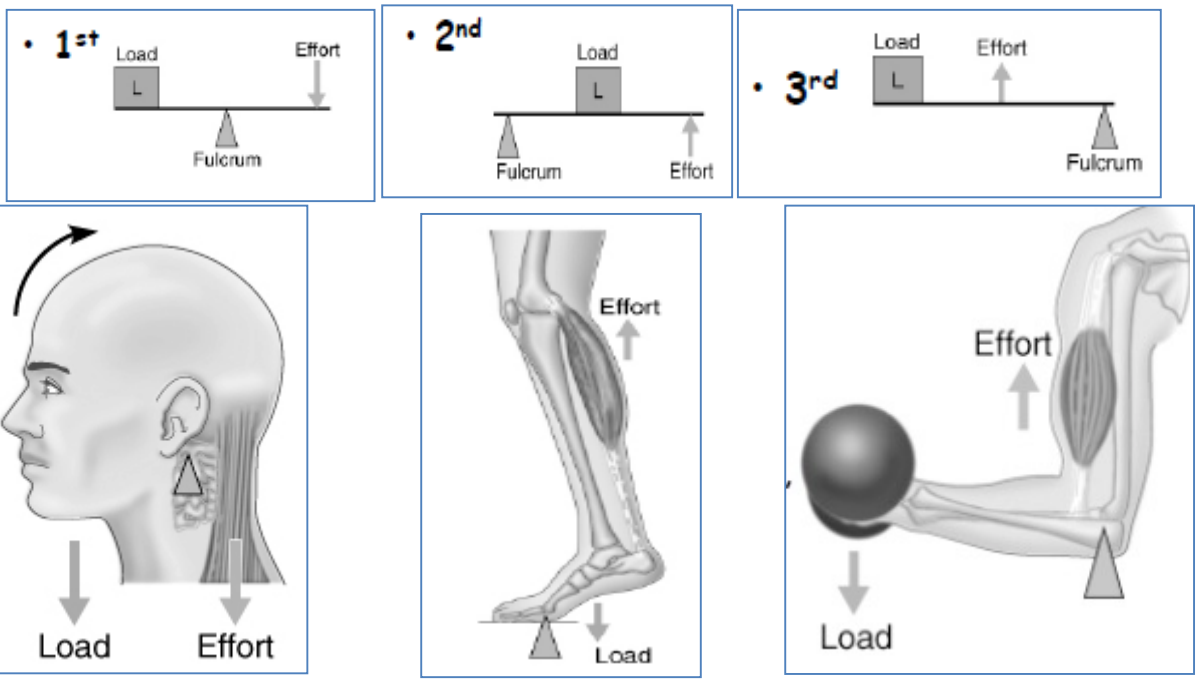
- **Lever**
- **Fulcrum**
- **Effort**
- **Load**

Lever Systems:

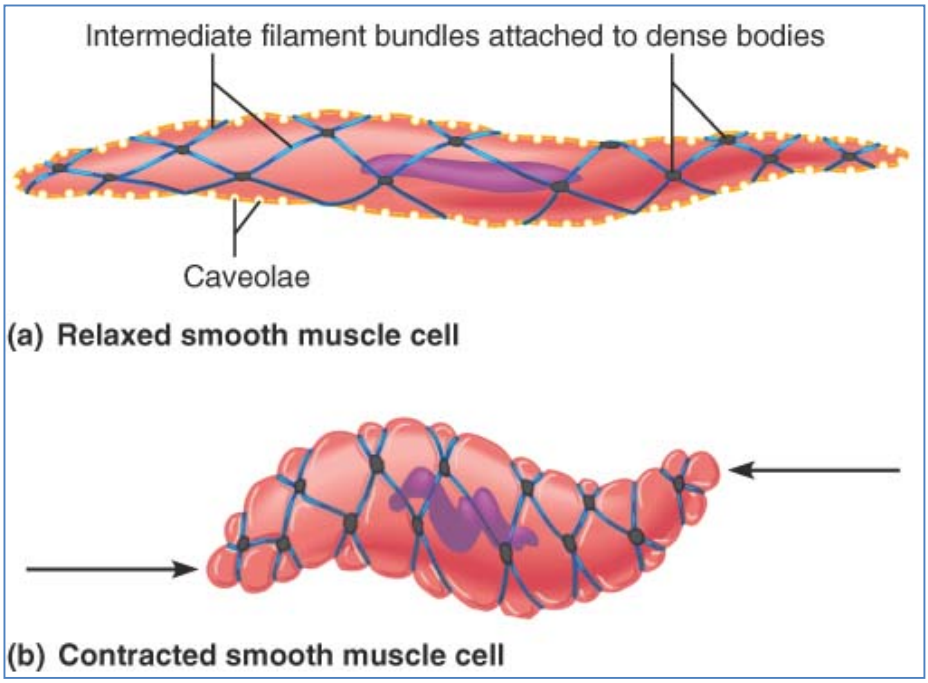
- **Power Advantage**
- **Speed Advantage**

Lever Classes:

1st. No Advantage
2nd. Mechanical Advantage
3rd. Mechanical Disadvantage



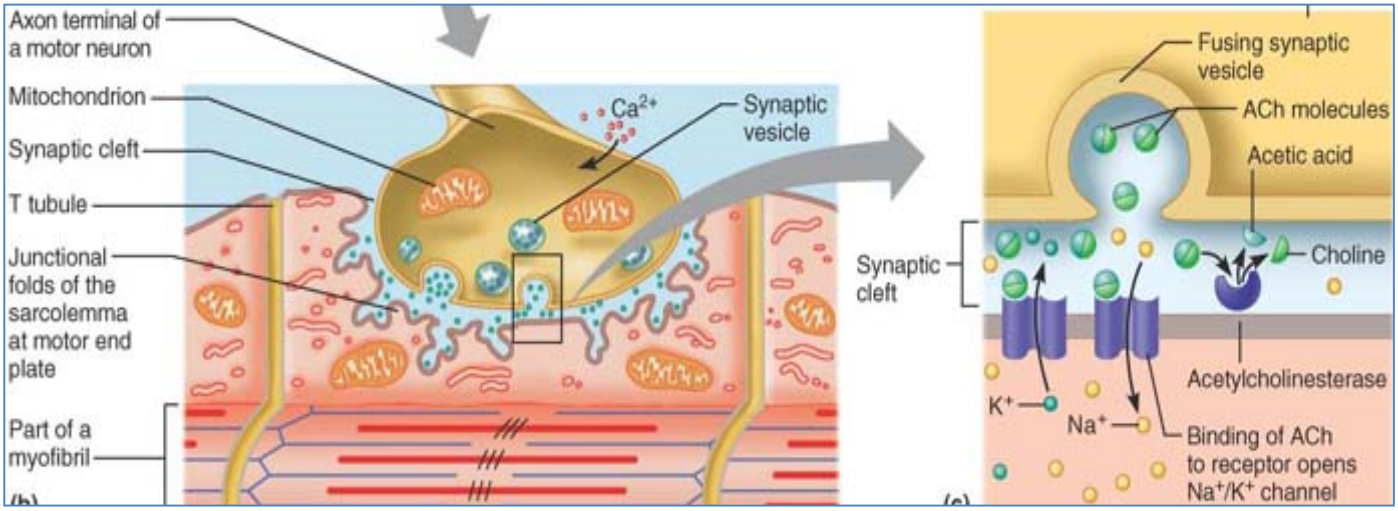
Contraction of Smooth Muscle:



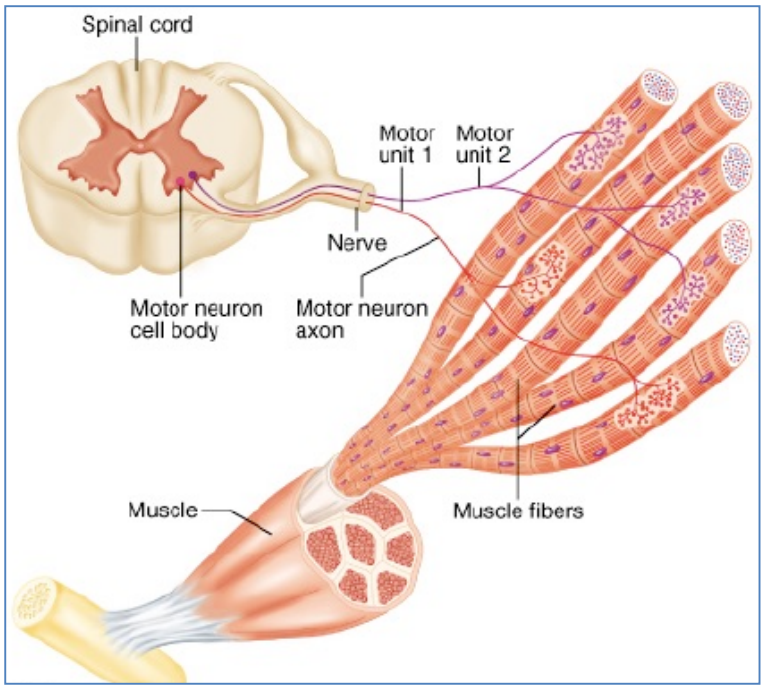
The Nerve-Muscle Interface (Efferent & Afferent)

Revision from last week:

- **Motor Neuron**
  - Cell bodies in the ventral horns of the spinal cord
- **Neuromuscular Junction**
  - Junction (synapse) between terminal parts of nerve & muscle fibres
  - Nerve terminals contain synaptic vesicles of **acetylcholine**
  - **Motor Endplate** – highly convoluted post-synaptic membrane
    - Site of neurotransmitter (ligand) gated receptors.
  - ACh causes depolarisation of muscle – Excitatory – stimulates contraction
  - **ACh** broken down by **acetylcholinesterase.**



- **Motor Unit**
  - The number of muscle fibres innervated by a single motor nerve.

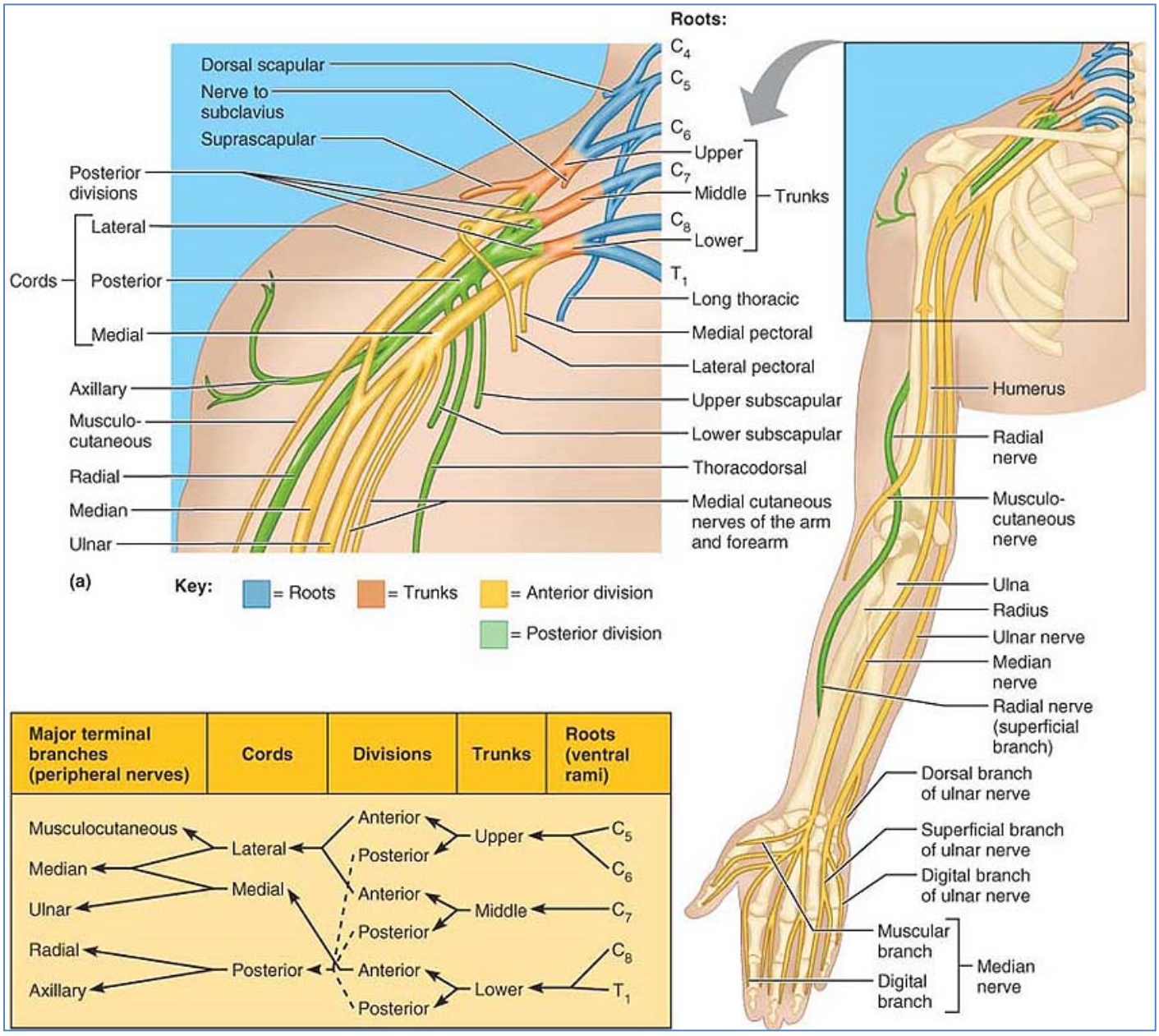


Requirements for Proper Muscle Function:

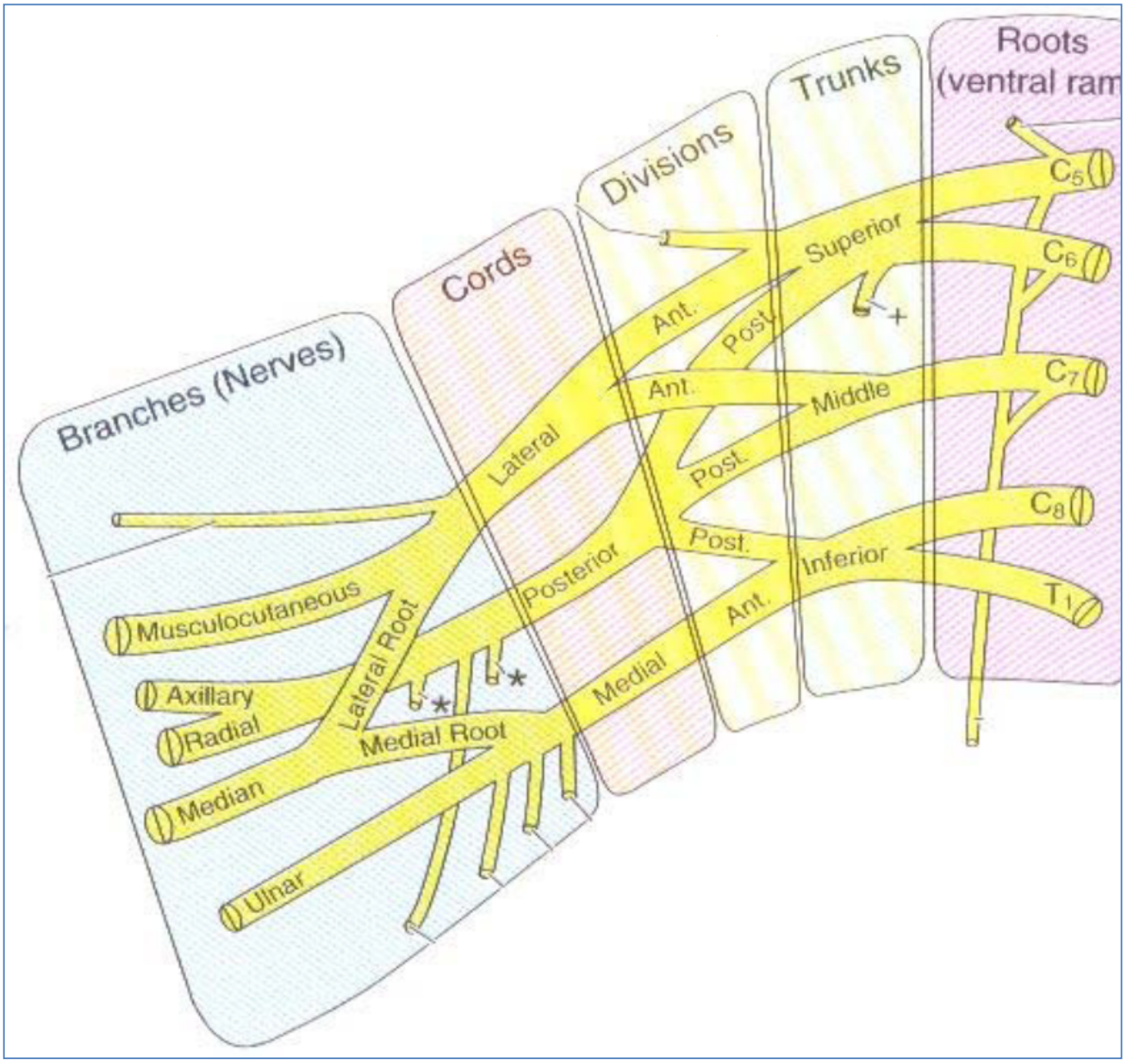
- **Rapid Action Potential –** see earlier notes: Excitable Membranes/Action Potentials
- **Input**
- **Sensory Feedback**
- **Muscle Tone**

Peripheral Nerves:

- Motor Fibres
- Sensory Fibres
- May form a **Plexus:**
  - Network of nerve fibres
  - Innervate limbs
    - Brachial
    - Lumbo-Sacral
  - Allows for well organised movements
  - Each limb receives nervous supply from more than one spinal nerve.
    - Provides backup innervation if some spinal fibres are damaged.
  - **Brachial Plexus:**

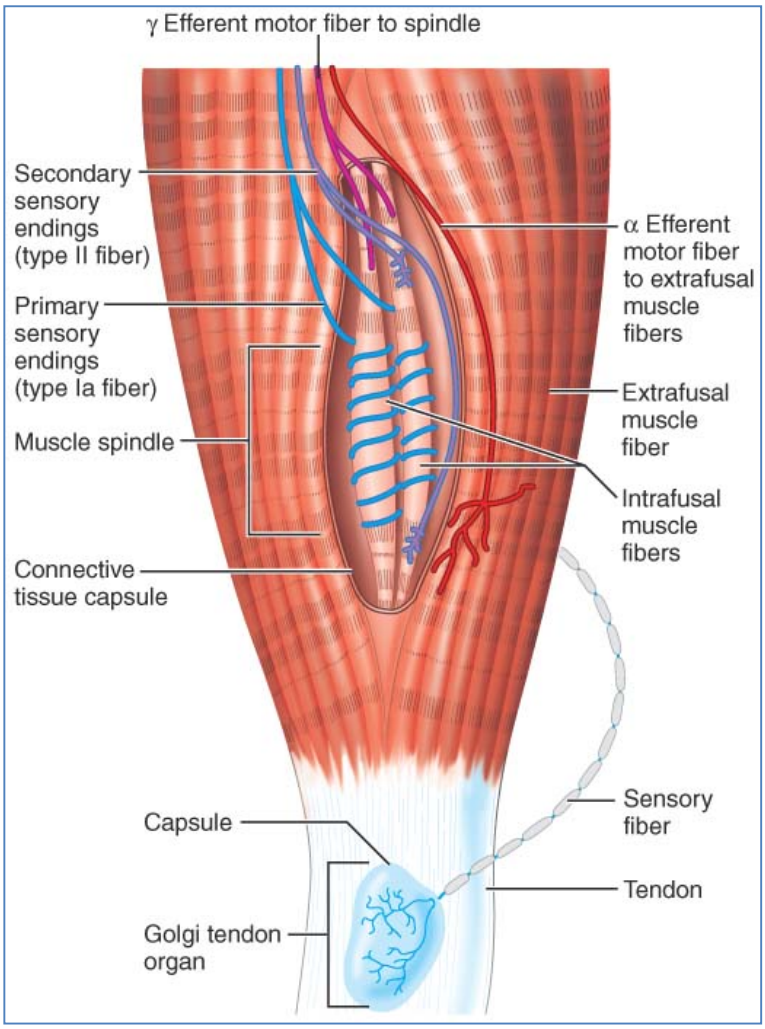


Major terminal branches (peripheral nerves)	Cords	Divisions	Trunks	Roots (ventral rami)
Musculocutaneous	Lateral	Anterior	Upper	C_5
Median		Posterior		C_6
Ulnar	Medial	Anterior	Middle	C_7
		Posterior		
Radial	Posterior	Anterior	Lower	C_8
Axillary		Posterior		T_1


Roots (ventral ram
Trunks
Divisions
Cords
Branches (Nerves)
C5
C6
C7
C8
T1
Superior
Middle
Inferior
Ant.
Post.
Ant.
Post.
Post.
Ant.
Lateral
Posterior
Medial
Lateral Root
Medial Root
Musculocutaneous
Axillary
Radial
Median
Ulnar

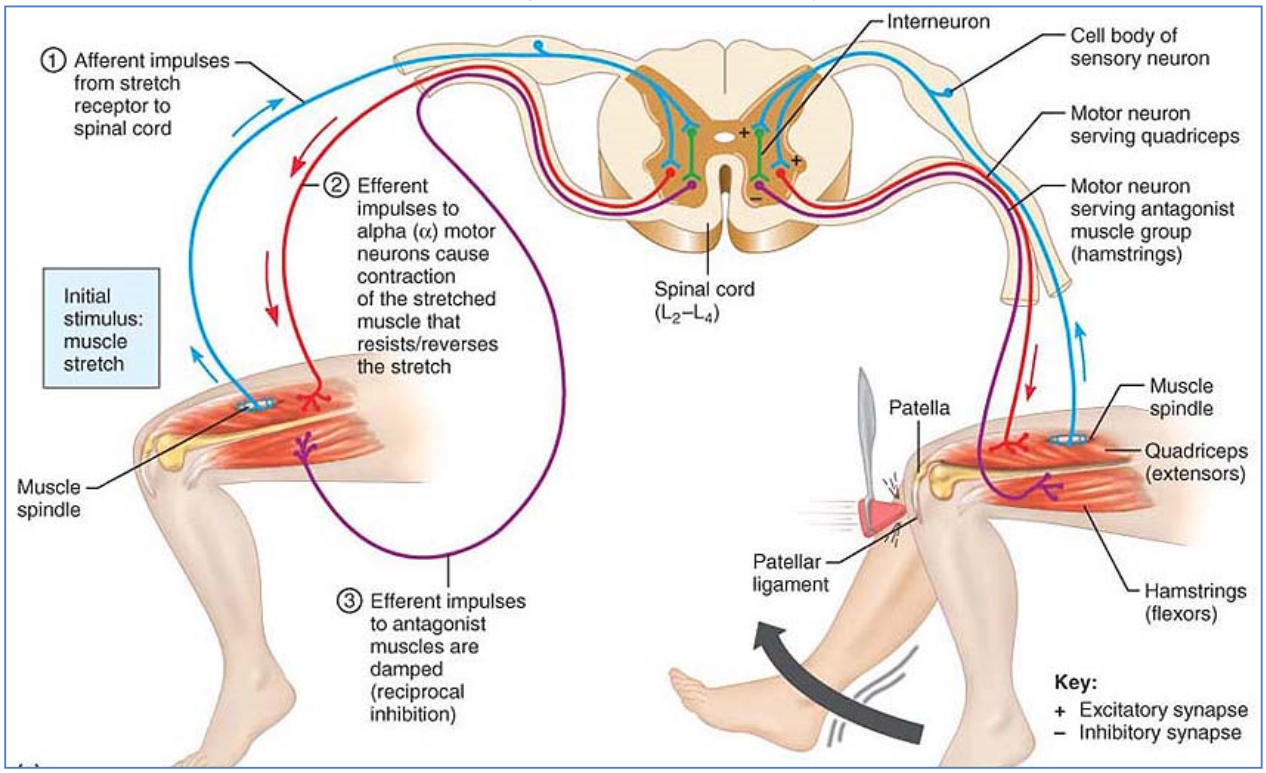
Muscle Sensory Feedback

- Muscles need to 'know what they are doing'
  - **Tension**...and....
  - **Length** of the muscle.
- **How? – Through "Proprioception"** (via proprioceptors)
  - Awareness of body positioning in space.
  - Mediated by Cerebral Cortex & Cerebellum
- **Proprioceptors:** (Muscle Spindles & Golgi Tendon Organs)

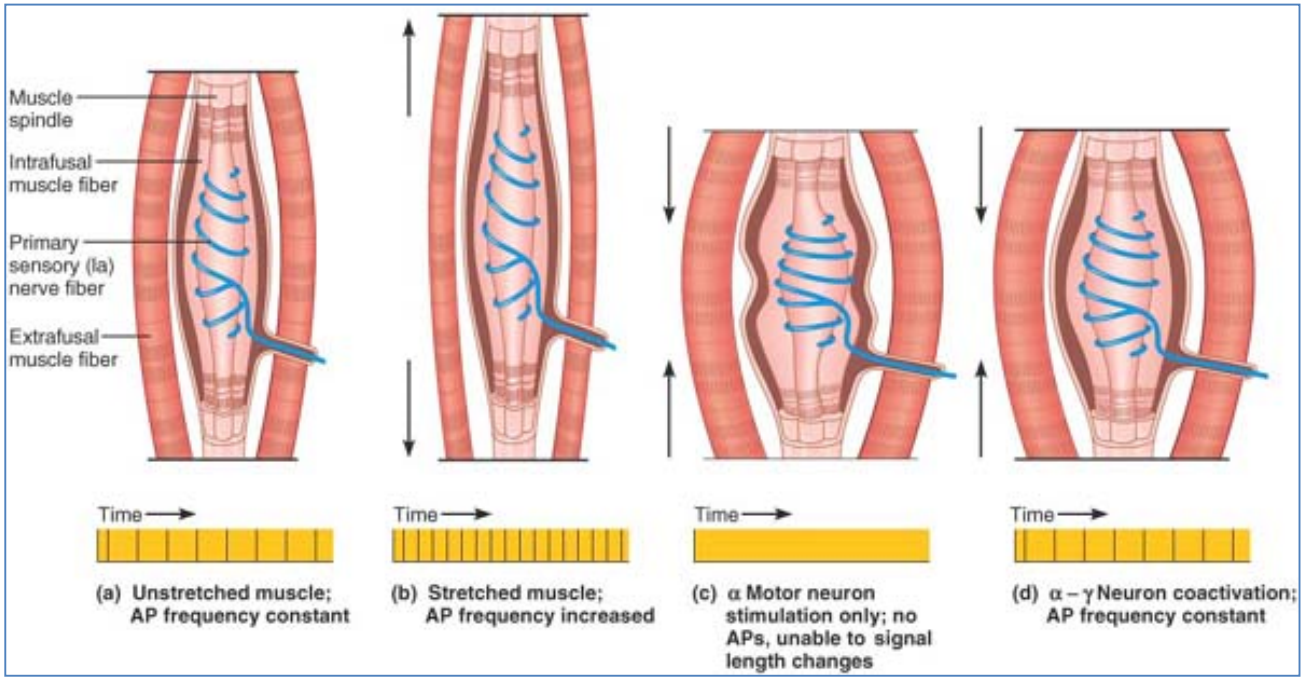


  - **Muscle Spindles:**
    - Encapsulated Proprio-Mechano-Receptors
    - Located inside muscle amongst normal (extrafusal) muscle fibres.
    - **Intrafusal Muscle Fibres** ("inside spindle")
      - **Receptive Central Region:**
        - Receptive
        - Non-contractile →Lack myofilaments
        - Wrapped by **primary** afferent endings of large **type Ia** sensory fibres:
          - Monitor **rate** & degree of **stretch**.
      - **Receptive Spindle Ends:**
        - Receptive
        - Wrapped by **secondary** afferent endings of small **type II** sensory fibres:
          - Monitor degree of **stretch** only.
      - **Distal Contractile Spindle Ends:**
        - Contractile →Contain myofilaments
        - Innervated by **gamma (γ) efferent fibres** – originate in ventral horn.
        - Maintain **spindle sensitivity.**

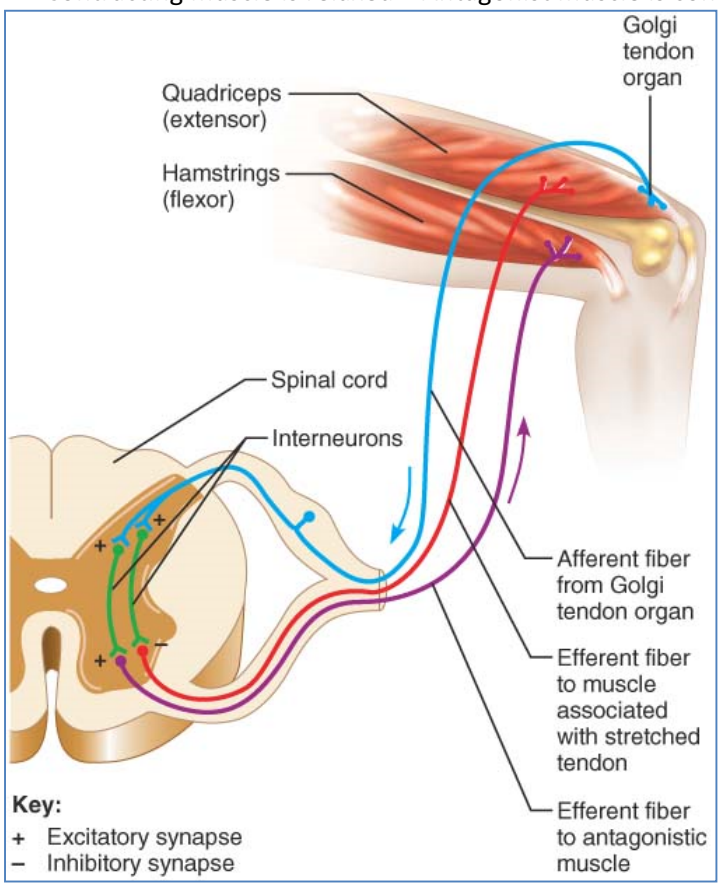
- **The Stretch Reflex:**
  1. Spindle activated by stretch
  2. Types Ia & II sensory fibres transmit impulses to spinal cord.
  3. Sensory fibres synapse with **α-Motor-Neurons** in spinal cord
  4. Transmits action potential to muscle
  5. Contracts extrafusal fibres of the stretched muscle
  6. Prevents further stretching of muscle
  7. Also inhibits antagonistic muscles → **Reciprocal Inhibition**



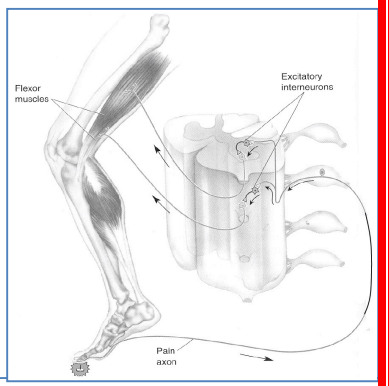
- **Adjusting Muscle Spindle Sensitivity:**
  - Muscle spindles require a certain tension to work properly.
  - If intrafusal fibres didn't contract with the extrafusal fibres during muscle contraction, the spindles would go slack & cease generating action potentials.
  - **α-γ Coactivation** prevents this by sending voluntary contractile action potentials to the intrafusal fibres as well as the extrafusal fibres.
  - Maintains spindle tension (and therefore its sensitivity)



- **Golgi Tendon Organs:**
  - Encapsulated Proprio-Mechano-Receptors
  - Innervated by **type Ib afferent fibres**
  - In tendons connecting to bone
  - Monitor muscle *tension*
  - Inhibits contraction of muscle when tension is too great - **Golgi Tendon Reflex:**
    - When tension reaches a threshold, Golgi tendon organs are activated.
    - Afferent impulses transmitted to spinal cord
    - Contracting muscle is relaxed + Antagonist muscle is contracted.



- **Cerebral Cortex & Cerebellum**
  - Integrates Afferent Input
  - Fine-tunes motor outputs
  - Subconscious level

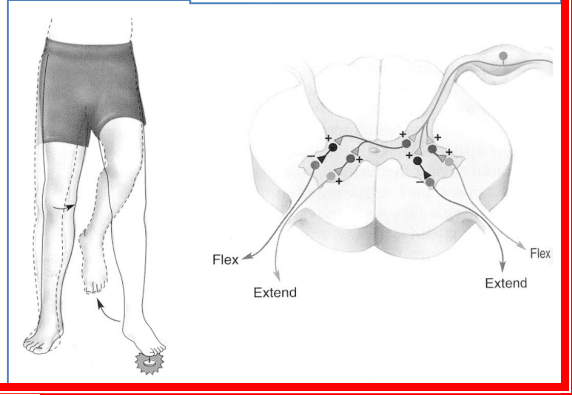


Flexor Reflex:

- Painful cutaneous stimuli of the limbs causes withdrawal from the stimulus.
- Polysynaptic – contracts & relaxes multiple different muscles.

Crossed Extensor Reflex:

- Painful cutaneous stimuli of a limb causes withdrawal of that limb and extension of the opposite limb.
- Information crosses over to opposite side of spinal cord → excites extensor muscles of opposite limb.

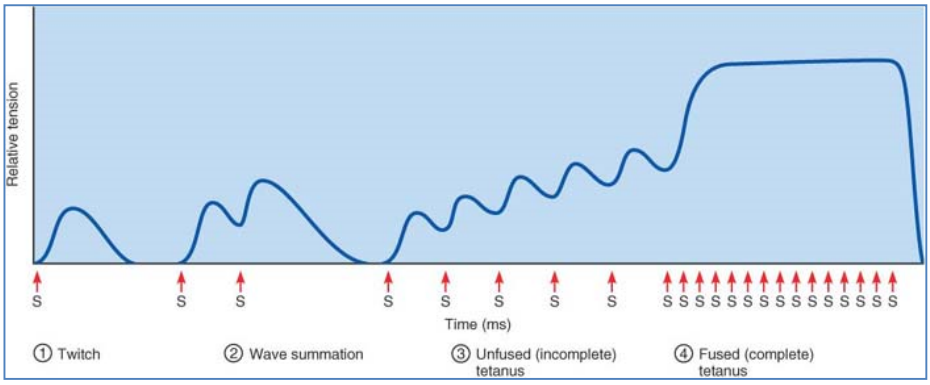


Muscle Tone:

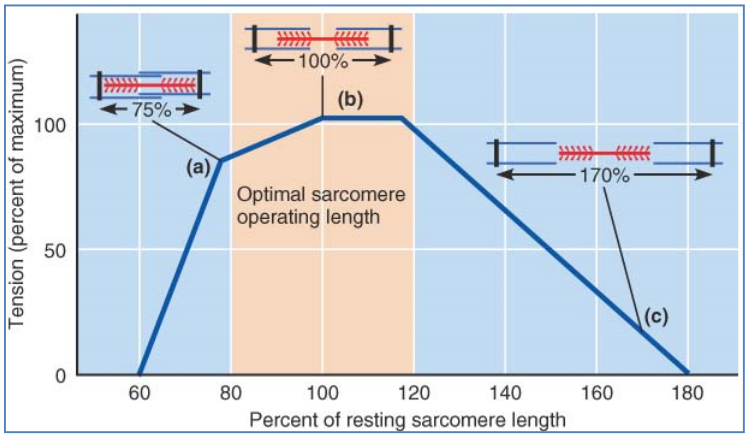
- Sustained partial contraction exhibited in 'relaxed' muscles.
  - In response to stretch receptors
- Keeps muscle poised & ready
- Keeps muscle healthy
- Maintains posture and stabilises joints.

Determinants of Contractile Force:

- **Number of Muscle Fibres Stimulated:**
  - The more motor units recruited, the greater the force.
  - The more muscle fibres recruited, the greater the force.
- **Size of Muscle Fibres Stimulated:**
  - Proportional to *cross-sectional area*
  - The larger the entire muscle→greater the force
  - The larger the muscle fibre →greater the force.
  - Muscle building causes *hypertrophy* of muscle fibres (cells).
- **Frequency of Stimulation:**
  - Wave summation of twitches
  - Cytosolic Ca^{2+} rises – contractile force increases
  - Highest frequency: **Tetanus.**



- **Degree of Muscle Stretch:**
  - Optimal: when all myosin heads can form cross-bridges.



- **Muscle Fibre Type:**
  - **White:**
    - Anaerobic
    - Larger cross-sectional area
    - Higher force generators
  - **Red**
    - Aerobic
    - Many mitochondria
    - Less force generated

The Structure of the Nervous System

The Nervous System - Overview:

- **Macro Structures:**
  - Brain
  - Spinal Chord
  - Peripheral Nerves
  - Sense Organs
    - Eyes
    - Ears
    - Tongue
    - Olfactory bulbs
    - Skin
- **Functions:**
  - Detection of stimuli (external/internal)
  - Response to stimuli
  - Coordinates activity of other organs & systems

Divisions of Nervous System:

- **Central Nervous System (the "CPU" & "Motherboard")**
  - Brain
  - Spinal Cord
- **Peripheral Nervous System (the "Cables")**
  - Cranial Nerves & Spinal Nerves
  - Communication between CNS & rest of body

<table>
<tr><th>Afferent / Sensory</th><th colspan="2">Efferent / Motor</th></tr>
<tr><td rowspan="2">Somatic & Visceral Nerve Fibres.
Conducts Impulses from receptors to CNS</td><td>Somatic (Voluntary)</td><td colspan="2">Autonomic (Involuntary)</td></tr>
<tr><td rowspan="2">Motor Function</td><td>Sympathetic</td><td>Parasympathetic</td></tr>
<tr><td>Mobilises body systems.
Fight / Flight Response</td><td>Conserves Energy.
Housekeeping Duties</td></tr>
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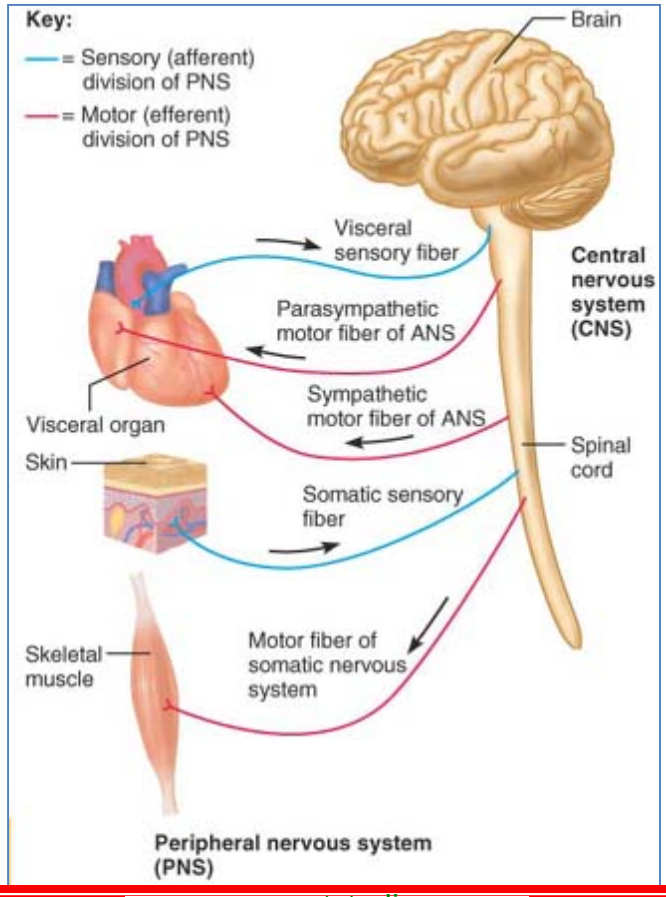
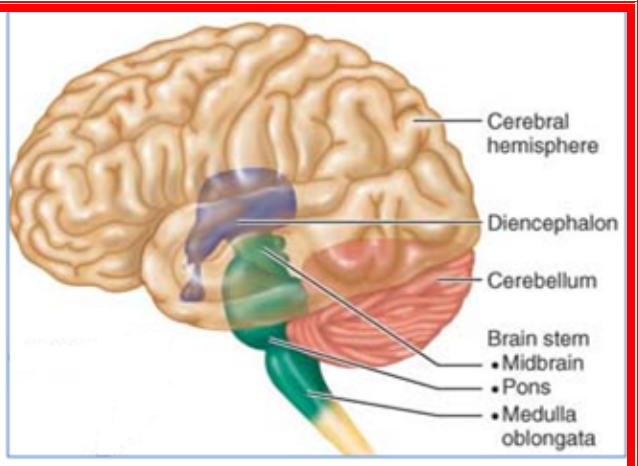


Central Nervous System – Functional Anatomy:

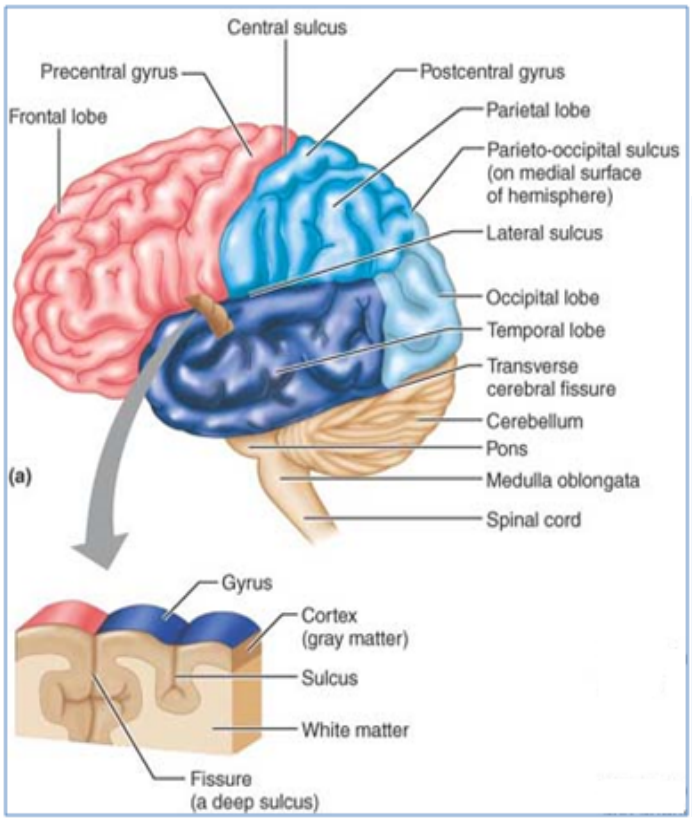


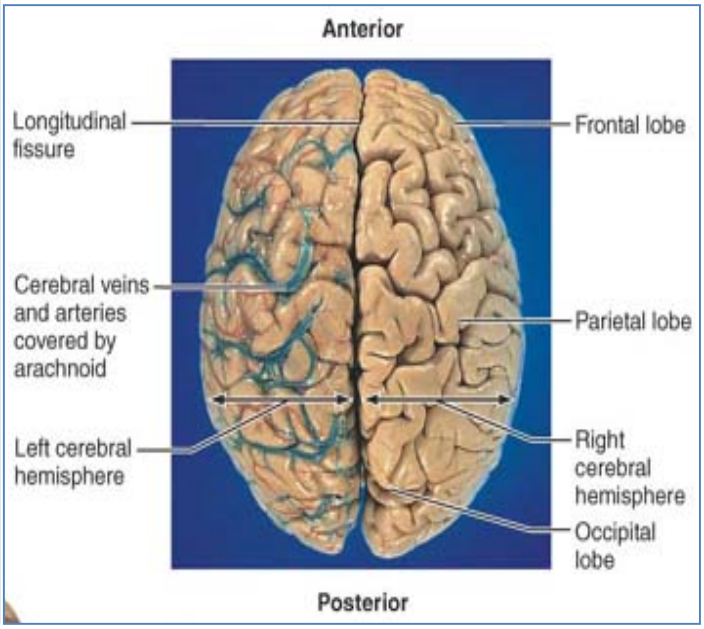
- **Brain:**
  - **Cerebrum**
    - **Telencephalon (Cerebral Hemispheres)**
      - 83% of total brain mass
      - Marked by elevated ridges of tissue

Cerebral Cortex

- Superficial Layer of **Grey Matter**
- Highly convoluted – High surface area

Sulci: ("Furrows")	Gyri: ("Twisters")	Fissures:	Lobes:
• Shallow grooves on cerebrum surface • Increases surface area • Forms boundaries of different functional regions • **Central Sulcus** separates frontal lobe from parietal lobe • **Lateral Sulcus** separates temporal lobe from frontal & parietal lobes.	• Elevated ridges created by Sulci. • Represent locations of specific functional regions.	• Deeper grooves on cerebrum surface • Separate the lobes of the brain • **Longitudinal Fissure** separates cerebral hemispheres • **Transverse Cerebral Fissure** separates cerebrum from cerebellum	• Frontal • Parietal • Temporal • Occipital

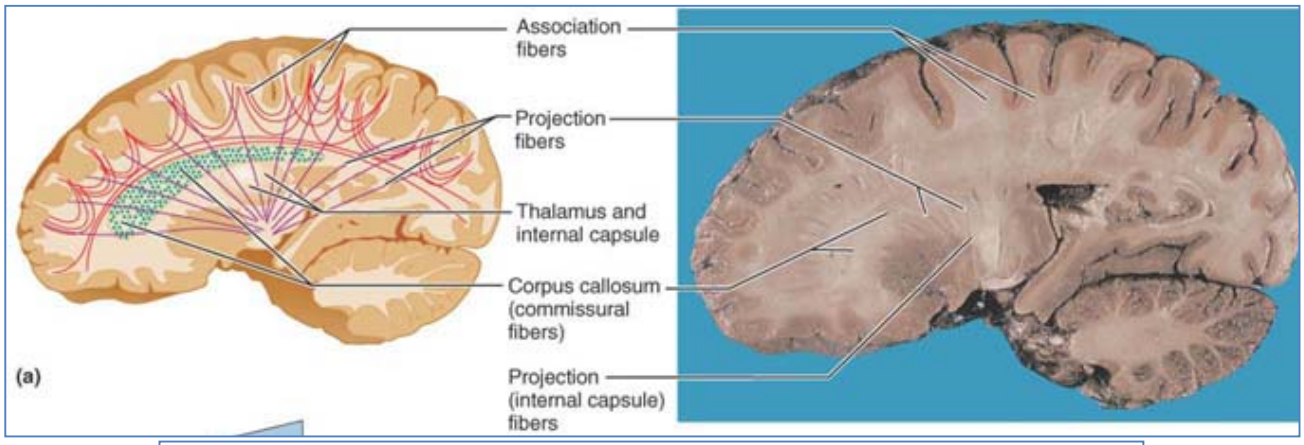


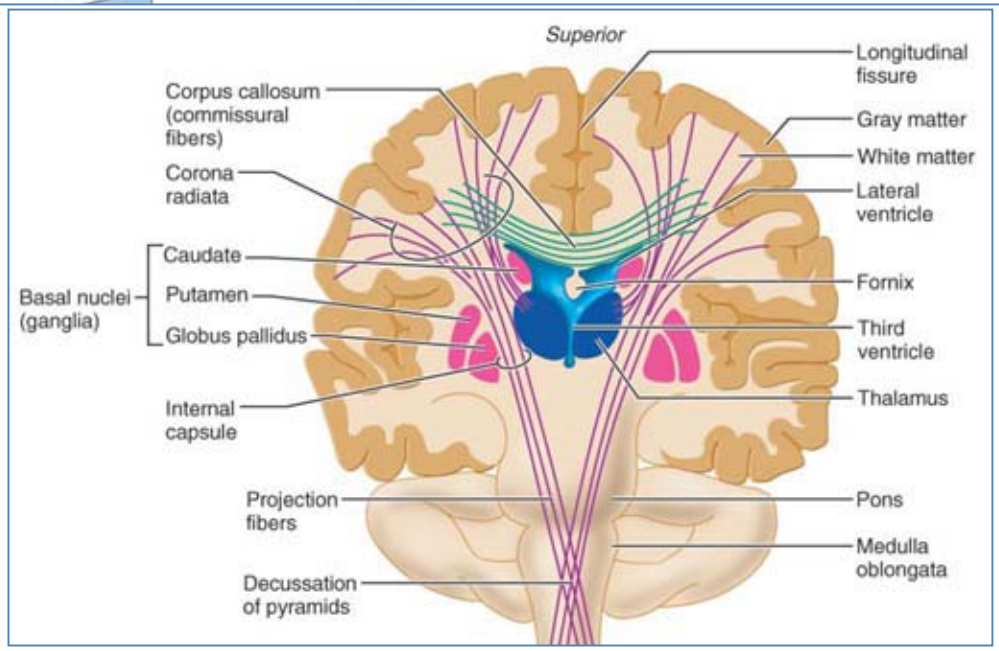


Cerebral White Matter:

- Located just deep to the cortex
- Myelinated axons connecting cells of different areas of cortex

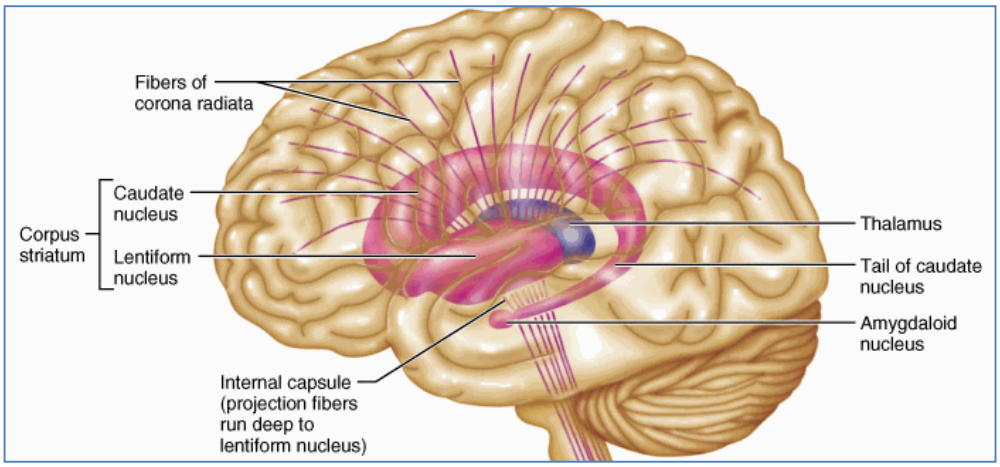
Association Fibres:	Commissural Fibres: (corpus Callosum)	Projection Fibres:
• Connects cortical regions of the **same hemisphere.**	• Connects cortical regions of **different hemispheres.**	• Connects hemispheres of cortex to lower CNS areas.





Bassal Nuclei: (Ganglia)

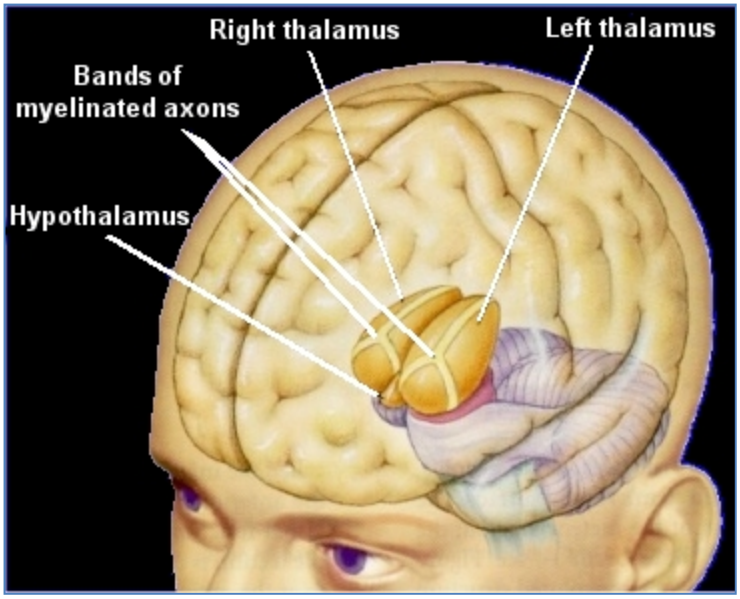
- Collections of functional Nuclei – **basal ganglia**
- Located deep to the sub-cortical white matter.
- **Corpus Striatum**



▪ Diencephalon (grey matter superior to brainstem)

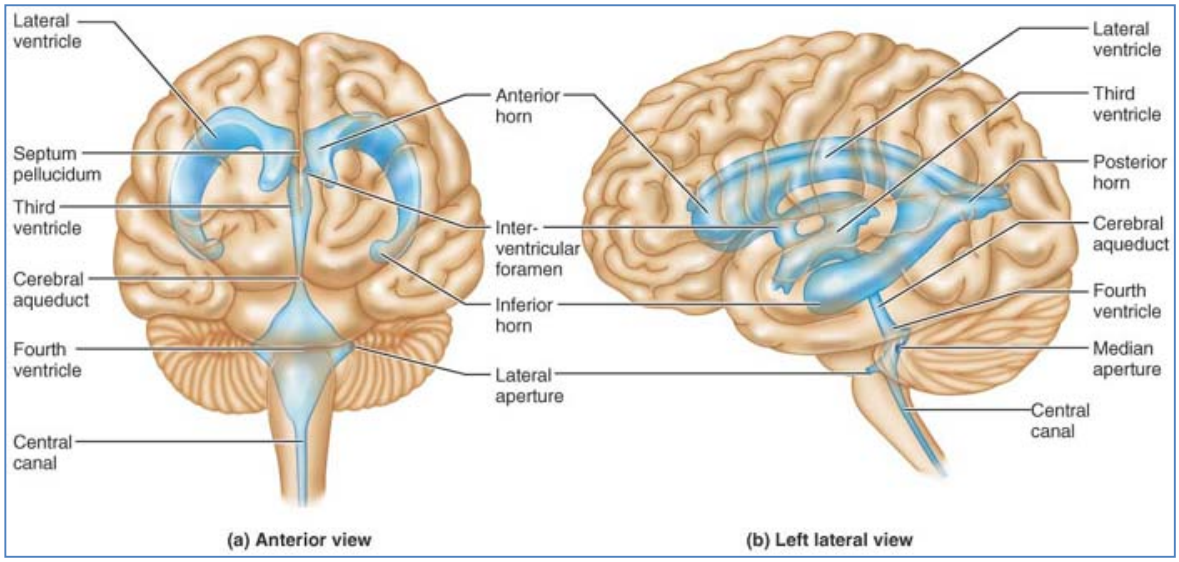
- Central core of forebrain

Thalamus "Inner Room"	Hypothalamus	Posterior Pituitary	Epithalamus
• 80% of Diencephalon • The **afferent** gateway to the cerebral cortex • Mediates sensation, motor activities, cortical arousal, learning & memory.	• Main visceral control center • Maintains overall body homeostasis ➢ Controls Autonomic Nervous System ➢ Emotion ➢ Thermoregulation ➢ Nutrient uptake, hunger, sugar levels ➢ H_2O balance & thirst ➢ Sleeping cycles ➢ Endocrine functions	• Endocrine Functions	• Also regulates sleeping cycles.

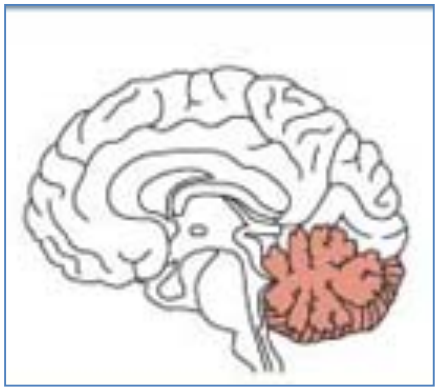


▪ Ventricles

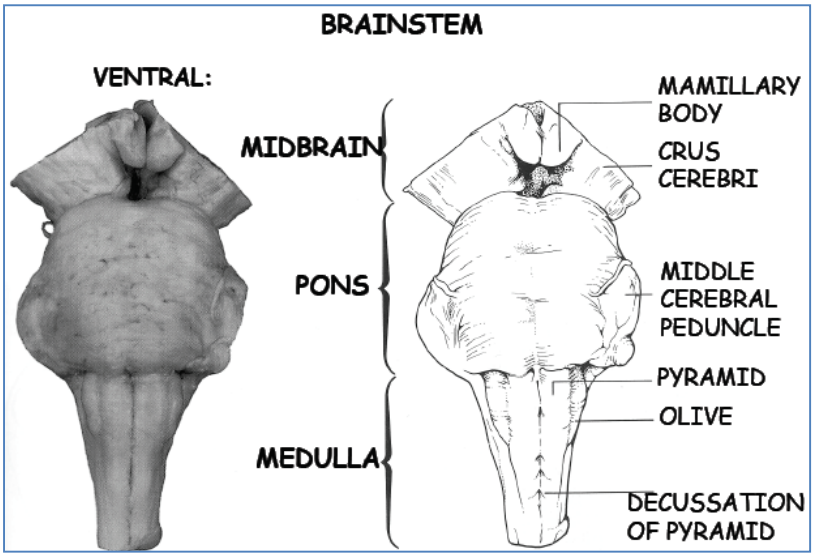
- Hollow ventricular chambers
- Continuous with one another
- Continuous with the central canal of the spinal cord.
- Continuous with the sub-arachnoid space surrounding the brain.
- Filled with cerebrospinal fluid
- Lined by ependymal cells



- **Cerebellum**
  - Posterior to brainstem – beneath occipital lobe
  - Controls maintenance of balance, posture & muscle tone
  - Coordinates movement



- **Brainstem**
  - Connects Diencephalon → Spinal Cord
  - Integrates acquired information (central/peripheral)
  - Monitors all brain outputs
  - Processes automatic control systems
  - Many of the cranial nerves originate here.
  - **3 Parts:**
    - **Midbrain**
    - **Pons**
    - **Medulla Oblongata** – becomes the brainstem @ Foramen Magnum.



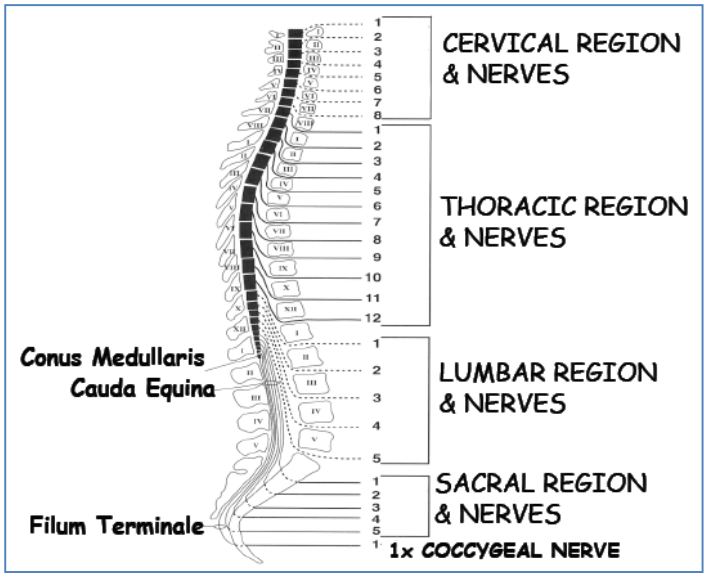
- **Spinal Cord**
  - Extends from Foramen Magnum
  - Resides in the vertebral canal
  - Bathed in cerebrospinal fluid
  - Terminates at the 'conus medullaris' (cone of medulla) – approx L1 in adults.
  - **Cauda Equina:**
    - Nerve rootlets of lower-lumbar & sacral regions extend further down vertebral canal.
  - **Filum Terminale:**
    - Conn. Tissue anchors Cauda Equina to the base of vertebral canal.

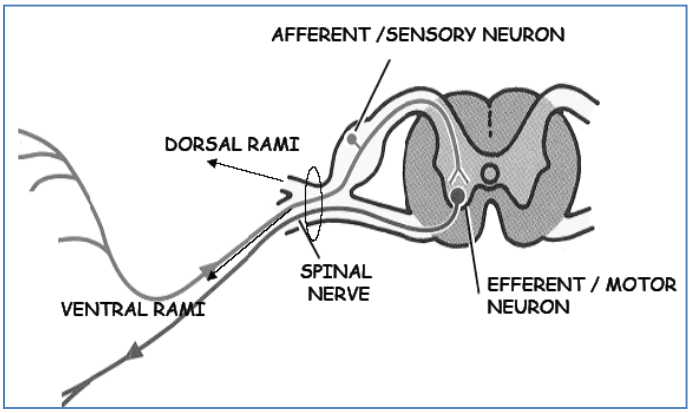
Internal Structure:

- **Grey Matter:**
  - All neuronal cell bodies
  - 2 Dorsal Horns
    - Nerve cells that receive sensory information from body
    - Via the dorsal root fibres.
  - 2 Ventral Horns
    - Contain motor nerve cells
    - Cell axons leave through ventral root fibres.
  - Lateral Horns:
    - Present in thoracic & upper lumbar regions
    - Autonomic motor nerves from sympathetic nervous system
    - Exit spinal cord through the ventral roots
- **White Matter:**
  - Ascending and descending fibre tracts.

External Structure:

- **Spinal Nerves:**
  - Merging of the Dorsal & Ventral root fibres
  - Carry mixed sensory & motor info to relevant body area
- **Branches of Spinal Nerves:**
  - **Ventral Rami:** "ventral branch"
  - **Dorsal Rami:** "dorsal branch"
- **Sympathetic Chain**
- **Sympathetic Ganglia:**

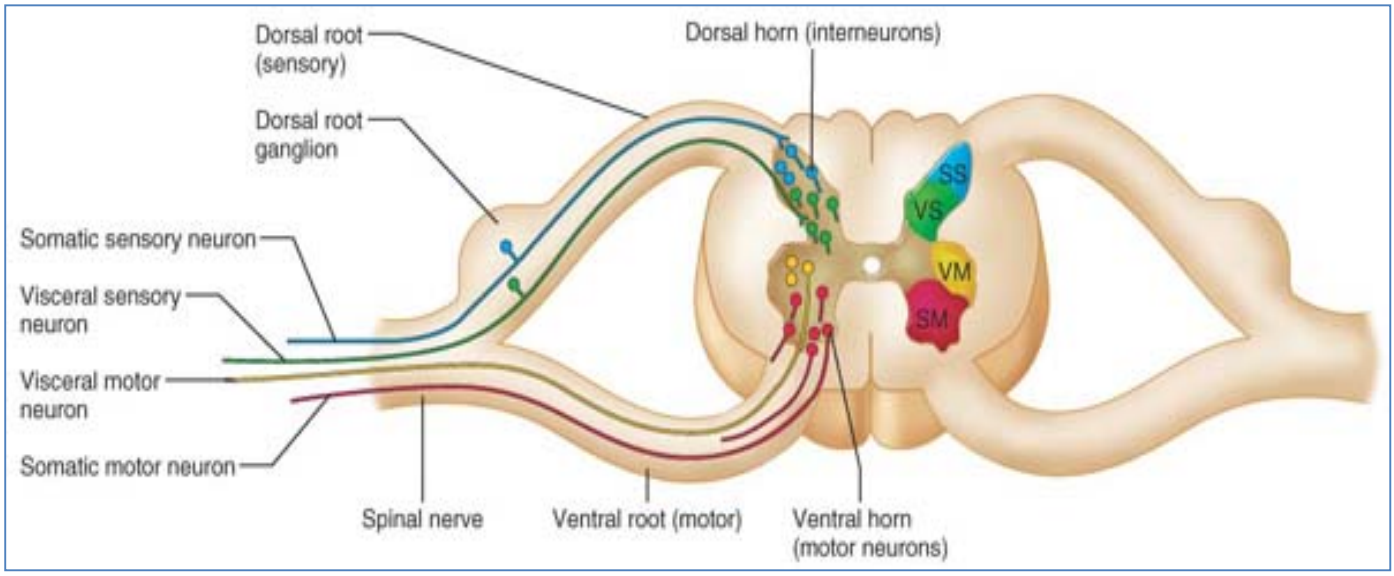




Information Pathways: Central → Peripheral

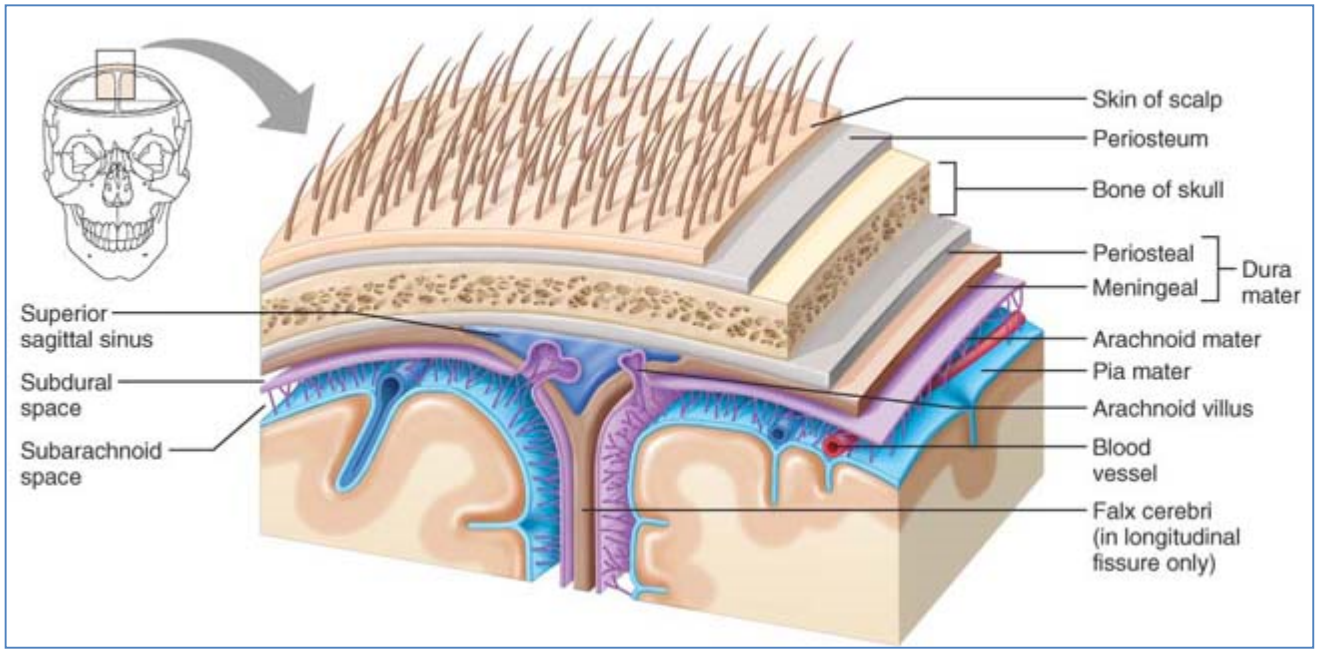
Somatic:	
• **Afferent (Sensory Info)** ○ Receptor cells in periphery ○ Info conveyed along peripheral axon → Soma (in dorsal root ganglion) ○ Info conveyed along proximal axon → spinal cord (CNS) ○ Info → ascending fibres (white matter) → brain for processing	• **Efferent (Skeletal Muscle)** ○ Neuronal cell bodies in ventral horn of grey matter. ○ Cell axon leaves spinal cord through ventral root → spinal nerve ○ Axon flows out of Ventral Rami ○ Directly innervates muscle @ neuromuscular junction

Visceral:	
• **Afferent (Sensory Info)** ○ Receptors in viscera ○ Info conveyed along peripheral axon → Soma (in dorsal root ganglion) ○ Info conveyed along proximal axon → spinal cord (CNS) ○ Info → ascending fibres (white matter) → brain for processing	• **Efferent (Smooth Muscle)** ○ Neuronal cell bodies in lateral horn of grey matter. ○ Cell axon leaves spinal cord through ventral root → spinal nerve ○ Axon flows out of Ventral Rami ○ Axon synapses with peripheral ganglia ○ Peripheral ganglia innervates internal viscera: ▪ smooth muscle/glandular tissue/cardiac muscle



Protection of CNS:

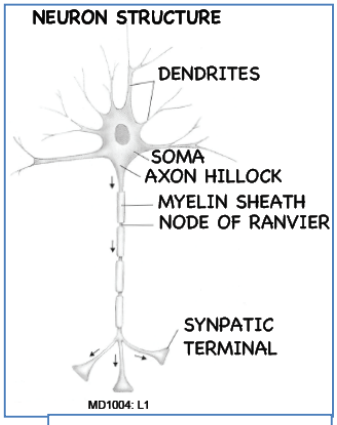
- **Bone**
  - Skull
  - Vertebra
- **3 Meningeal Layers:**
  - **Dura Mater (brain only)**
    - Thick, leathery film of Conn.Tiss.
    - Lines inside of bone of skull
  - **Arachnoid ("spider") Mater**
    - Thin, loose brain covering film.
    - Separated from Dura Mater by a serous cavity, the Subdural Space.
    - Underneath = subarachnoid space
    - Weblike extensions span this space, anchoring it to the underlying Pia Mater
  - **Pia Mater**
    - Delicate Conn.Tiss.
    - Rich in capillaries
    - Clings tightly to brain – even into sulci & fissures.
- **Cerebrospinal Fluid:**
  - Found in & around brain & spinal chord
  - Forms a liquid cushion
  - Gives buoyancy to CNS structures
  - Adds nourishment (in addition to blood)



- **Blood-Brain Barrier:**
  - Maintains a stable environment for brain
  - In other body regions, concentrations of hormones/amino acids/ions are constantly changing.
  - However, the brain is **absolutely** dependant on constant conditions – therefore must be kept separate from the blood.
  - **How?:**
    - Capillary endothelial cells seamlessly joined by **tight junctions**.
    - Selective passive diffusion of nutrients (glucose/essential amino acids/some electrolytes)
    - Bloodborne metabolic wastes/proteins/toxins/most drugs are denied entry.
    - Not only are some substances denied access, they are also actively removed.
  - Ineffective against fats/fatty acids/oxygen/CO_2/alcohol/nicotine/anaesthetics. – diffuse across PM.

The Musculo-Skeletal System

Introduction to the Nervous System



Receptive Field:
- stimulated by inputs

Cell Body:
- responds to graded inputs

Efferent Projection:
- conducts nerve impulses to target
- myelinated/unmyelinated

Output:
- chemical signal to target

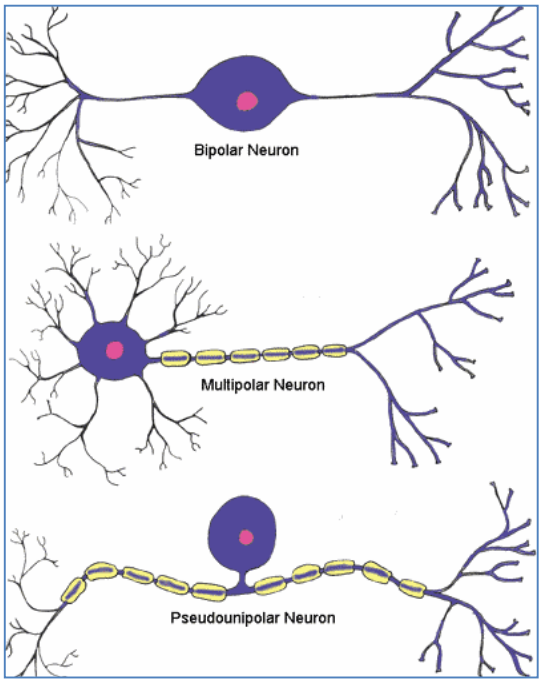
2 Types of Cells:

- **Neurons**
  - Basic functional unit
  - Impulse conduction
    - Salutatory (myelinated)
    - Continuous (unmyelinated)
  - Stimulate muscles & glands

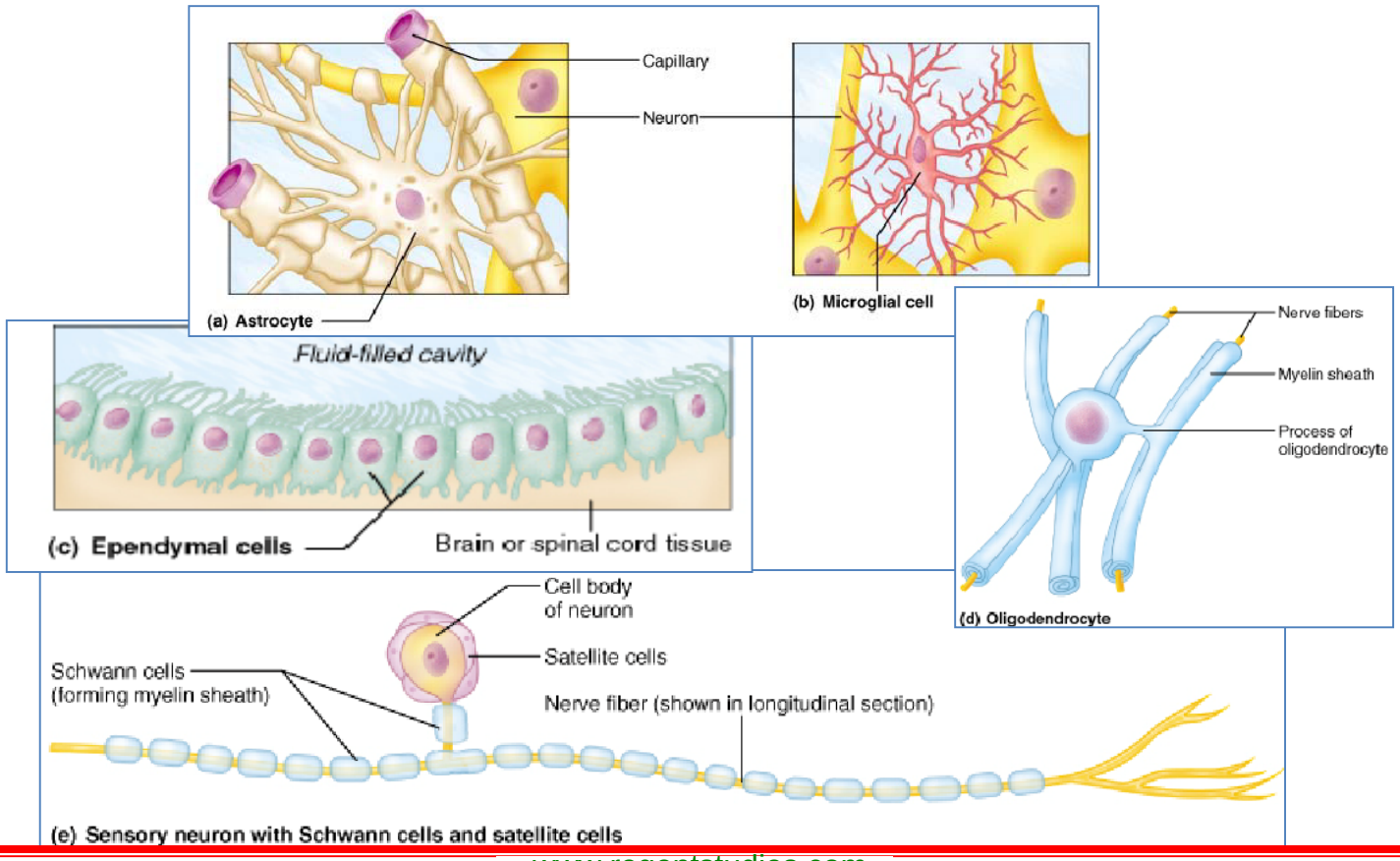
  - '**Communication'** cells of the NS
    - **Afferent** – Incoming information (graded inputs)
      - Dendrites
      - Cell Body
    - **Efferent** – Outgoing information (action potentials)
      - Axon

  - **Specialized Structures & Organelles**:
    - **Structures:**
      - **Neurites:** Axon + Dendrites
        - Branched axons = **'collaterals'**
      - **Myelination:**
        - Produced by Schwann cells in PNS
        - Produced by Oligodendrocytes in CNS
        - Insulates axon
        - Speeds up Action Potential Propagation
    - **Organelles:**
      - **Rough ER (nissl bodies):** protein synthesis
      - **Smooth ER:** lipid synthesis
      - **Golgi:** Storage & transport of secretory products

  - **Types of Neurons:**
    - **Multipolar:**
      - 99% of all neurons
      - Many dendrites
      - 1 myelinated axon
    - **Pseudounipolar:**
      - T-shaped
      - Receptive endings (not dendrites)
      - Long, myelinated axon
        - Central end
        - Peripheral end
          - Sensory receptors
    - **Bipolar:**
      - In Retina + Olfactory mucosa.
      - T-Shaped
      - Long Dendrite
      - Long Axon

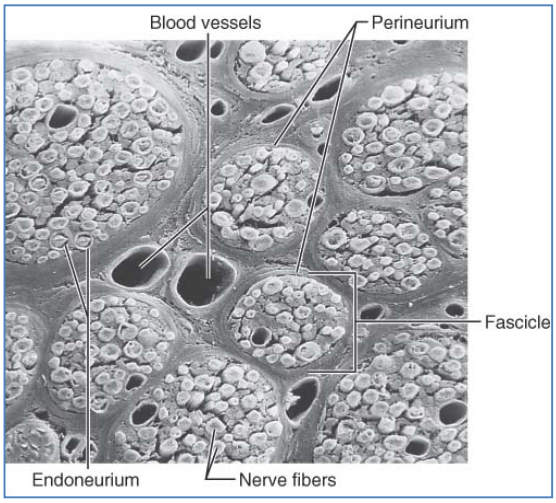


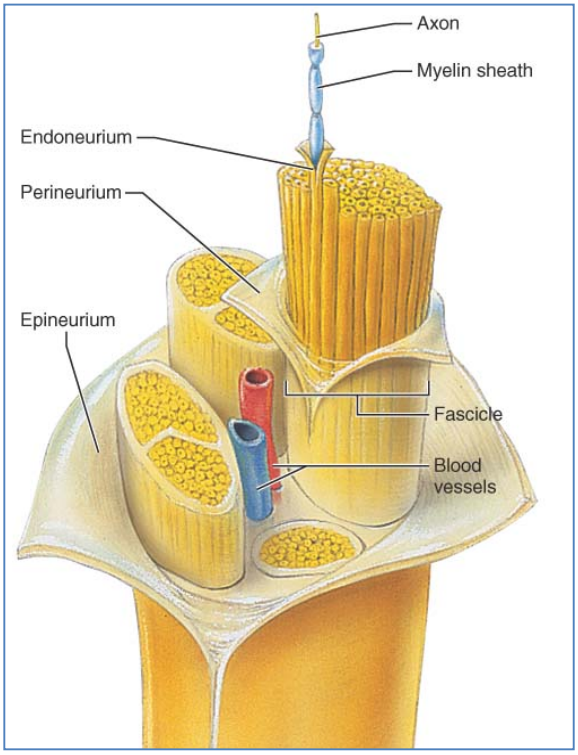
- **Neuroglia (Glia)**
  - Smaller **support cells** of NS
  - Outnumber neurons 10:1
  - Structural & mechanical support
  - Roles in maintaining homeostasis
  - Myelination
  - Immune responses via phagocytosis.
  - **Types of neuroglia:**
    - **CNS:**
      - **Astrocytes**
        - Nutrient bridge between neuron & capillaries
        - Guide migrating young neurons
        - Synapse formation
        - Mop up excess K^+ ions + neurotransmitters
      - **Oligodendrocytes**
        - Myelin formation in CNS
      - **Microglia**
        - Long thorny processes
        - Monitors neuron health
        - Senses damaged neurons
        - Migrates to damaged neuron
        - Phagocytoses microbes & debris (immune cells are denied access to CNS)
      - **Ependymal Cells**
        - Lines central cavities of brain + spinal chord
        - Blood-brain barrier
        - Beating cilia circulates cerebrospinal fluid
    - **PNS:**
      - **Schwann Cells**
        - Myelin Formation – wrap around axon
        - Regeneration of damaged neurons
      - **Satellite cells**
        - Surround neuron bodies
        - Structure, nutritional support & protection.



Connective Tissue Sheaths on Peripheral Nerves:

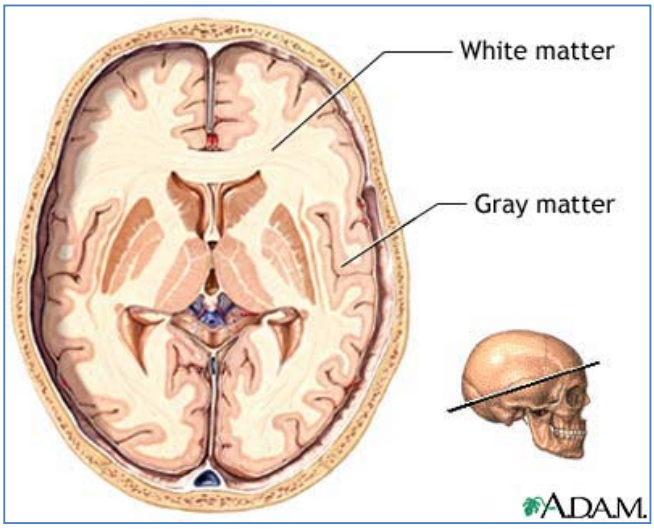
- **Endoneurium**
  - Delicate connective tissue layer
  - Surrounds each axon
- **Perineurium**
  - Coarser connective tissue layer
  - Bundles groups of fibres into **fascicles**
- **Epineurium**
  - Tight, fibrous sheath
  - Bundles fascicles into a **single nerve**.
  - Houses blood vessels





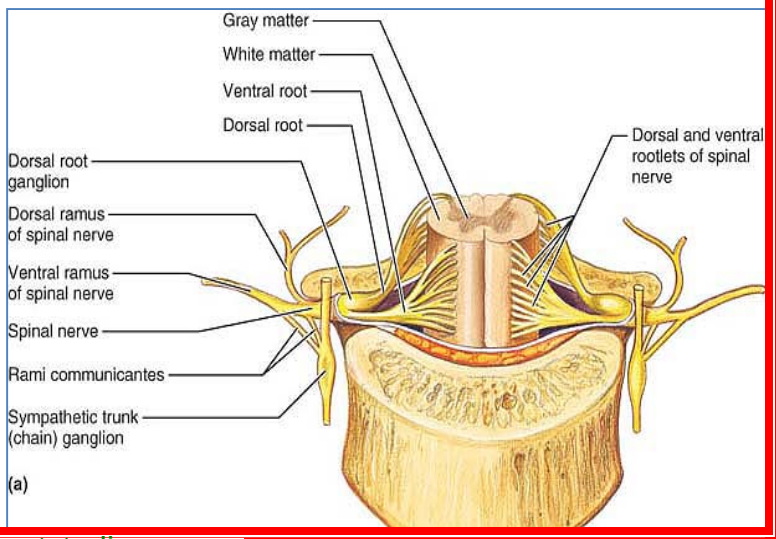
Grey Matter & White Matter:

- **Grey Matter**
  - Neuron bodies (Soma)
  - Imbedded in neuroglial cells
  - Eg:
    - Cortex of Brain
    - Centre of Spinal Chord
    - Ganglia/nuclei
- **White Matter**
  - Neuron fibres (axons & dendrites
  - White due to myelin
  - Eg:
    - Peripheral Nerves & Plexuses
    - Central fibre tracts



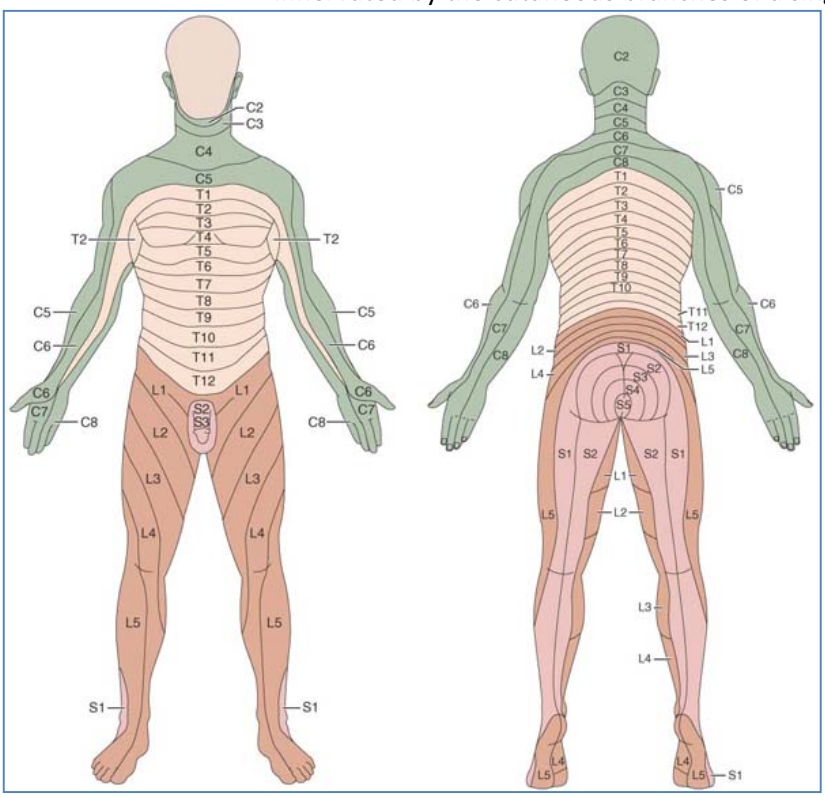
Ganglia

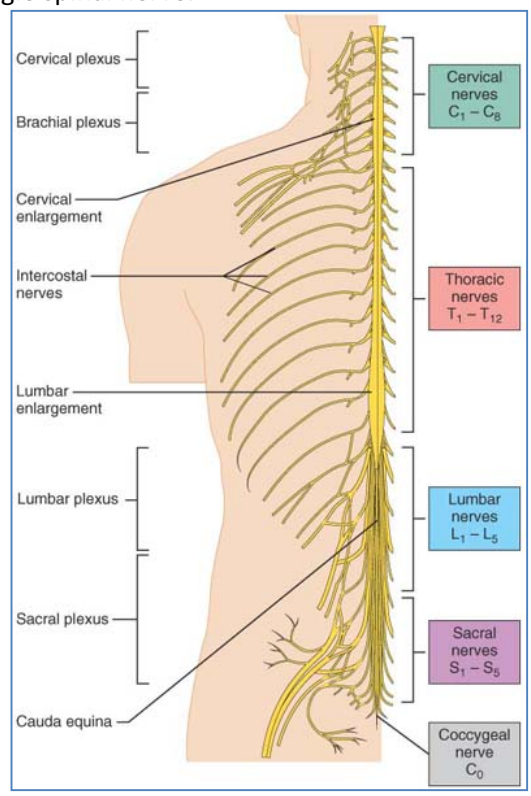
- **Collections** of neuron **cell bodies** in **PNS**
  - **Afferent** Spinal Nerves:
    - Cell bodies of sensory neurons
    - 'Dorsal root ganglion'
  - **Efferent** Spinal Nerves:
    - Cell bodies of autonomic nerve fibres
    - 'Sympathetic trunk ganglion'
  - **In Central Nervous System:**
    - Called: **Basal Nuclei / Nuclei**



Spinal Nerves:

- **Innervation of the Skin:**
  - **Dermatomes:**
    - A portion of the mesoderm (skin, sensory receptors, sebaceous glands, blood vessels) innervated by the cutaneous branches of a single spinal nerve.





- **Innervation of the Skeletal Muscles**
  - **Cervical Plexus**
  - **Brachial Plexus**
  - **Lumbar-Sacral Plexus**

Cranial Nerves:

I. **Olfactory**
   - Smell

II. **Optic**
   - Vision

III. **Oculomotor ('eye-mover')**
   - Controls 4 of the 6 eye muscles.

IV. **Trochlear ('pulley')**
   - Controls 1 of the extrinsic eye muscles – pulley shaped

V. **Trigeminal**
   - 3-branched sensory fibres to the face and mastication muscles

VI. **Abducens ('abduct')**
   - Controls the extrinsic eye muscle that abducts the eyeball (lateral rotation)

VII. **Facial**
   - Facial expression

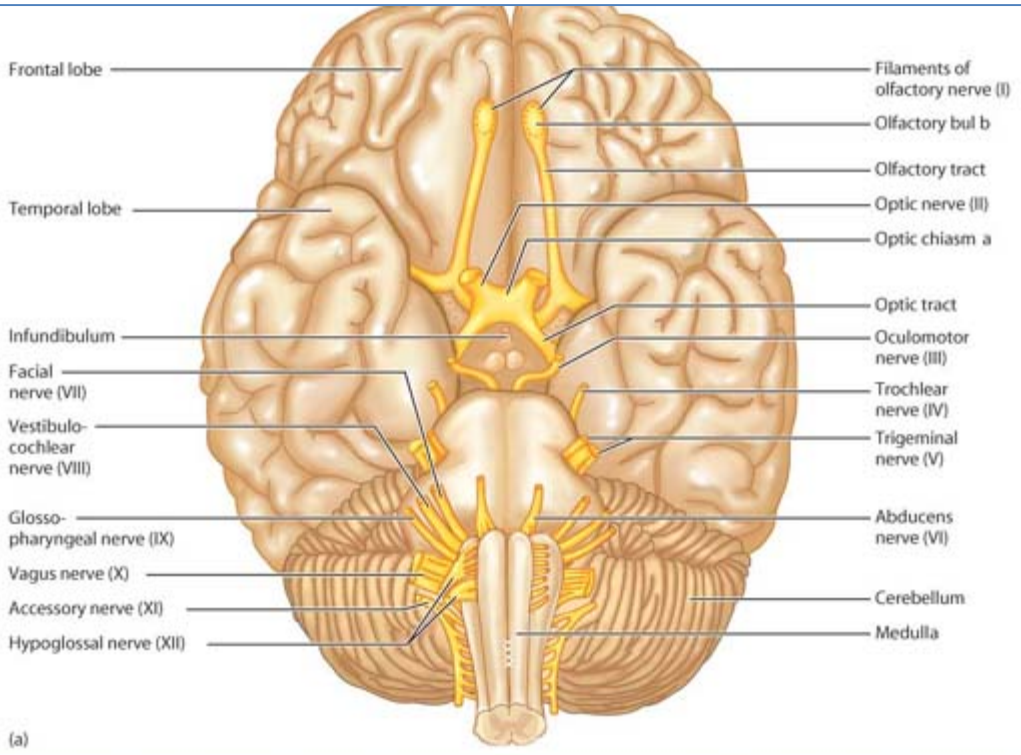
VIII. **Vestibulocochlear**
   - Hearing and balance (formerly the auditory nerve)

IX. **Glossopharyngeal ('tongue & pharynx')**
   - Tongue and pharynx

X. **Vagus ('the wanderer')**
   - The only nerve to extend beyond the head and to the thorax & abdomen.

XI. **Accessory**
   - An accessory part of the Vagus nerve

XII. **Hypoglossal ('under-tongue')**
   - Runs beneath the tongue to control tongue movement.



(a)

Cranial nerves I – VI	Sensory function	Motor function	PS* fibers
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

Cranial nerves VII – XII	Sensory function	Motor function	PS* fibers
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	Some	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

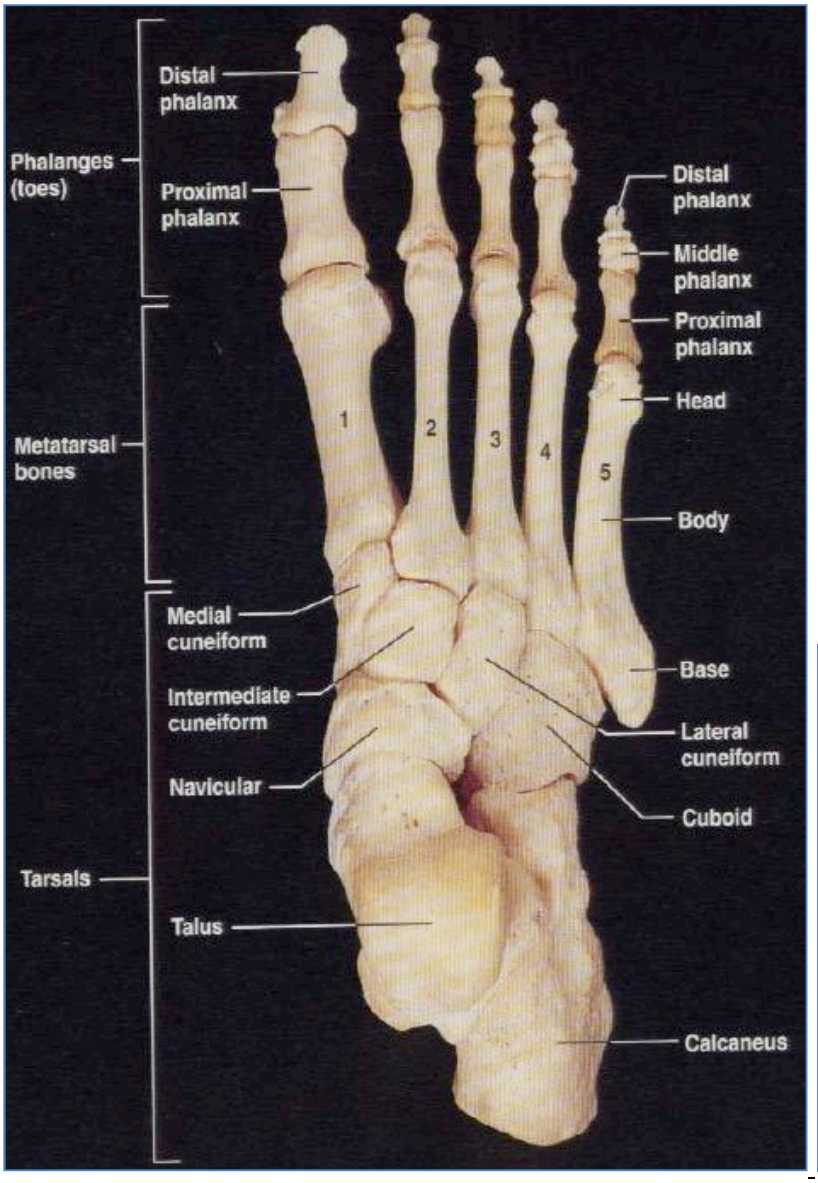
(b) *PS = parasympathetic

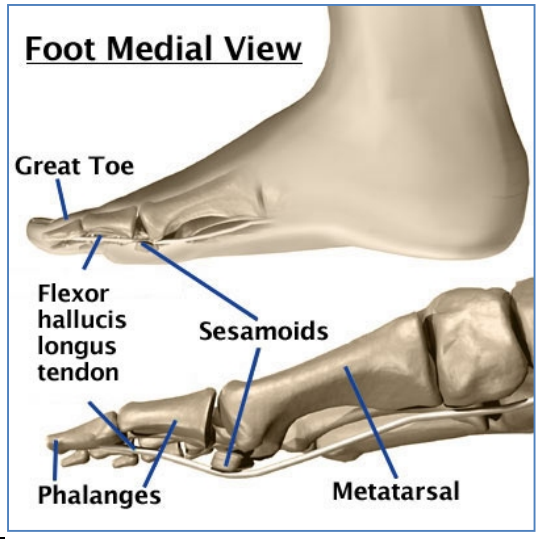
Bones, Joints & Muscles of the Lower Leg & Foot

(NB: vasculation & innervation covered in wk 10s notes)

Bones:

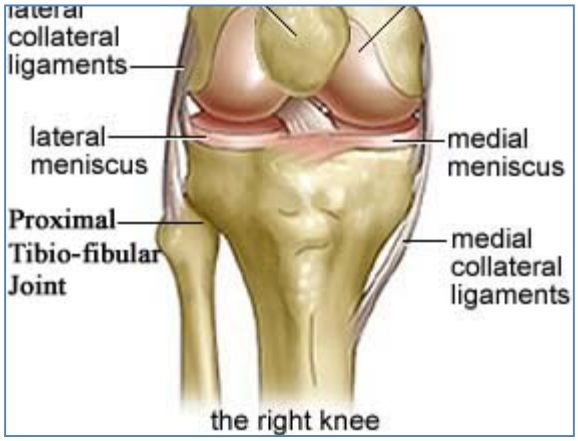
- **Tibia:** - See Last Week's Notes
- **Fibula:** - See Last Week's Notes
- **Foot:**
  - **7x Tarsals:**
    - **Talus**
    - **Calcaneus**
    - **Navicular**
    - **Cuboid**
    - **Lateral Cuneiform**
    - **Intermediate Cuneiform**
    - **Medial Cuneiform**
  - **5x MetaTarsals:**
    - **1 → 5**
  - **Phalanges:**
    - **1: Proximal & Distal**
    - **2→5: Proximal, Middle & Distal**
  - **2x Sesamoids:**
    - **"Ball" of the foot.**



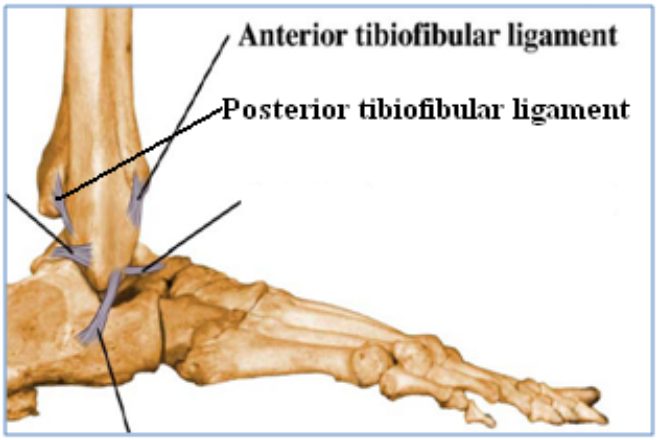


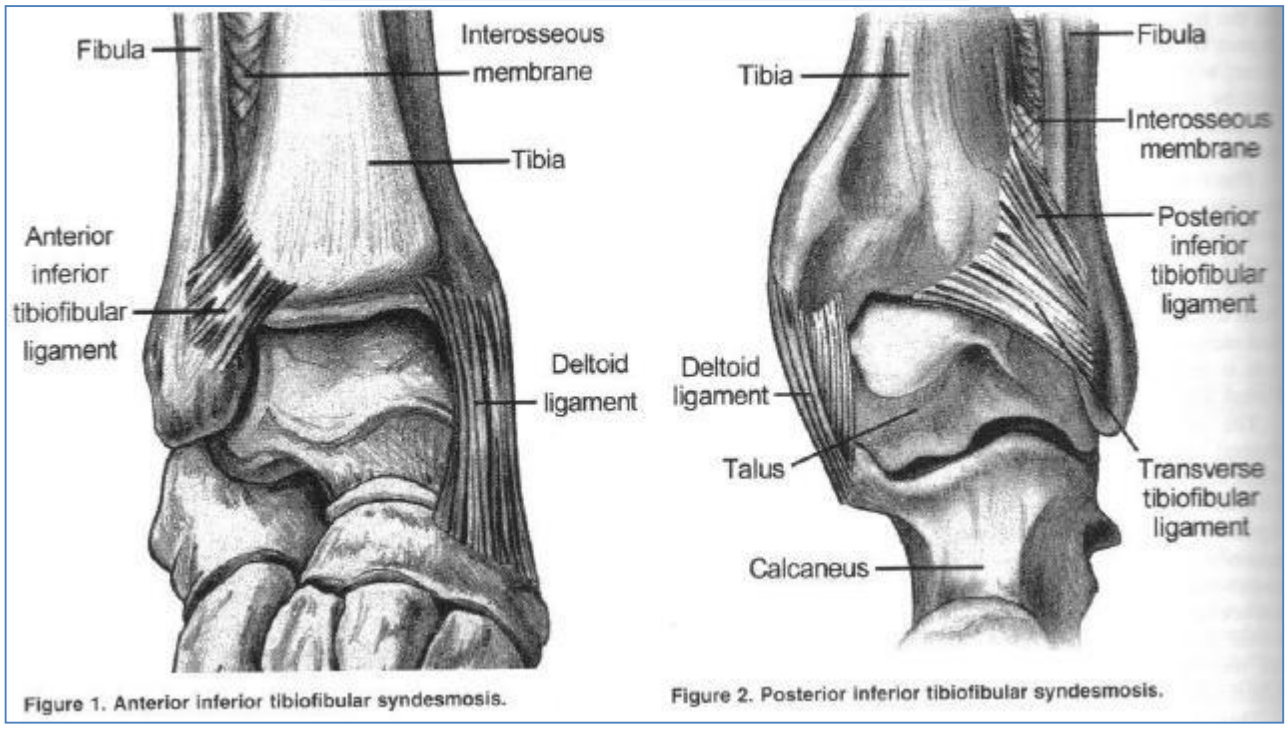
Joints:

- **(Proximal) Superior TibioFibular Joint:**
  - **Features:**
    - Synovial Planar Joint
  - **Bones:**
    - Tibia
    - Fibula
  - **Ligaments:**
    - TibioFibular Anterior &
    - TibioFibularPosterior:

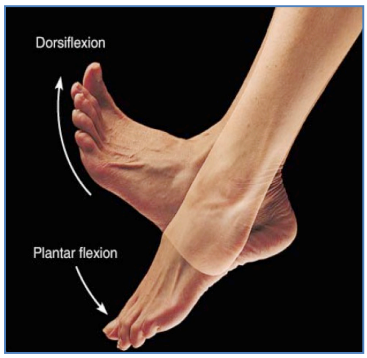


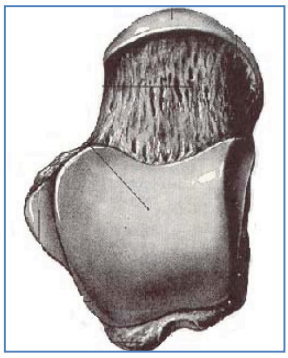
- **(Distal) Inferior TibioFibular Joint:**
  - **Features:**
    - Syndesmosis - where the contiguous bony surfaces are united by an interosseous ligament
  - **Bones:**
    - Tibia Fibula
  - **Ligaments:**
    - Interosseus Ligament
    - TibioFibular Anterior &
    - TibioFibularPosterior:
      - Both: Strong & Thick
      - Prevent separation of Tibia & Fibula



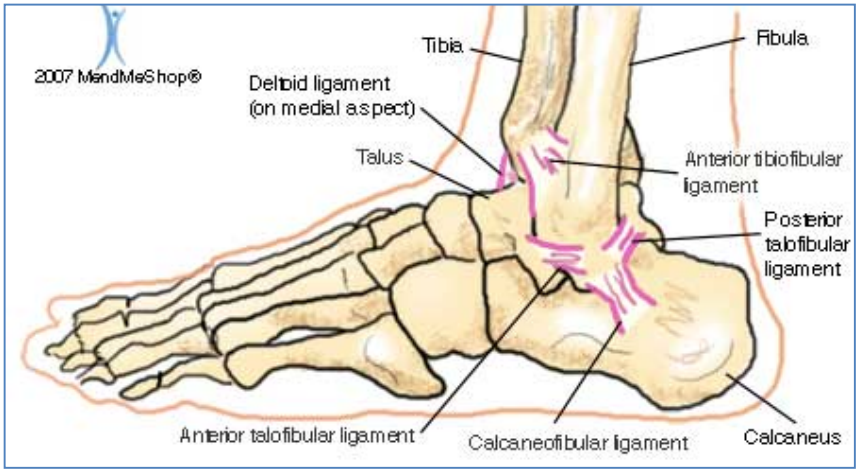


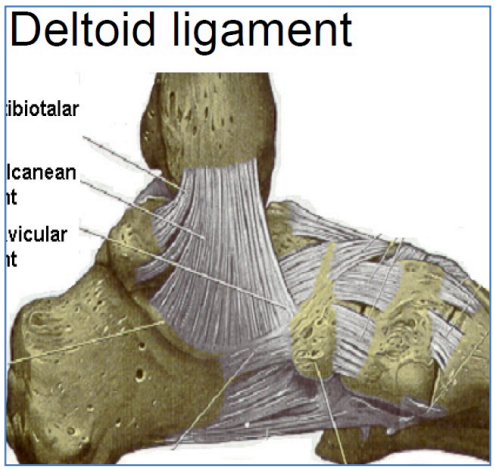
- **Ankle Joint (Talo-Crural):**
  - Ie. "Talus-Leg"
  - **Features:**
    - Synovial Hinge Joint
    - Good bony congruity
    - Stability comes from Very Strong Ligaments
    - Dorsiflexion/Plantarflexion
    - During dorsiflexion, the shape of the Trochlea of the Talus forces the Tibia & Fibula apart → tightens ligaments → most stable position.



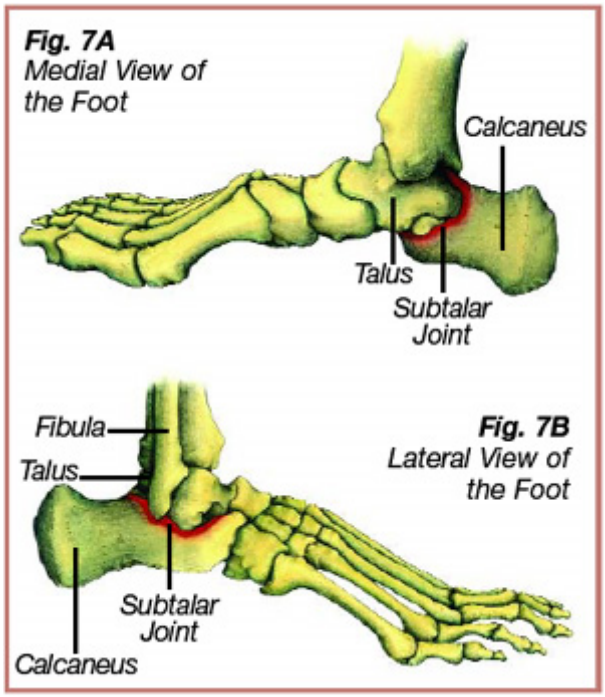


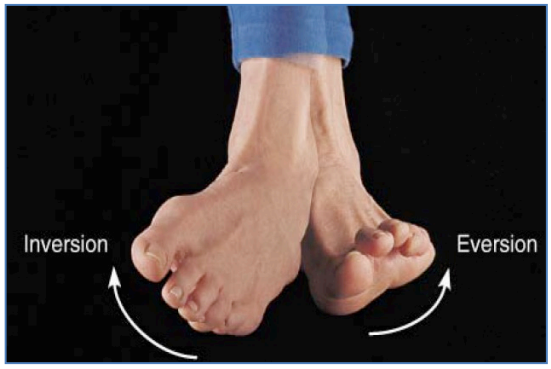
  - **Bones:**
    - Trochlea of Talus
    - Distal end of Tibia
    - Distal end of Fibula
  - **Ligaments:**
    - Joint Capsule
    - 3 Lateral Collaterals: (don't bother with names)
      - Posterior TaloFibular Ligament
      - Anterior TaloFibular Ligament
      - CalcaneoFibular Ligament
    - Medial Collaterals:
      - Deltoid: 4 Parts: (don't bother with names)



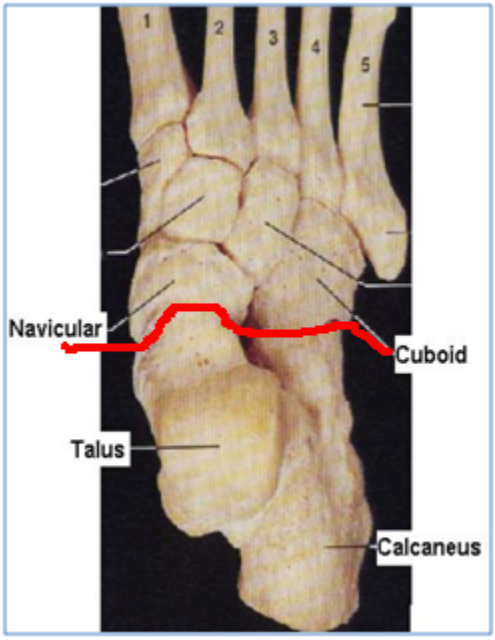


- **Subtalar Joint:**
  - **Features:**
    - Synovial Planar Joint
    - Inversion
    - Eversion
  - **Bones:**
    - Talus
    - Calcaneus
  - **Ligaments:**

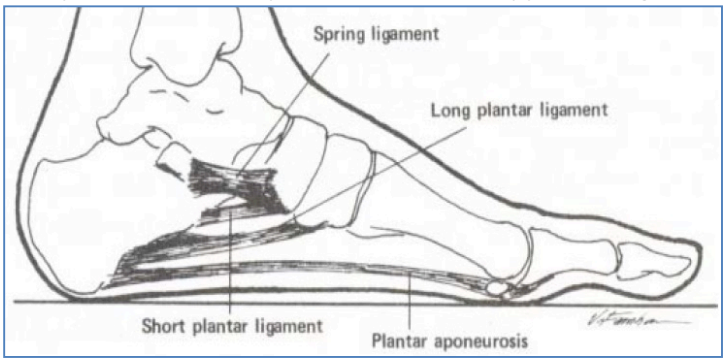




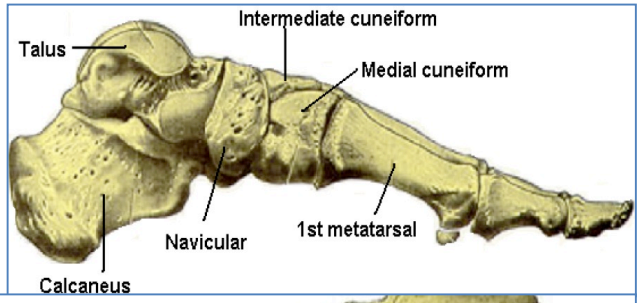
- **Transverse Tarsal Joint:**
  - **Features:**
    - Combo of: Talonavicular Joint & CalcaneoCuboid Joint (both Synovial Planar)
  - **Bones:**
    - Talus + Navicular
    - Calcaneus + Cuboid



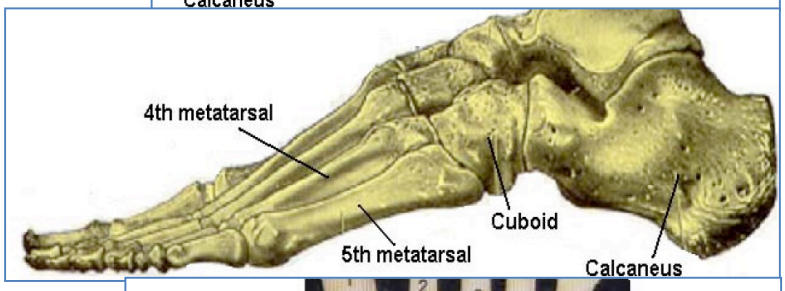
- **Arches in Foot:**
  - Shock Absorption
  - Propulsion on Different Surfaces
  - **Maintained by Plantar Ligaments:**
    - "Spring" Ligament (aka: CalcaneoNavicular) – Supports Medial Longitudinal Arch
    - Short Plantar Ligament
    - Long Plantar Ligament
    - Plantar Aponeurosis – Deep Fascia of Foot – Supports Longitudinal Arches



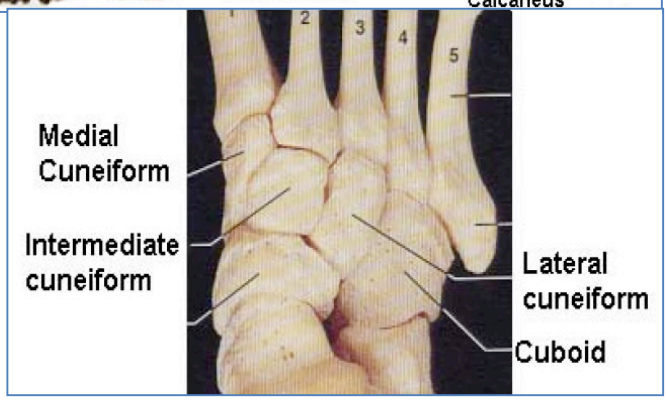
  - **Medial Longitudinal:** (the highest)
    - **Bones:**
      - Calcaneus
      - Talus
      - Navicular
      - Medial Cuneiform
      - Intermediate Cuneiform
      - 1st Metatarsal



  - **Lateral Longitudinal:**
    - **Bones:**
      - Calcaneus
      - Cuboid
      - 5th Metatarsal
      - 4th Metatarsal



  - **Transverse:**
    - **Bones:**
      - Cuboid
      - Lateral Cuneiform
      - Intermediate Cuneiform
      - Medial Cuneiform
      - Bases of Metatarsals

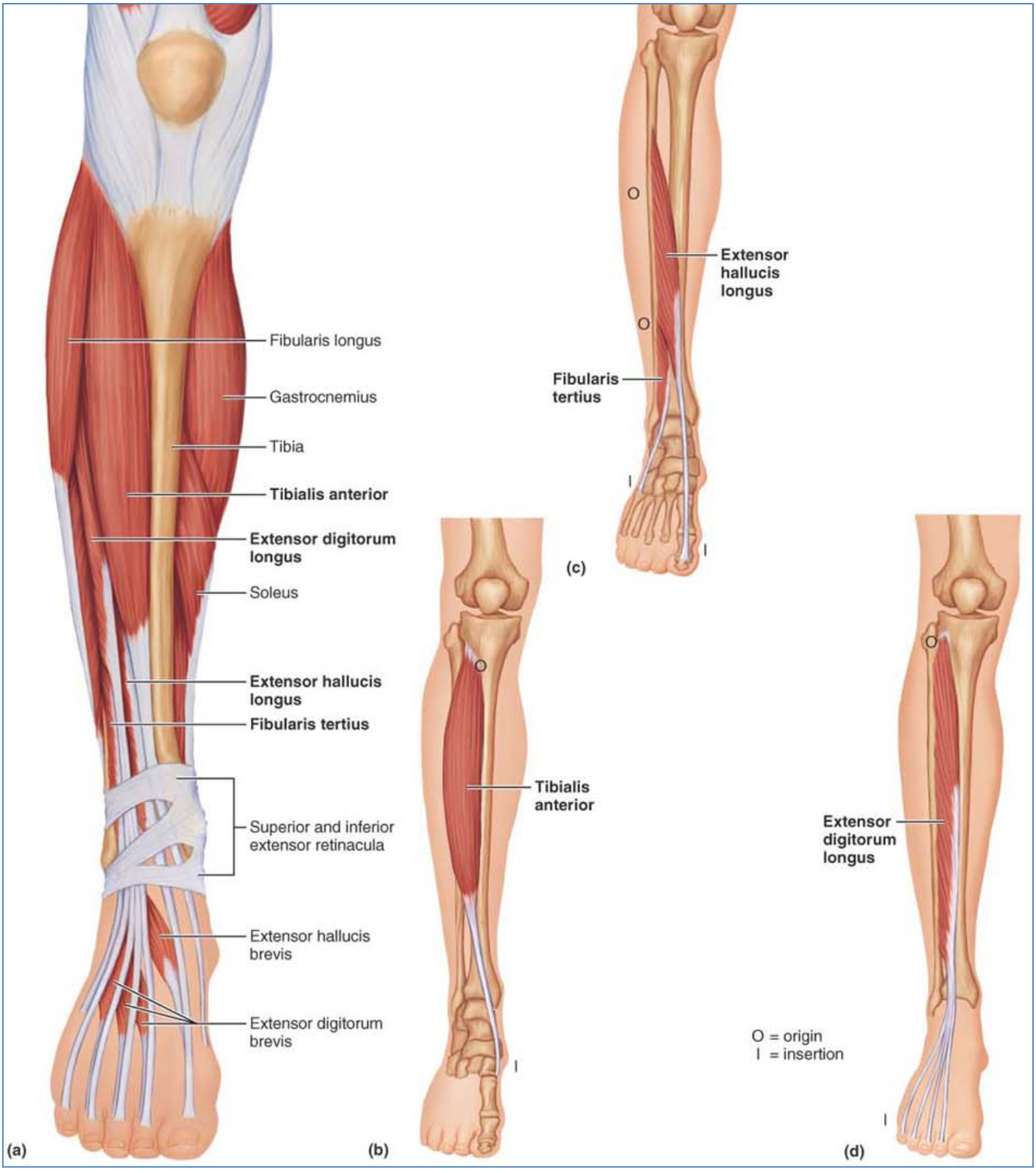


- **MetatarsoPhalangeal Joints:**
  - **Features:**
    - Synovial Condyloid
    - Flexion/Extension
    - Abduction/Extension
    - Circumduction

- **Interphalangeal Joints: (Proximal & Distal)**
  - **Features:**
    - Synovial Hinge
    - Flexion/Extension

Muscles – See Netter's Flash Cards:

- **Anterior Compartment of Leg:**
  - **Tibialis Anterior:**
    - Dorsiflexion
    - Deep Fibular Nerve
  - **Extensor Hallucis Longus:**
    - Extension of Big Toe
  - **Extensor Digitorum Longus:**
    - Extension of Phalanges 2→5
  - **Fibularis Tertius:**
    - Dorsiflexion
    - Deep Fibular Nerve



- **Lateral Compartment of Leg:**
  - **Fibularis Longus**
  - **Fibularis Brevis**

MUSCLE GALLERY TABLE 10.15 *(continued)*

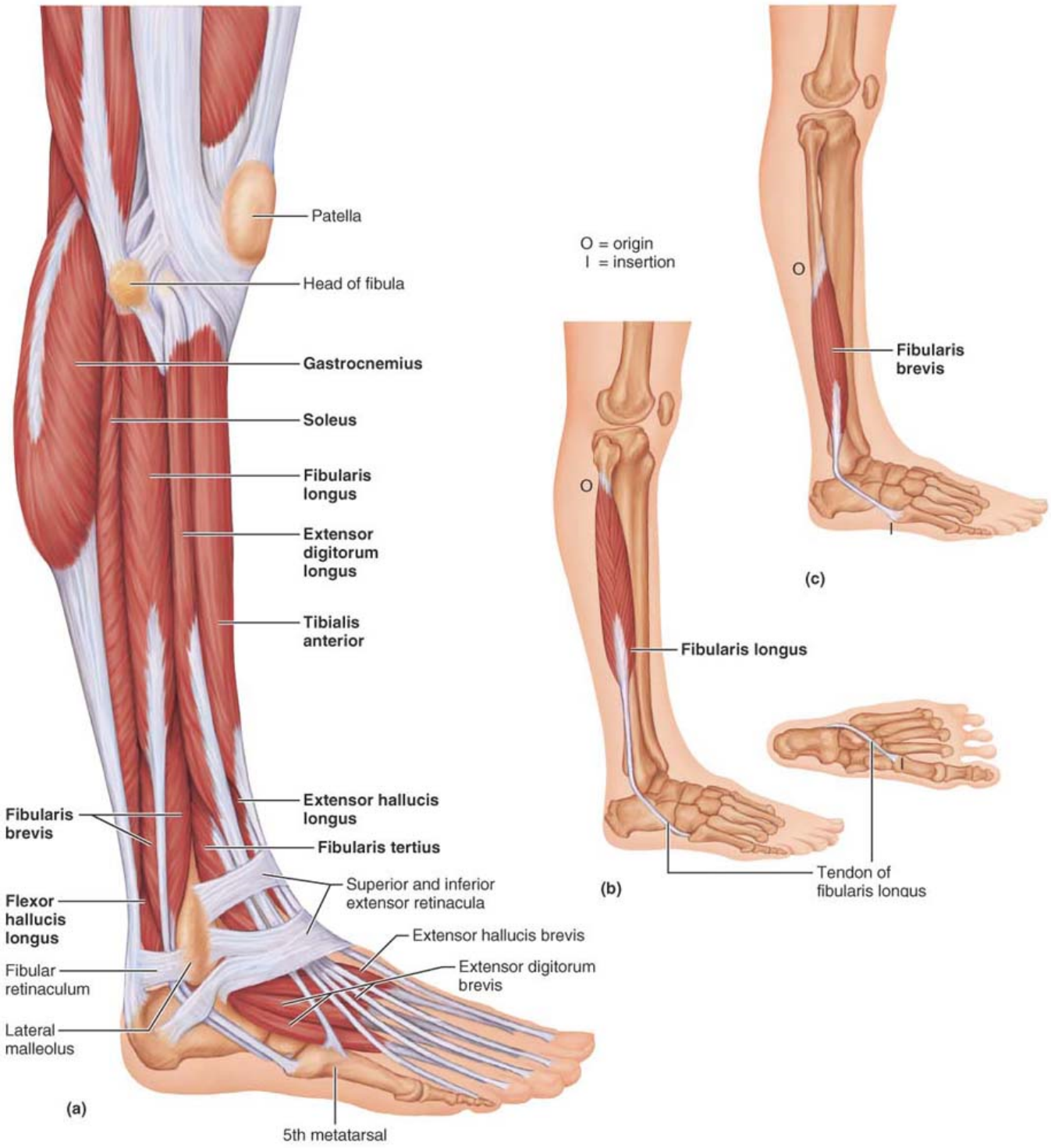


FIGURE 10.22 **Muscles of the lateral compartment of the right leg.** **(a)** Superficial view of lateral aspect of the leg, illustrating positions of lateral compartment muscles (fibularis longus and brevis) relative to anterior and posterior leg muscles. **(b)** Isolated view of fibularis longus; inset illustrates the insertion of the fibularis longus on the plantar surface of the foot. **(c)** Isolated view of the fibularis brevis muscle. (See *A Brief Atlas of the Human Body*, Figure 42.)

- **Posterior Compartment of Leg:**
  - **Triceps Surae:**
    - **Gastrocnemius Medial Head:**
    - **Gastrocnemius Lateral Head:**
    - **Soleus:**
  - **Plantaris:**
  - **Tibialis Posterior:**
  - **Flexor Digitorum Longus:**
  - **Flexor Hallucis Longus:**

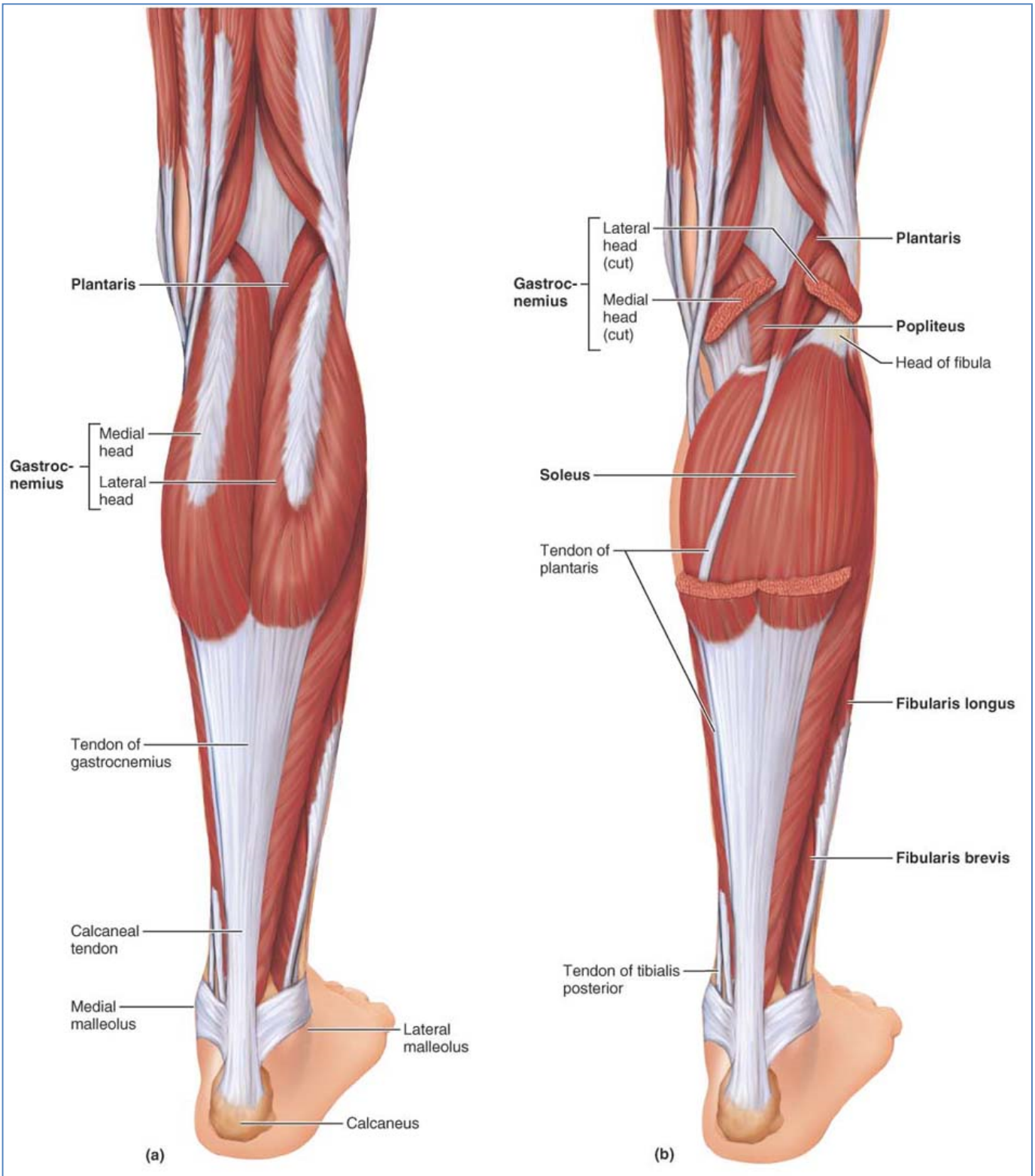


FIGURE 10.23 **Muscles of the posterior compartment of the right leg.**
(a) Superficial view of the posterior leg. **(b)** The gastrocnemius has been removed to show the soleus immediately deep to it.

MUSCLE GALLERY TABLE 10.15 **Muscles of the Leg: Movements of the Ankle and Toes (Figures 10.21 to 10.23)** *(continued)*

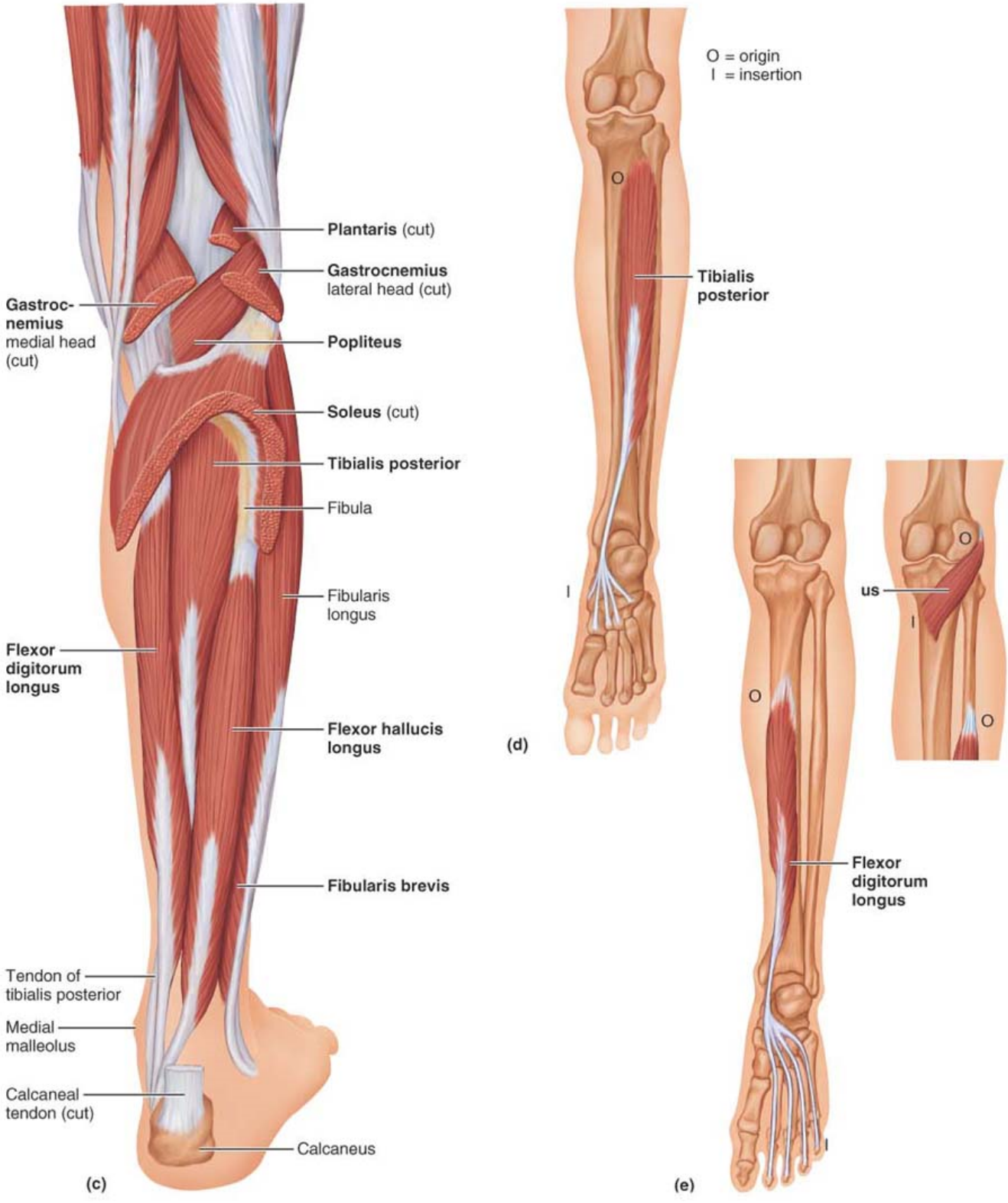
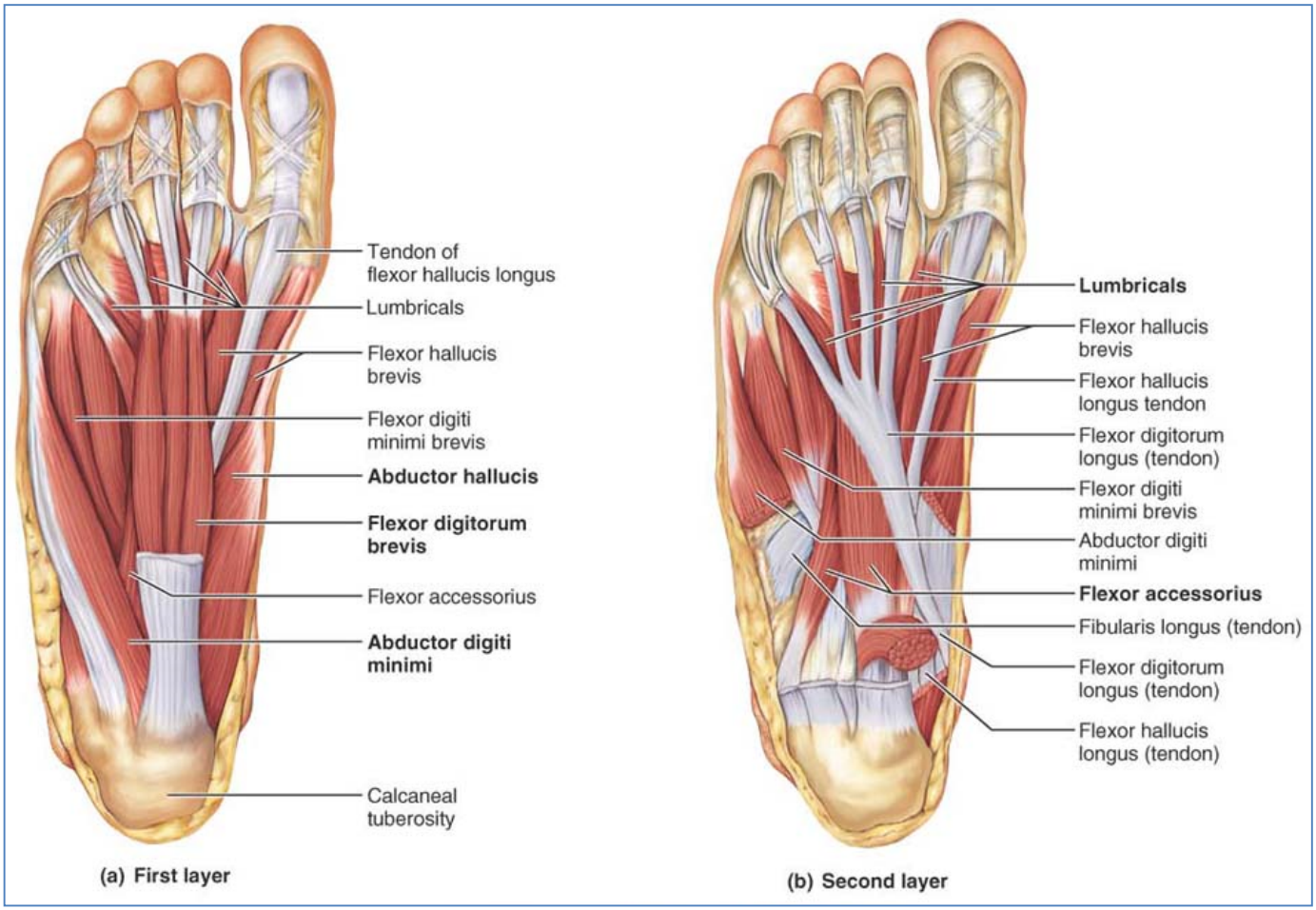


FIGURE 10.23 *(continued)* **Muscles of the posterior compartment of the right leg. (c)** The triceps surae has been removed to show the deep muscles of the posterior compartment. **(d–f)** Individual deep muscles are shown in isolation.

- **Intrinsic Muscles of the Foot:**
  - **Plantar Aspect:**
    - **First Layer:**
      - **Abductor Hallucis**
      - **Flexor Digitorum Brevis**
      - **Abductor Digiti Minimi**
    - **Second Layer:**
      - **Flexor Hallucis Brevis**
      - **Quadratus Plantae**
      - **Flexor Digiti Minimi Brevis**
      - **Lumbricals**
    - **Third Layer:**
      - **Adductor Hallucis – Transverse Head**
      - **Adductor Hallucis – Oblique Head**
    - **Fourth Layer:**
      - **Plantar Interossei** – Abduct Toes



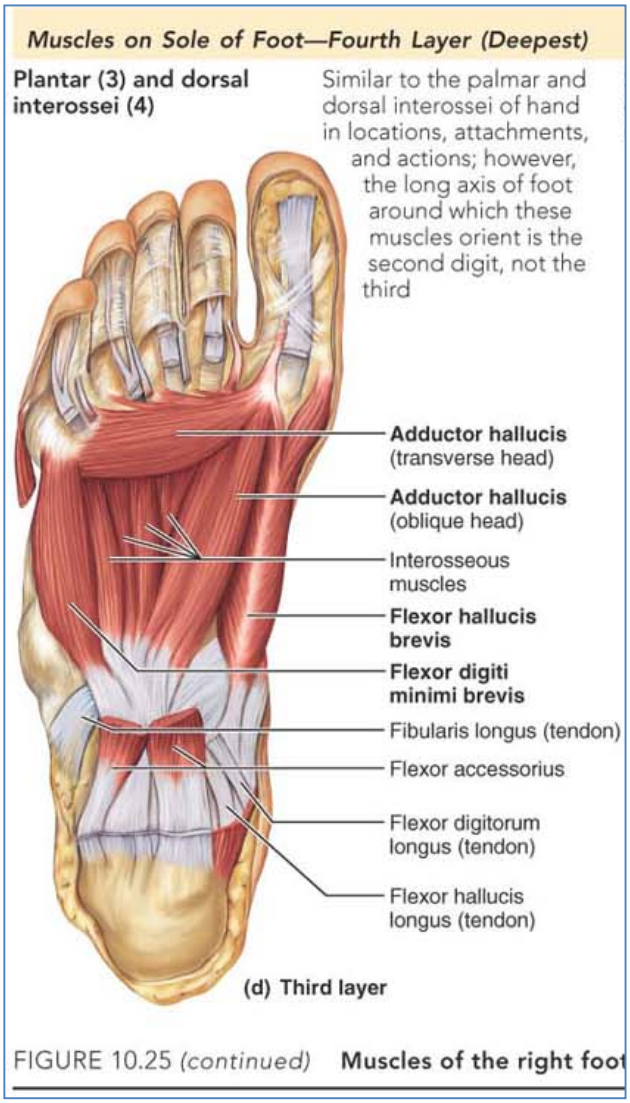
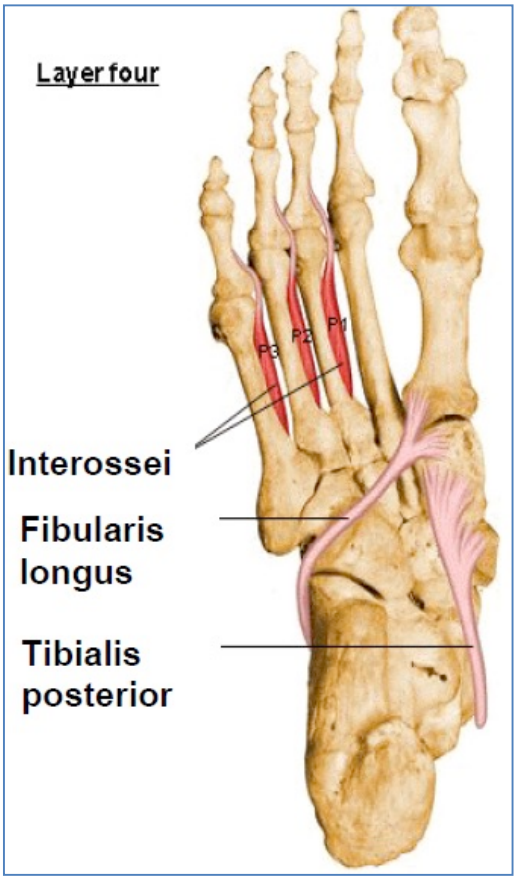
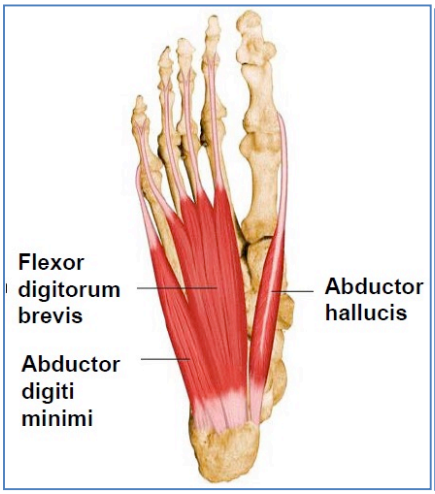
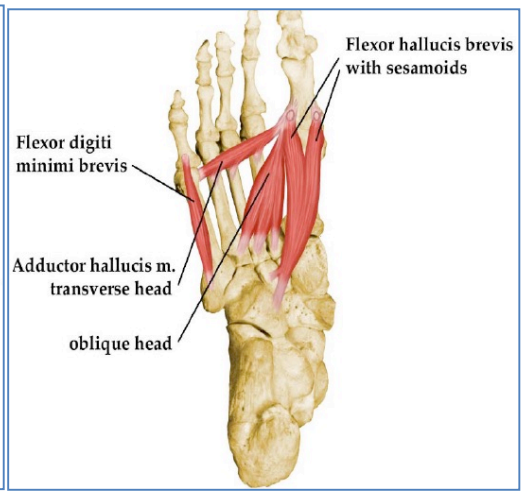
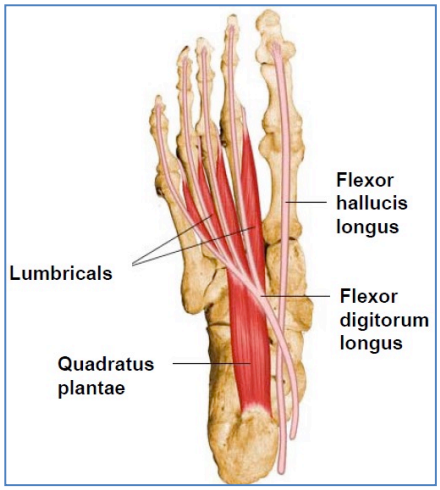


FIGURE 10.25 *(continued)* **Muscles of the right foot**

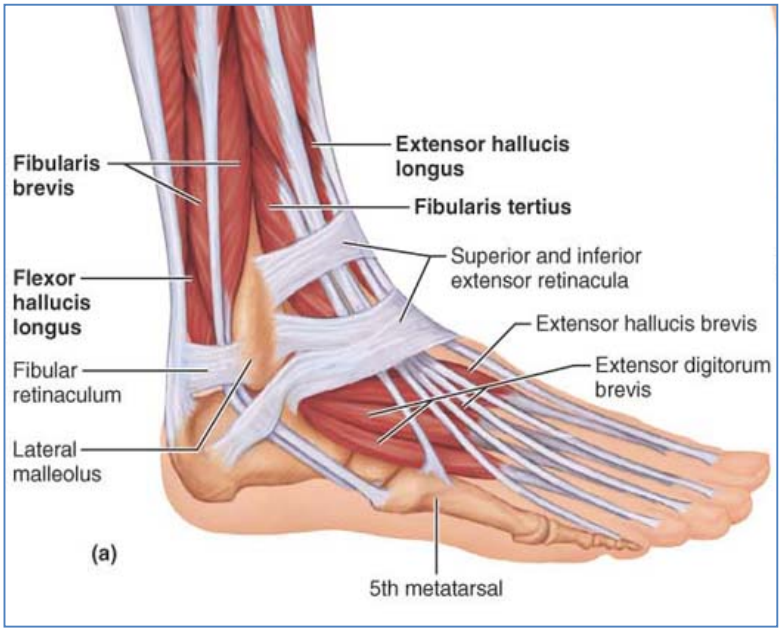


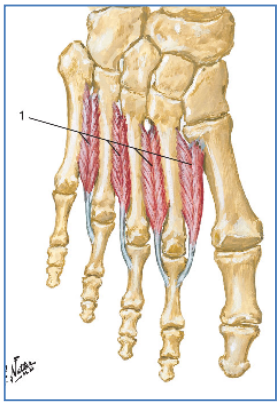






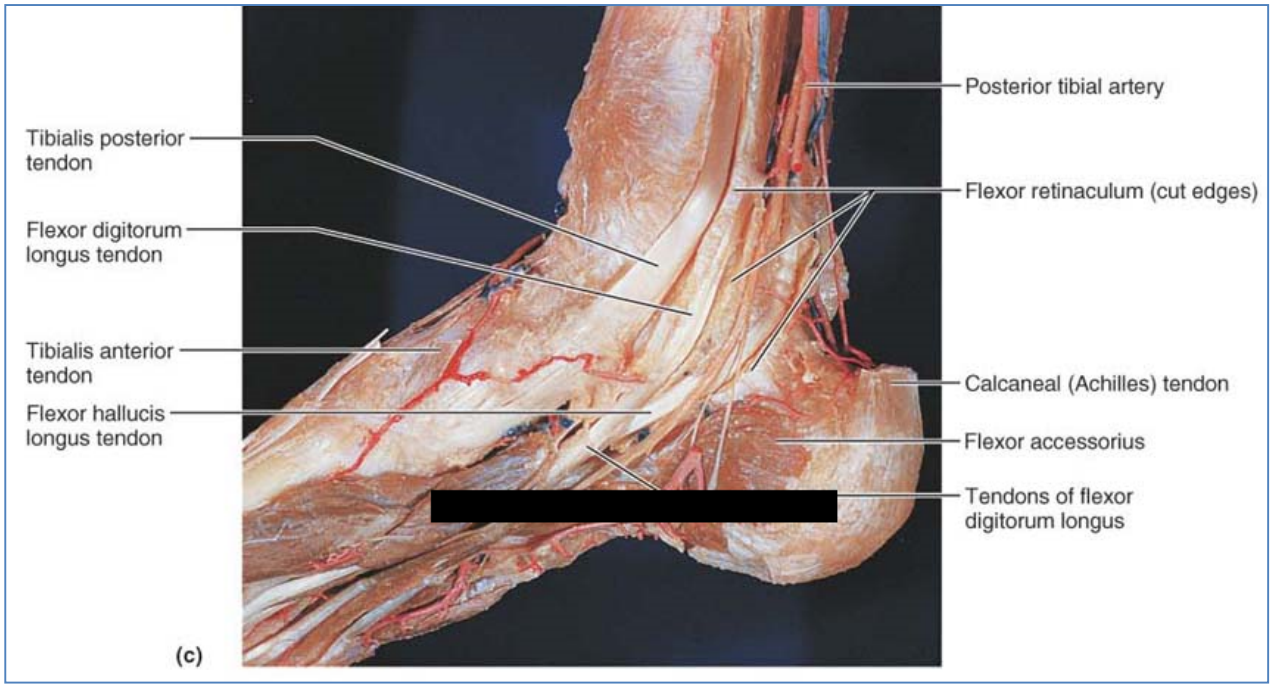
- **Dorsal Aspect:**
  - **First Layer:**
    - **Extensor Hallucis Brevis**
    - **Extensor Digitorum Brevis**
  - **Second Layer:**
    - **Dorsal Interossei –** Abduct Toes





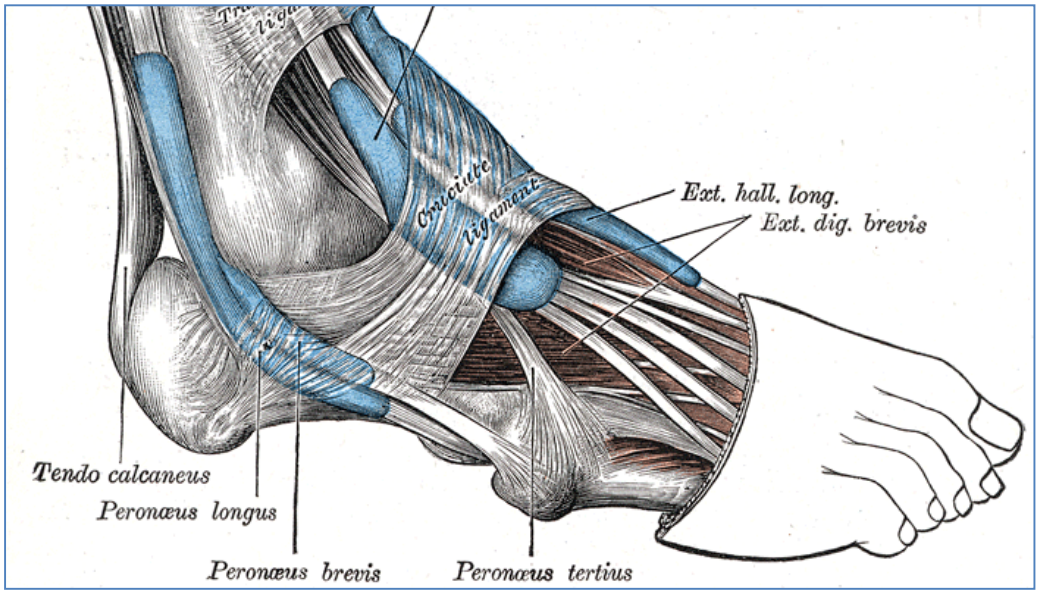
Structures Passing Medial Malleolus:

- **Tom** - **Tibialis Posterior**
- **Dick** - **Flexor Digitorum Longus**
- **And** - **Posterior Tibial Artery**
- **Naughty** - **Tibial Nerve**
- **Harry** - **Flexor Hallucis Longus**



Structures Passing Lateral Malleolus:

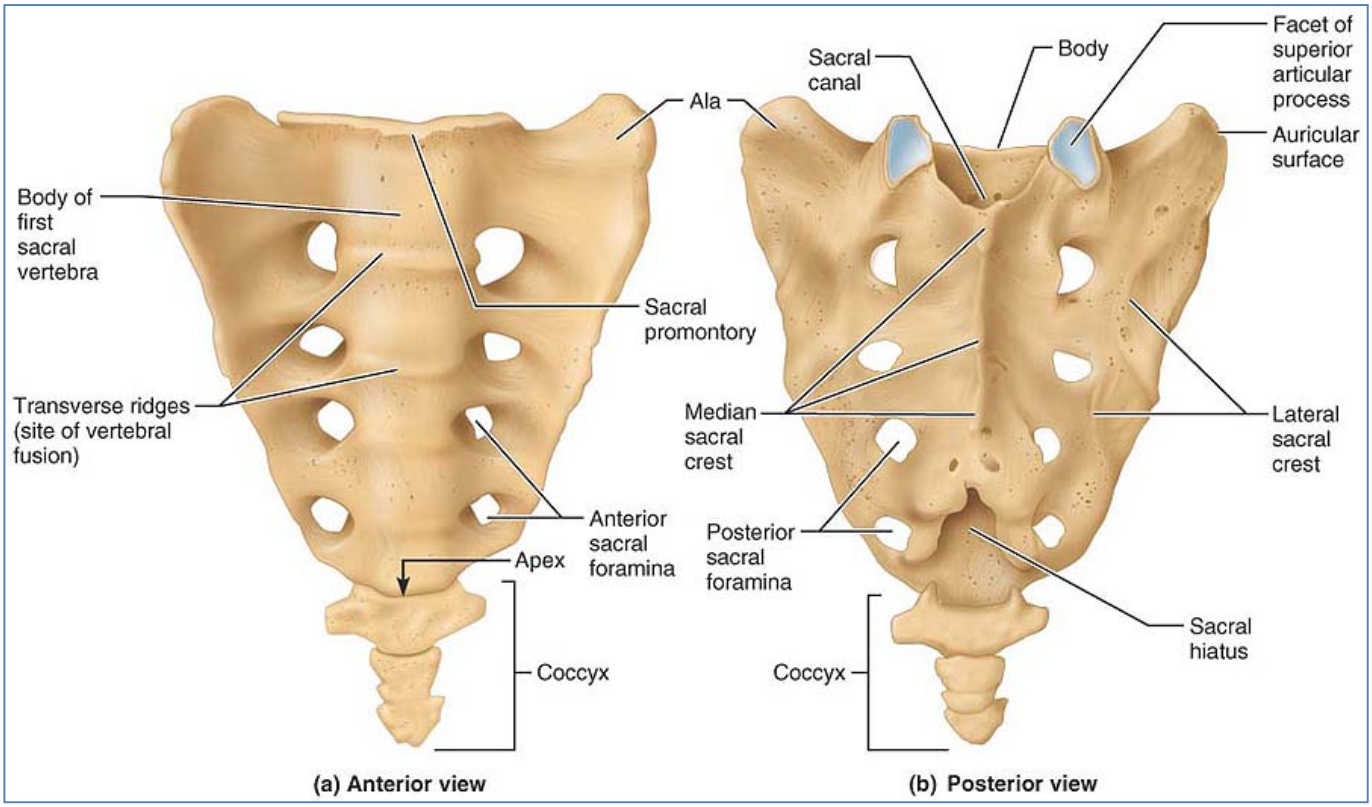
- **Fibularis Longus**
- **Fibularis Brevis**



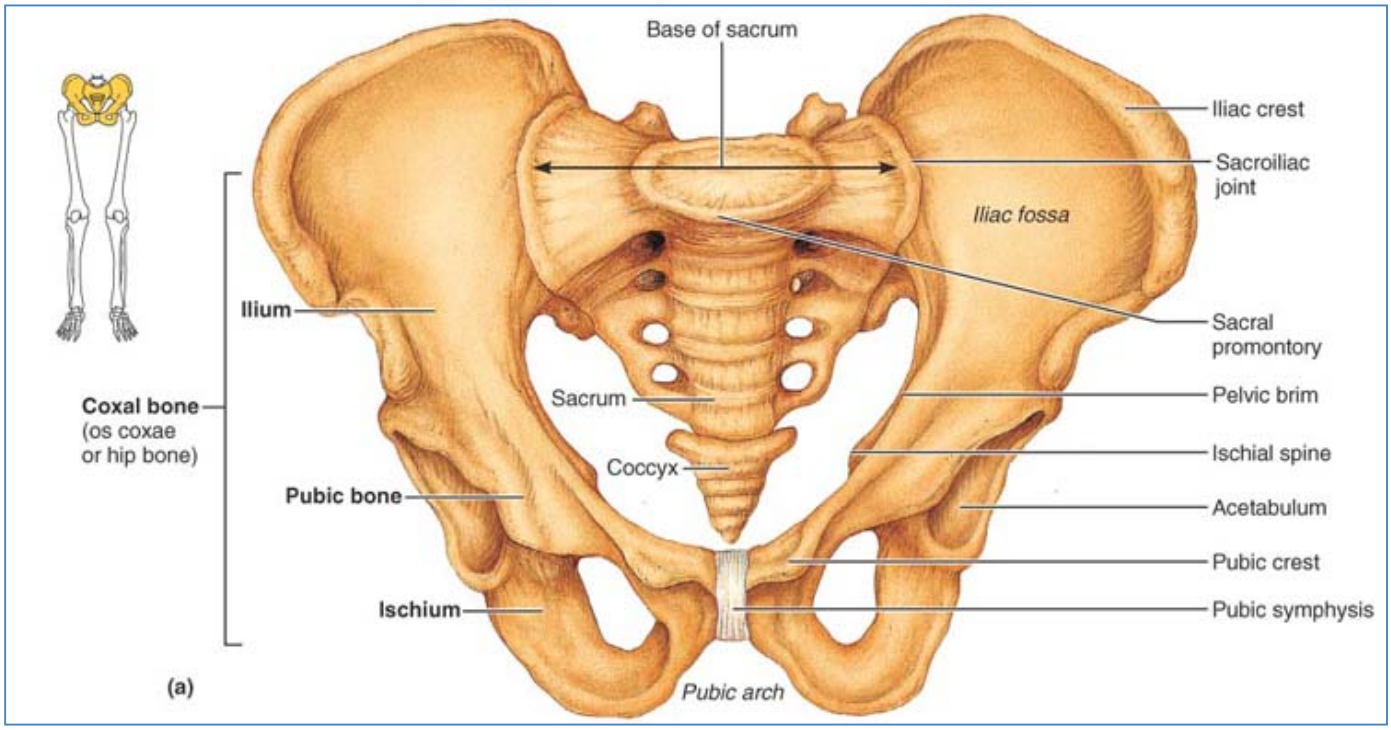
The Pelvic Girdle & The Lower Limb: Bones, Joints, Muscles, Nerves & Vasculation

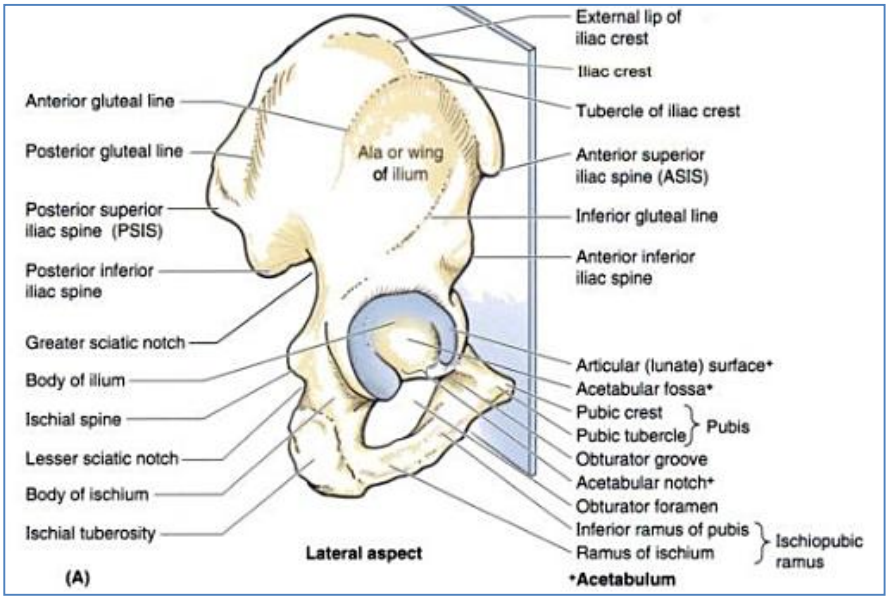
Bones:

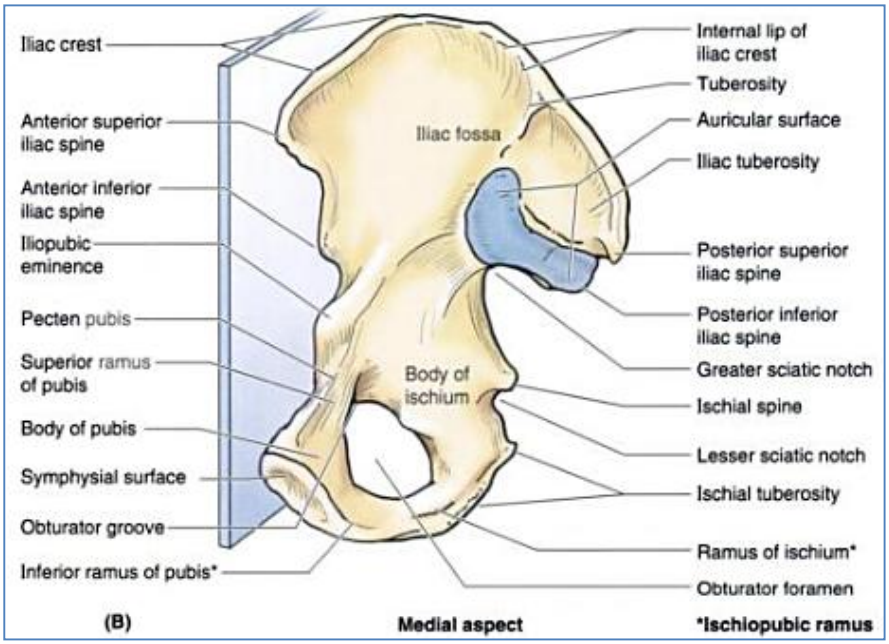
- **The "Bony Pelvis":**
  - **Sacrum:**
    - **Type/Features:**
      - Irregular Bone
      - The 5 last vertebrae fused together.
    - **Landmarks:**
      - Transverse ridges – the 'lines of fusion' between sacral vertebrae.
      - Anterior/Posterior Sacral Foramina
        - Penetrate sacrum lateral to the Transverse Ridges
        - Transmits blood vessels
        - Transmits Anterior/Posterior Sacral Rami of sacral spinal nerves.
      - Median Sacral Crest – fused spinous processes of sacral vertebrae.
      - Lateral Sacral Crests
      - Sacral Canal – continuation of vertebral canal
      - Sacral Hiatus – external inferior opening
    - **Articulations:**
      - Last Lumbar Vertebra
      - The 2 Hip Bones (Sacroiliac Joints)
      - The Coccyx
    - **Origins/Insertions:**
      - Iliacus O
      - Gluteus Maximus O
      - Piriformis O



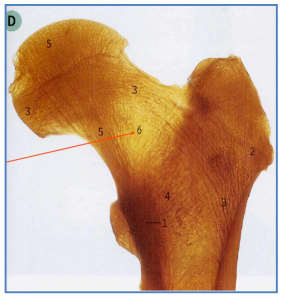
- **Coxal Bones (hip bones):**
  - **Type/Features:**
    - Irregular Bones
    - Made up of 3 Bones during Childhood:
      - Ilium
      - Ischium
      - Pubis
  - **Landmarks:**
    - Acetabulum ("Wine Cup") – Hemispherical Socket
    - Pelvic Brim
    - **Ilium**
      - Iliac Crest
      - Tubercle of the Iliac Crest
      - Anterior Superior Iliac Spine ASIS
      - Posterior Superior Iliac Spine PSIS
      - Anterior Inferior Iliac Spine AIIS
      - Posterior Inferior Iliac Spine PIIS
      - Greater Sciatic Notch – Sciatic Nerve passes through
      - Gluteal Lines – Posterior/Anterior/Inferior
      - Iliac Fossa
      - Auricular Surface
    - **Ischium**
      - Ischial Ramus
      - Ischial Spine
      - Lesser Sciatic Notch
      - Ischial Tuberosity –(Huge Sacrotuberous Ligaments run from here to sacrum)
    - **Pubis**
      - Pubic Crest
      - Pubic Tubercle
      - Obturator Foramen – blood vessel & nerves pass through
      - Pubic symphysis
      - Pubic Arch/Subpubic Angle (Wide in females)
  - **Articulations:**
    - Sacrum
    - Femurs
    - The other Coxal Bone (pubic symphysis)
  - **Origins/Insertions:**
    - Iliacus O
    - Sartorius O
    - Adductor Magnus O
    - Adductor Longus O
    - Adductor Brevis O
    - Pectineus O
    - Gracilis O
    - Rectus Femorus O
    - Tensor Fasciae Latae O
    - 3 Gluteus Muscles O
    - Gemellus Superior O
    - Obturator Externus O
    - Gemellus Inferior O
    - Obturator Internus O
    - Quadratus Femorus O
    - Biceps Femoris O
    - Semitendinosus O
    - Semimembranosus O







NB: The Innominate bones: (ilium, ischium & pubis) all fuse together in late childhood.

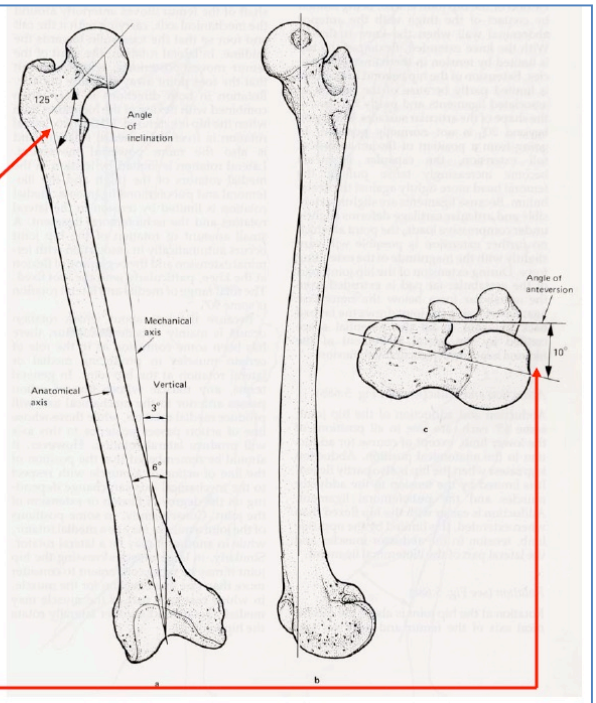


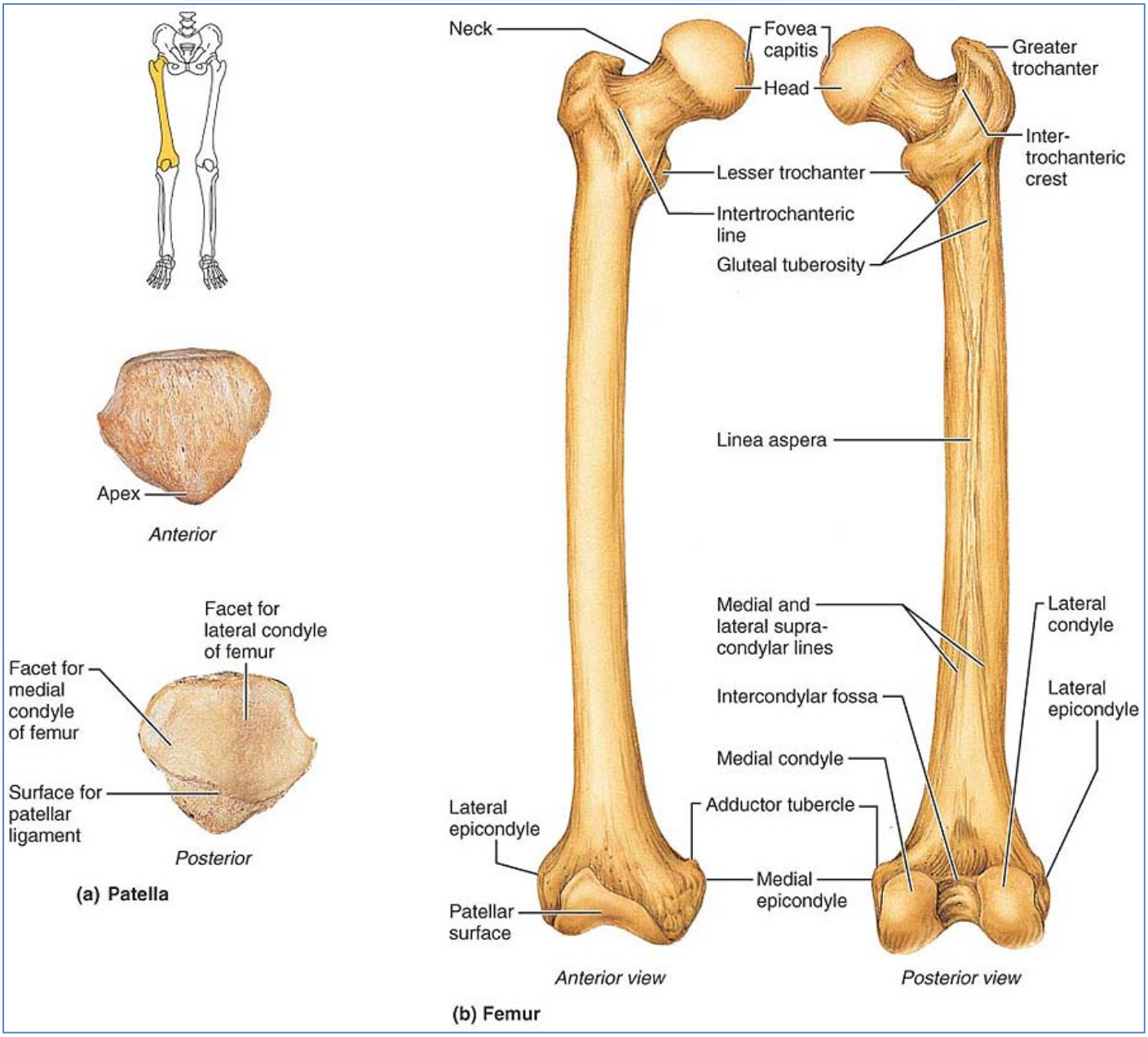
- **Femur:**
  - **Type/Features:**
    - Long bone
    - Longest & Strongest bone of the body.
    - Angle of Inclination - 125°
    - Angle of Anteversion - 10°
    - Neck of femur – prone to fracture due to lack of trabeculae.
  - **Landmarks:**
    - Head
    - Fovea Capitis - “pit of head” – short ligament of the femur head runs from this ‘pit’ to the acetabulum.
    - Neck
    - Greater Trochanter
    - Lesser Trochanter
    - Intertrochanteric Line (Anterior)
    - Intertrochanteric Crest (Posterior)
    - Gluteal Tuberosity
    - Linea Aspera
    - Medial & Lateral Epicondylar Lines
    - Lateral Epicondyle
    - Medial Epicondyle
    - Lateral Condyle
    - Medial Condyle
    - Intercondylar Fossa
    - Adductor Tubercle
    - Patellar Surface
  - **Articulations:**
    - Acetabulum of the Coxal Bones of the Hip
    - Patella
    - Tibia
  - **Origins/Insertions:**
    - Iliacus I
    - Psoas Major I
    - Adductor Magnus I
    - Adductor Longus I
    - Adductor Brevis I
    - Gluteus Maximus I
    - Gluteus Medius I
    - Gluteus Minimus I
    - Piriformis I
    - Superior Gemellus I
    - Obturator Internus I
    - Inferior Gemellus I
    - Obturator Externus I
    - Quadratus Femoris I
    - Biceps Femoris O (short head)
    - Gastrocnemius O (both heads)
    - Plantaris O
    - Popliteus O

Femur

Angle of inclination

Angle of anteversion

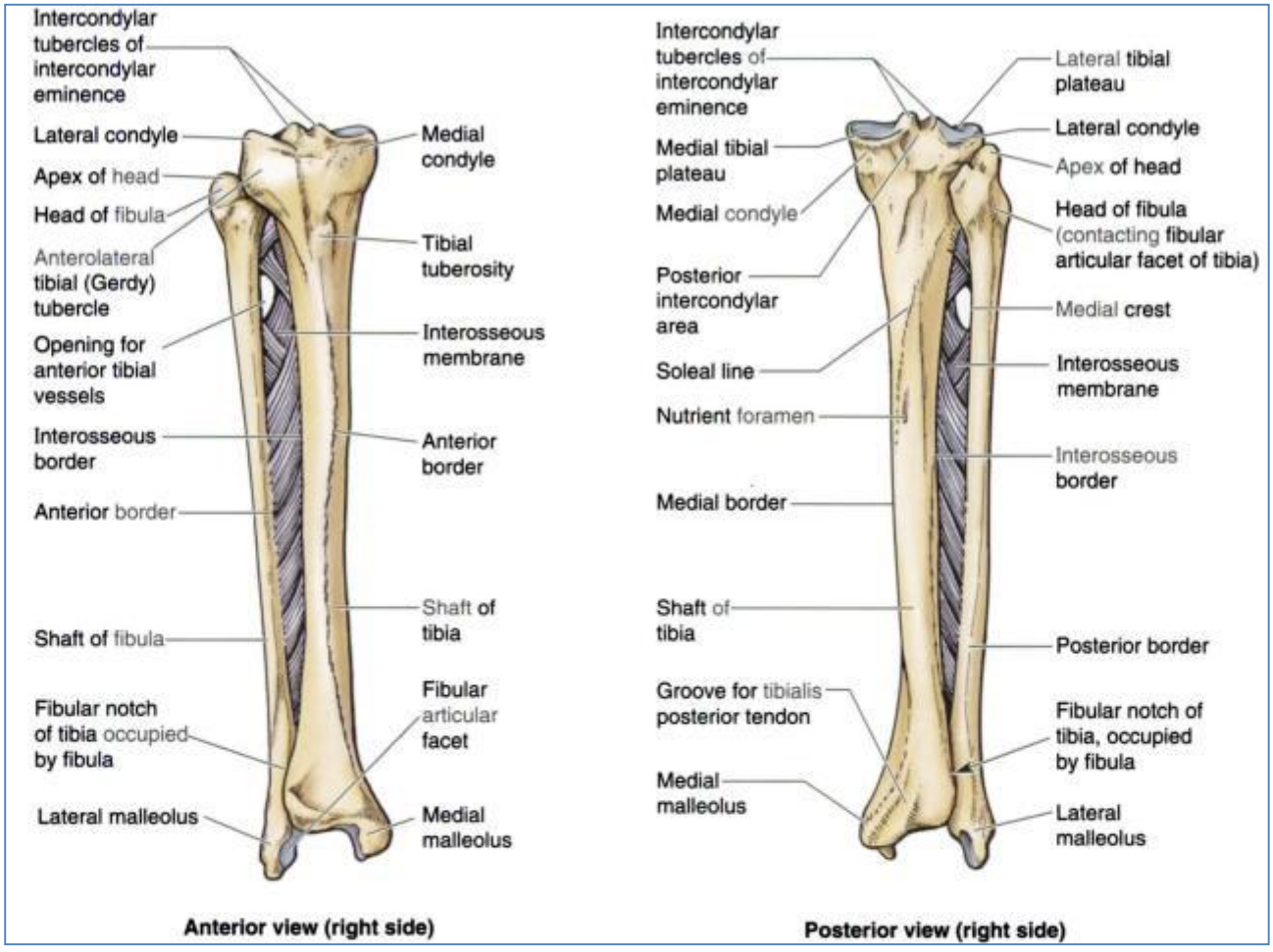




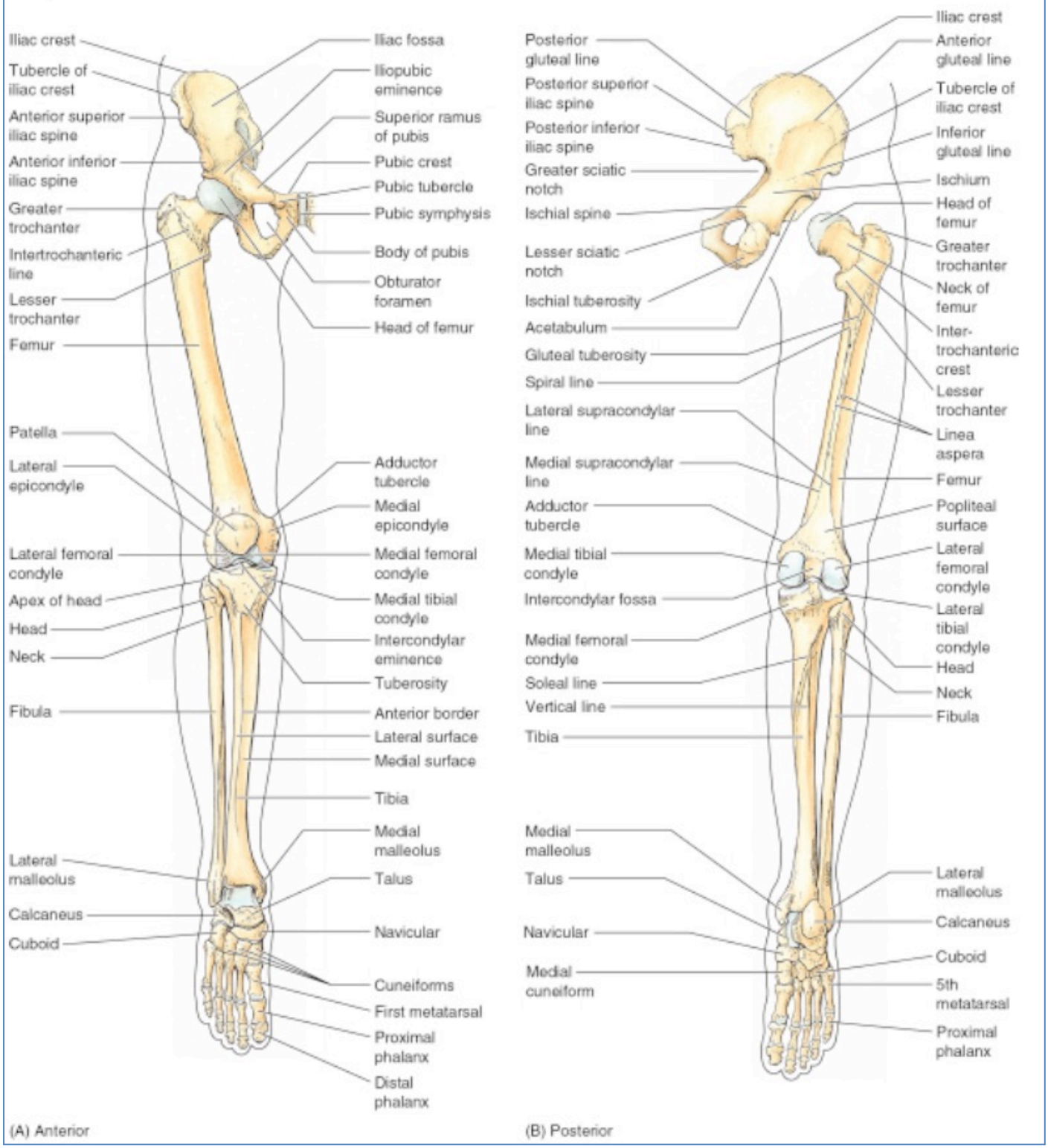
- **Patella**
  - **Type/Features:**
    - Triangular Sesamoid Bone
    - Enclosed in Quadriceps Tendon
    - Protects Knee Joint Anteriorly
    - Improves Leverage of thigh muscles across the knee.
  - **Landmarks:**
    - Lateral Facet
    - Medial Facet
    - Apex
  - **Articulations:**
    - Femur – Patellar Surface (extended knee)
    - Femur – Lateral & Medial Condyles (Flexed knee)
  - **Origins/Insertions:**
    - I – Quadriceps Tendon (Rectus Femoris, Vastus Medialis/Intermedius/Lateralis)
    - Patellar Ligament

- **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)
    - Intercondylar Eminence – formed by 2 Intercondylar Tubercles
    - Intercondylar Areas – Anterior & Posterior – Attachments for Cruciate Ligaments
    - Tibial Tuberosity
    - Fibular Articular Facet – proximal Fibular articulation point
    - Soleal Line (origin of Soleus Muscle)
    - Anterior Border (of shaft)
    - Interosseous Border (of shaft)
    - Medial Malleolus
    - Fibular Notch – distal Fibular articulation point
  - **Articulations:**
    - Condyles of Femur
    - Fibula – Fibular Facet (proximally)
    - Trochlea of Talus Bone of Tarsals of the Foot.
    - Fibula – Fibular Notch (distally)
  - **Origins/Insertions:**
    - Quadriceps Femoris I (Via Patellar Tendon)
    - Sartorius I
    - Gracilis I
    - Tensor Fascia Latae I (Via Iliotibial Tract)
    - Semitendinosus I
    - Semimembranosus I
    - Popliteus I
    - Posterior Tibialis O
    - Flex. Digitorum Longus O (part)
    - Anterior Tibialis O
    - Ext. Digitorum Longus O
    - Soleus (part) O

- **Fibula**
  - **Type/Features:**
    - Slender Long Bone
    - Attached to Tibia by *Tibiofibular Syndemosis* (Incl. Interosseous Membrane)
    - Unlike Radius & Ulna, the leg is fixed (can't supinate/pronate)
    - No function in weight-bearing – mainly for muscle attachment
  - **Landmarks:**
    - Head
    - Apex of Head
    - Neck
    - Shaft
      - Anterior Border
      - Interosseous Border
      - Posterior Border
    - Lateral Malleolus
  - **Articulations:**
    - Tibia Proximally & Distally
    - Trochlea of Talus Bone of Tarsals of the Foot.
  - **Origins/Insertions:**
    - Biceps Femoris I
    - Soleus (part) O
    - Ext. Digitorum Longus O
    - Flex. Hallucis Longus O
    - Tibialis Posterior O (part)
    - Ext. Hallucis Longus O
    - Fibularis Tertius O
    - Fibularis Longus O
    - Fibularis Brevis O
    - Flex. Digitorum Longus O (part)



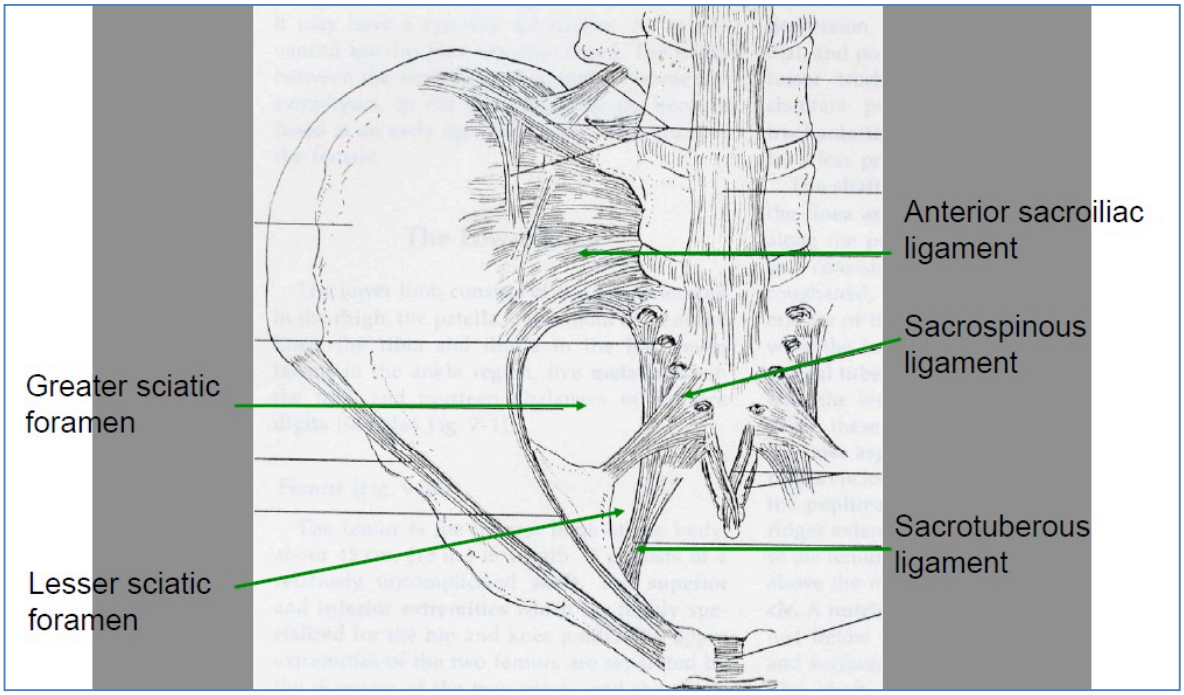
5.2A, B. Bones of the lower limb.

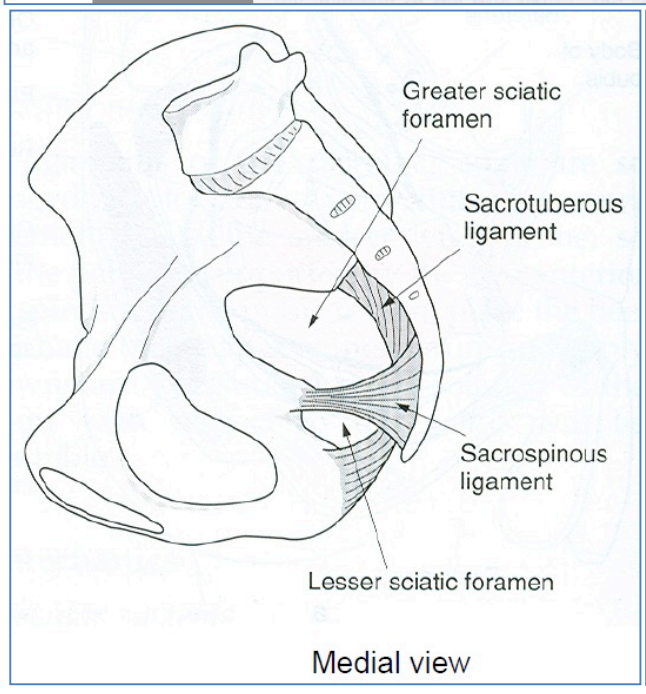


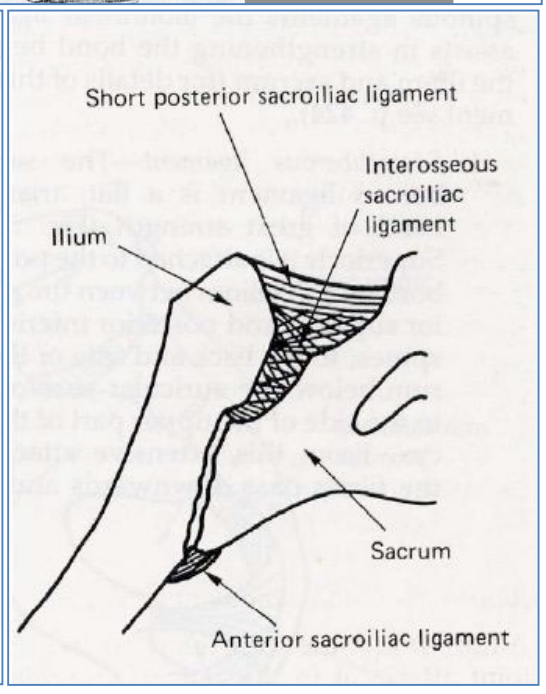
Joints:

- **Sacro-Iliac:**
  - **Features:**
    - Synovial Planar Joint
    - Loosens during labour.
  - **Bones:**
    - Sacrum
    - Ilium
  - **Ligaments:**
    - Anterior Sacroiliac Ligament
    - Posterior Sacroiliac Ligament
    - Interosseous Sacroiliac Ligament
  - **Accessory Ligaments:**
    - Sacrotuberous — Ischial Tuberosity → Sacrum
    - Sacrospinous — Ischial Spine → Sacrum

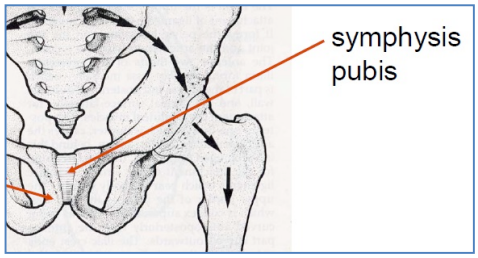
      - Form the Greater & Lesser Sciatic Foramina



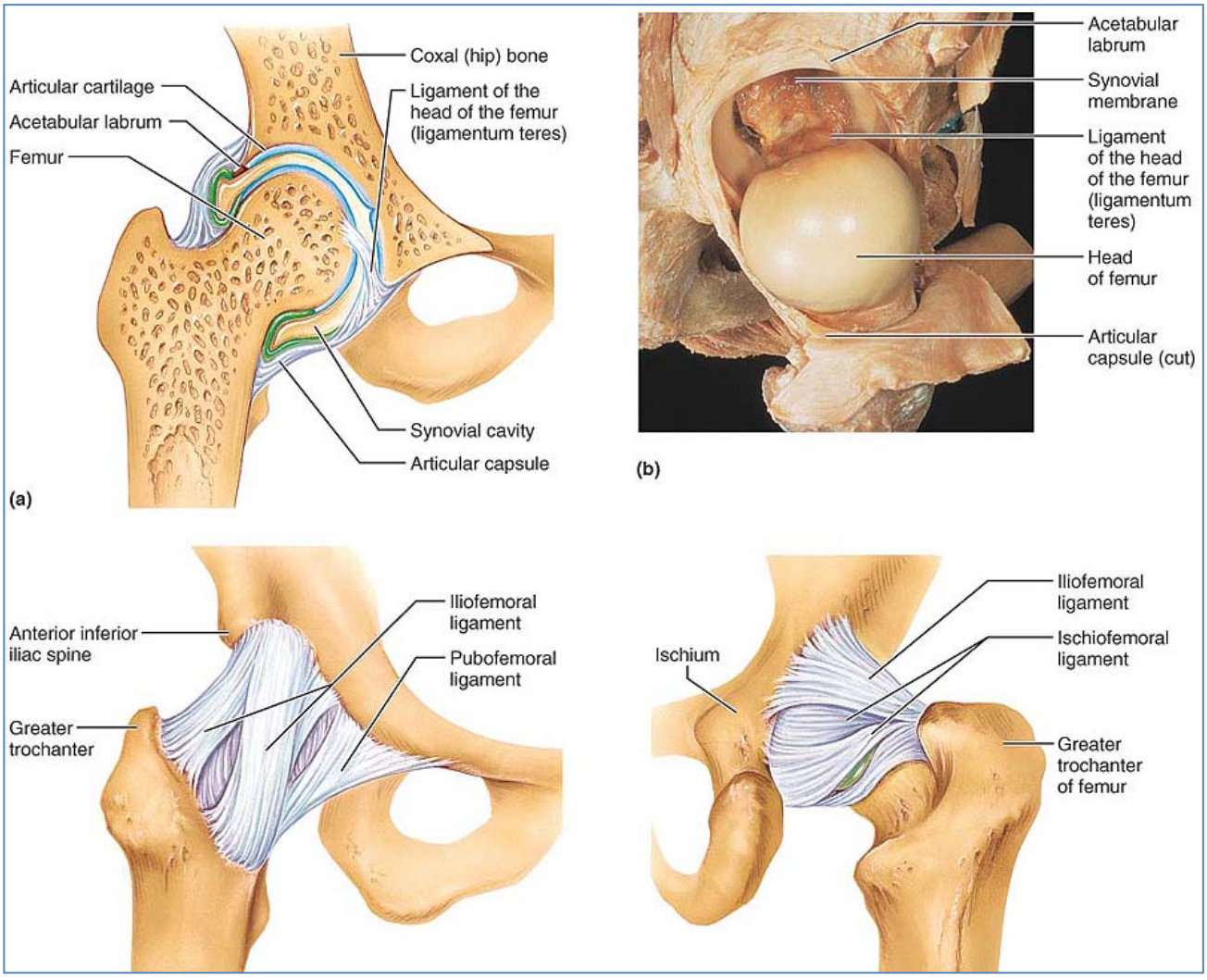




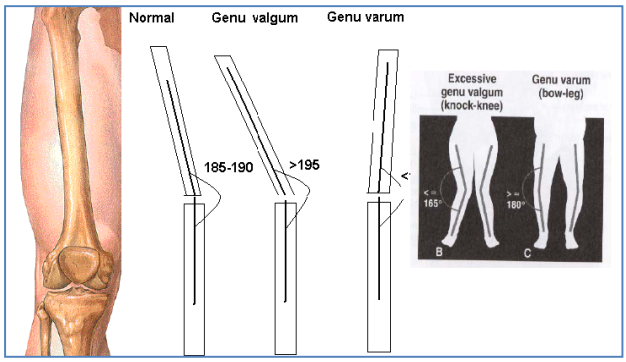
- **Pubic Symphysis**
  - **Features:**
    - Cartilagenous Joint
    - Loosens during labour
  - **Bones:**
    - Left & Right Pubis
  - **Ligaments:**
    - Ligamentous Capsule encases Fibrocartilagenous Disc.



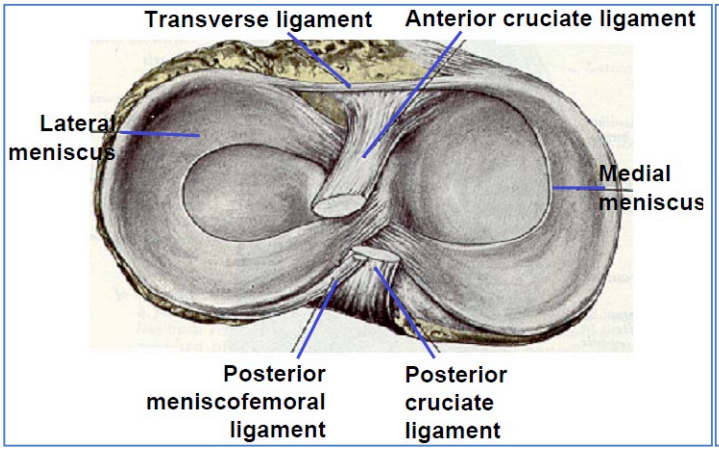
- **Hip Joints:**
  - **Features:**
    - Synovial, MultiAxial Ball & Socket
    - Acetabular Labrum (lip) of fibrocartilage – deepens socket – High Bony Congruency
    - Central fat-filled acetabular fossa.
  - **Bones:**
    - Rounded head of Femur
    - Acetabulum of Innominate Bones.
  - **Ligaments:**
    - **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

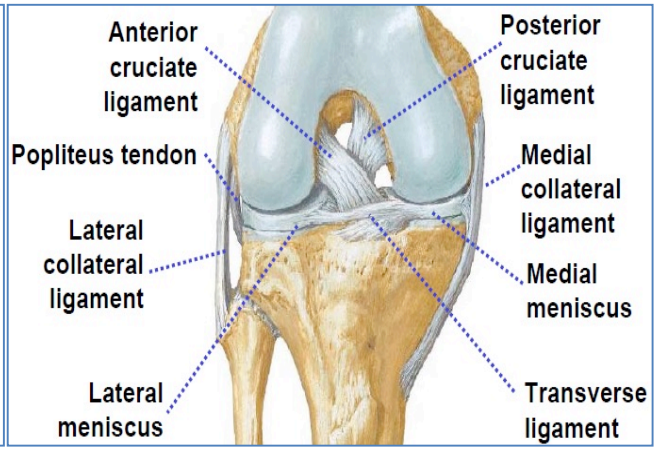


- **Knee Joint:**
  - **Features of The Knee Joint:**
    - Synovial Modified Bicondylar **Hinge** Joint
    - **Relatively Unstable:**
      - Some Gliding & Rolling
      - Some Rotation
      - Ligaments provide the stability – not Bony Congruity.
    - Poor Bony Congruity
    - **2 Parts:**
      - **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.

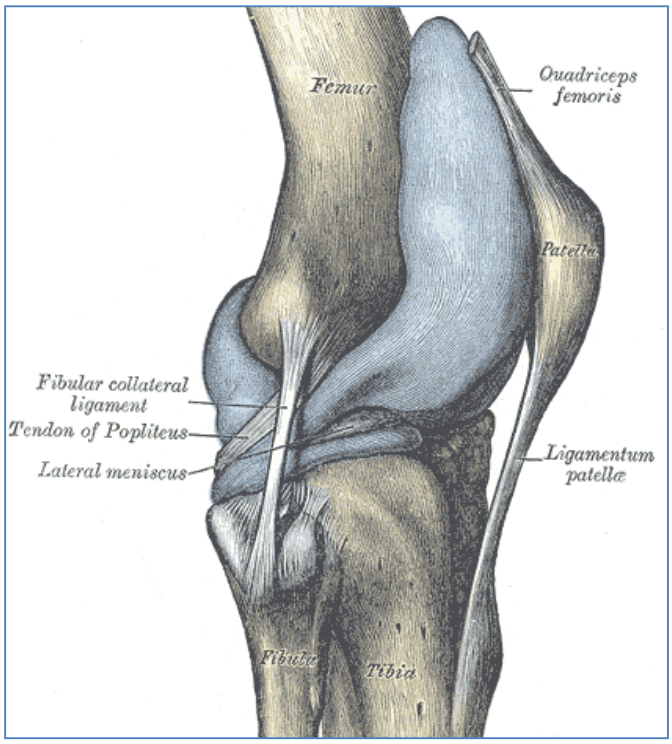


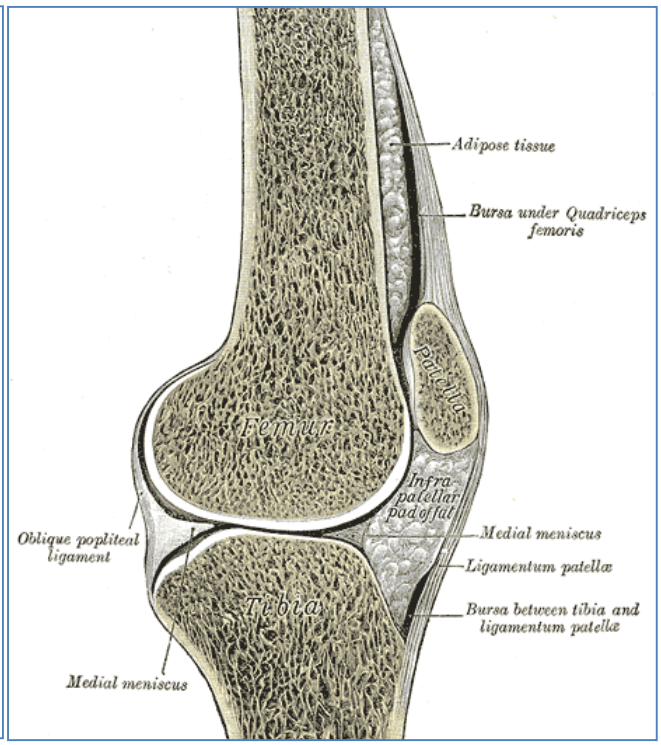
    - **Menisci:**
      - Fibrocartilage on Tibial Plateaus
      - Deepens the socket – increases congruity
      - Shock absorption
      - Peripheral Aspects are Vasculated – Central Aspects aren't → heal very slowly
      - **Lateral:**
        - More freely movable than Medial Meniscus due to attachments
        - **Attachments:**
          - Intercondylar Areas – Anterior & Posterior
          - Post. Cruciate Ligament – via Post. Meniscofemoral Ligament
          - Weak attachment to Joint Capsule
          - Not attached to Lateral Collateral Ligament
          - 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

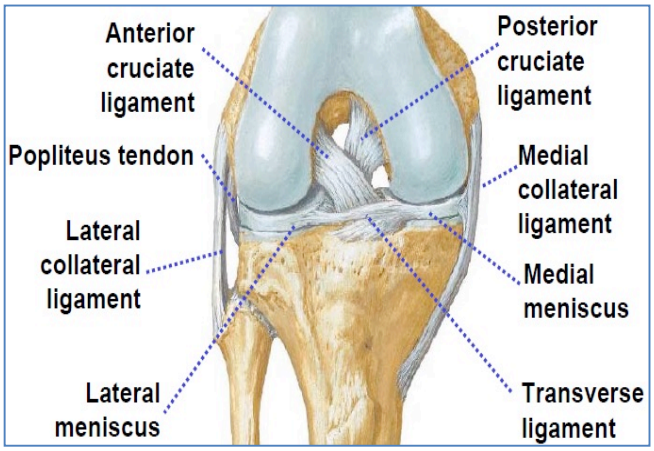




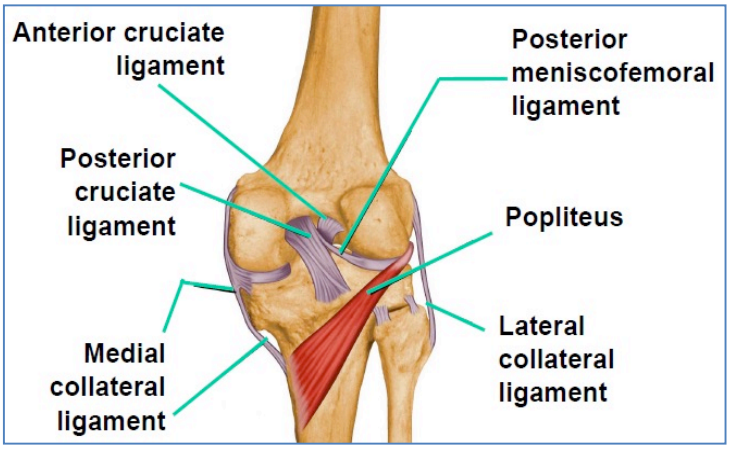
- **Bones:**
  - Femur
  - Patella
  - Tibia
- **Ligaments:**
  - Fibrous Capsule
    - Thick on Medial & Lateral aspects
    - 'Sleeve' around joint.
  - Extracapsular:
    - Patellar Ligament – Very Stong
    - Collaterals (Medial & Lateral)
  - Intracapsular:
    - Cruciates (Anterior & Posterior – 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)





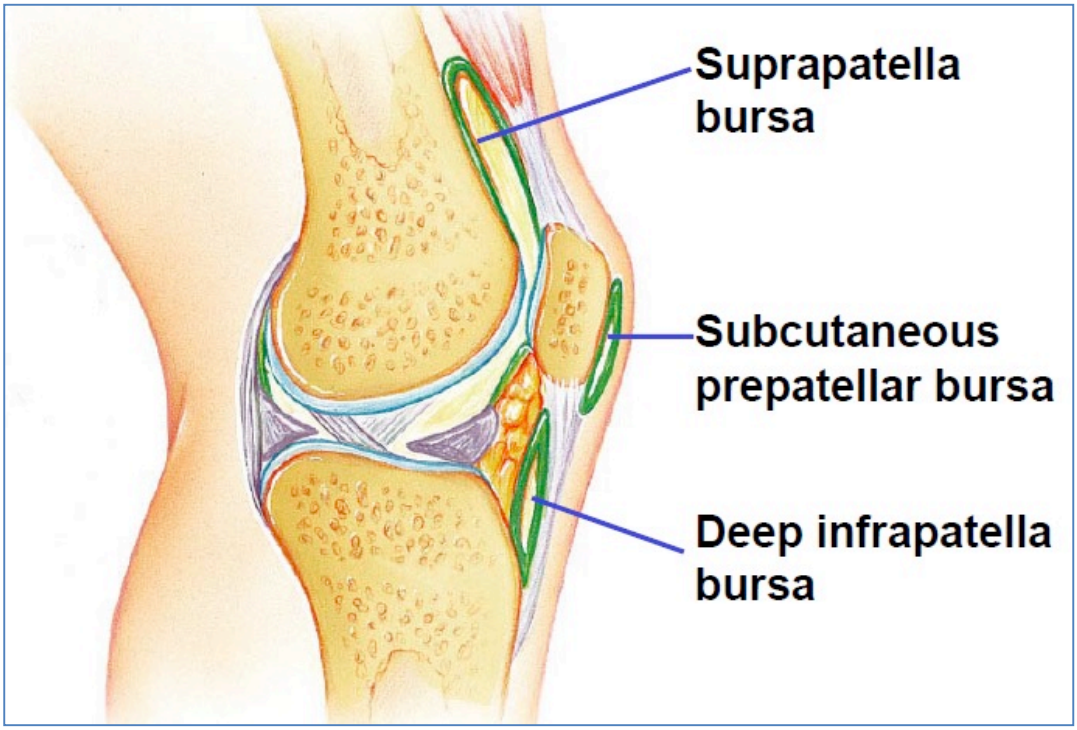


Anterior

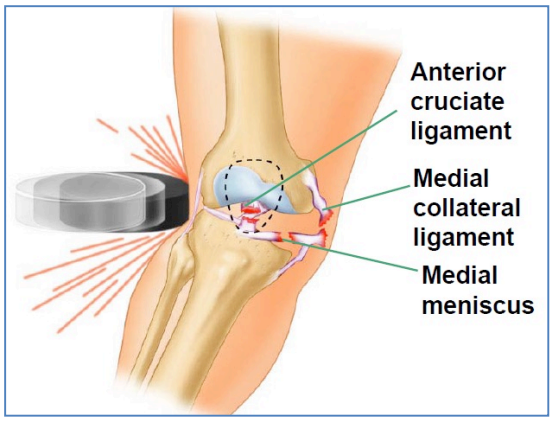


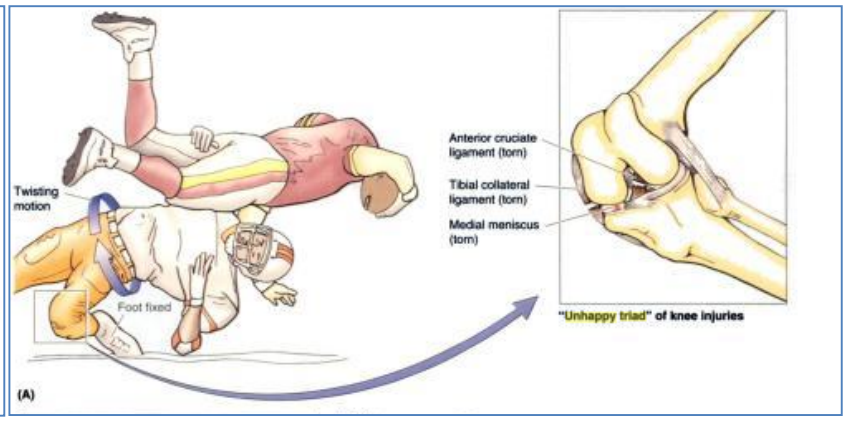
Posterior

- **Bursae:**
  - **SupraPatella Bursa**
    - Continuous with Snyovial 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

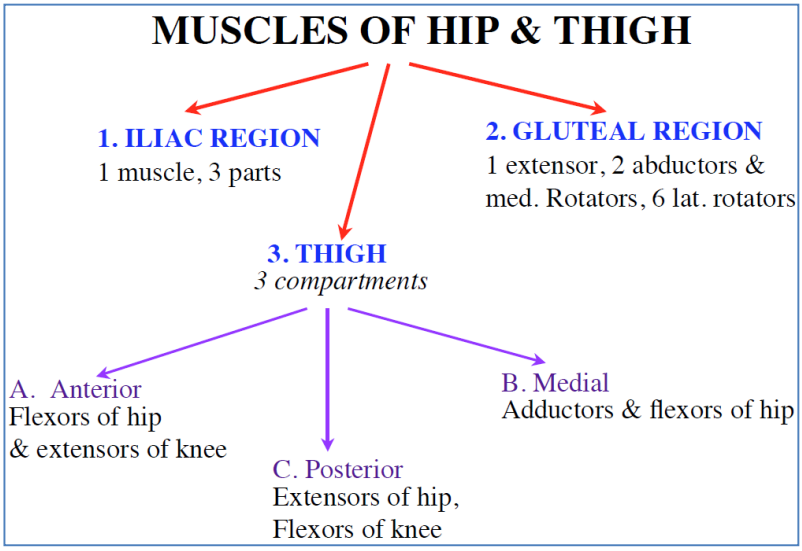


- **Injury: The Unhappy Triad:**
  - Anterior Cruciate Ligament
  - Medial Collateral Ligament
  - Medial Meniscus

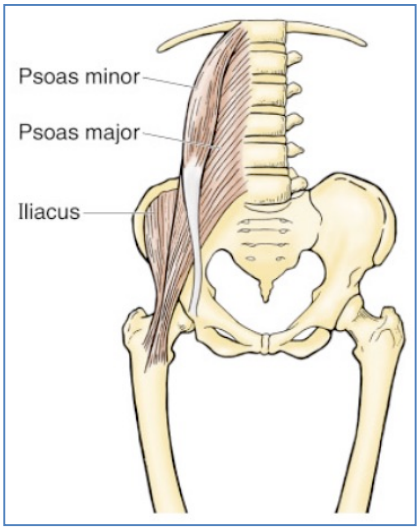




Muscles:

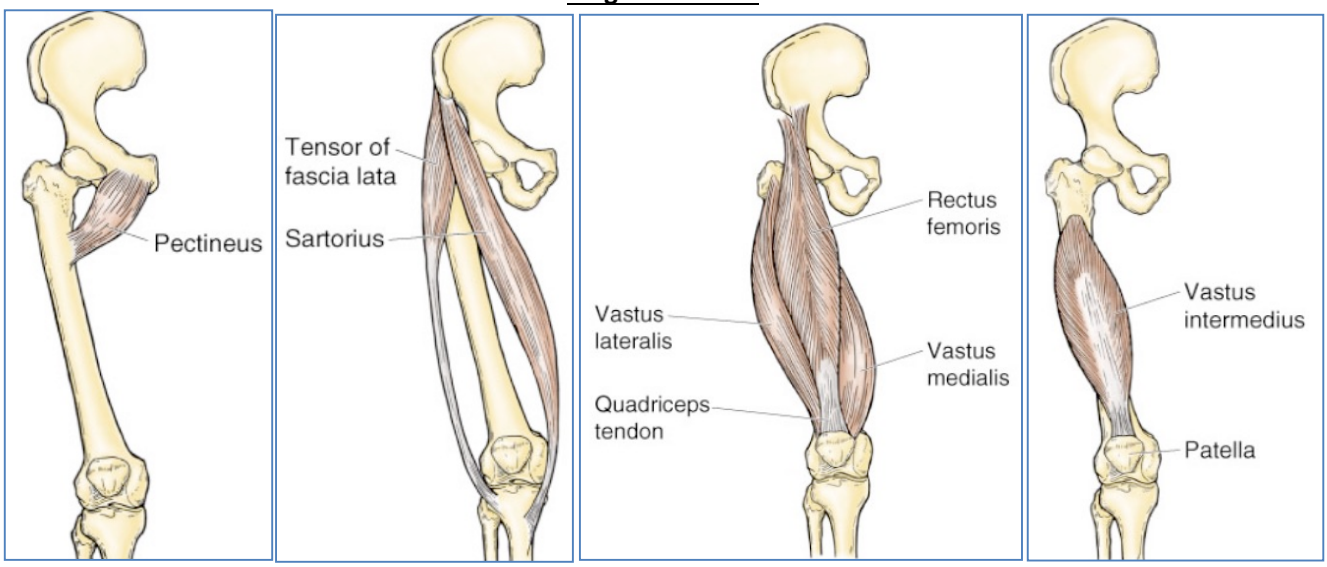


Iliac Region



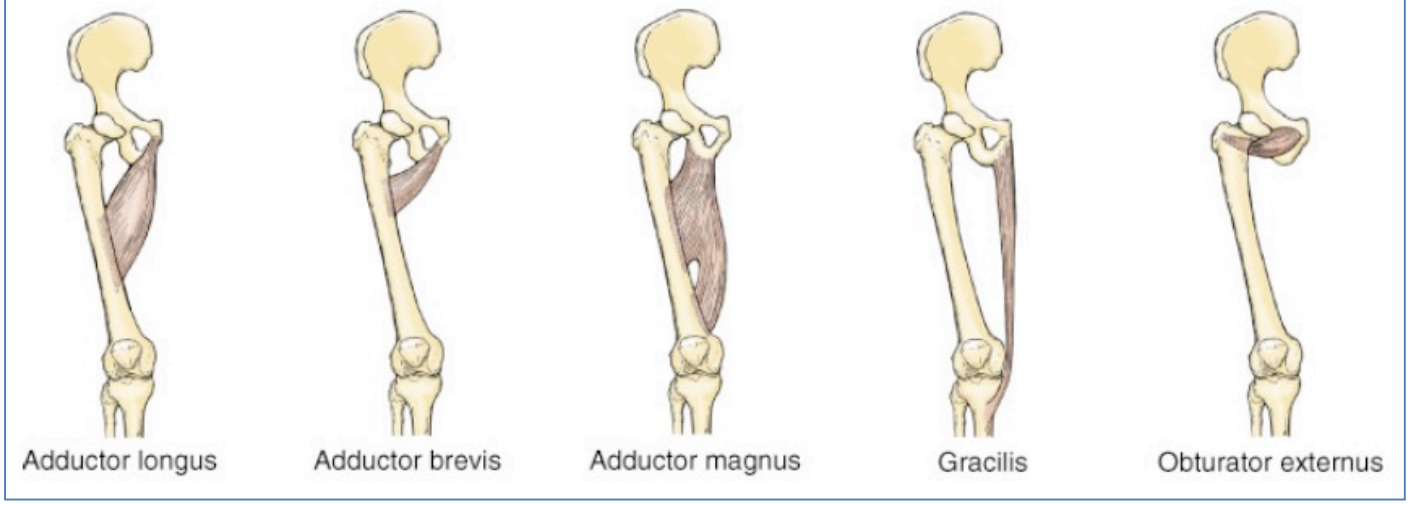
Iliopsoas: Iliacus, Psoas Major, Psoas Minor

Thigh: Anterior:

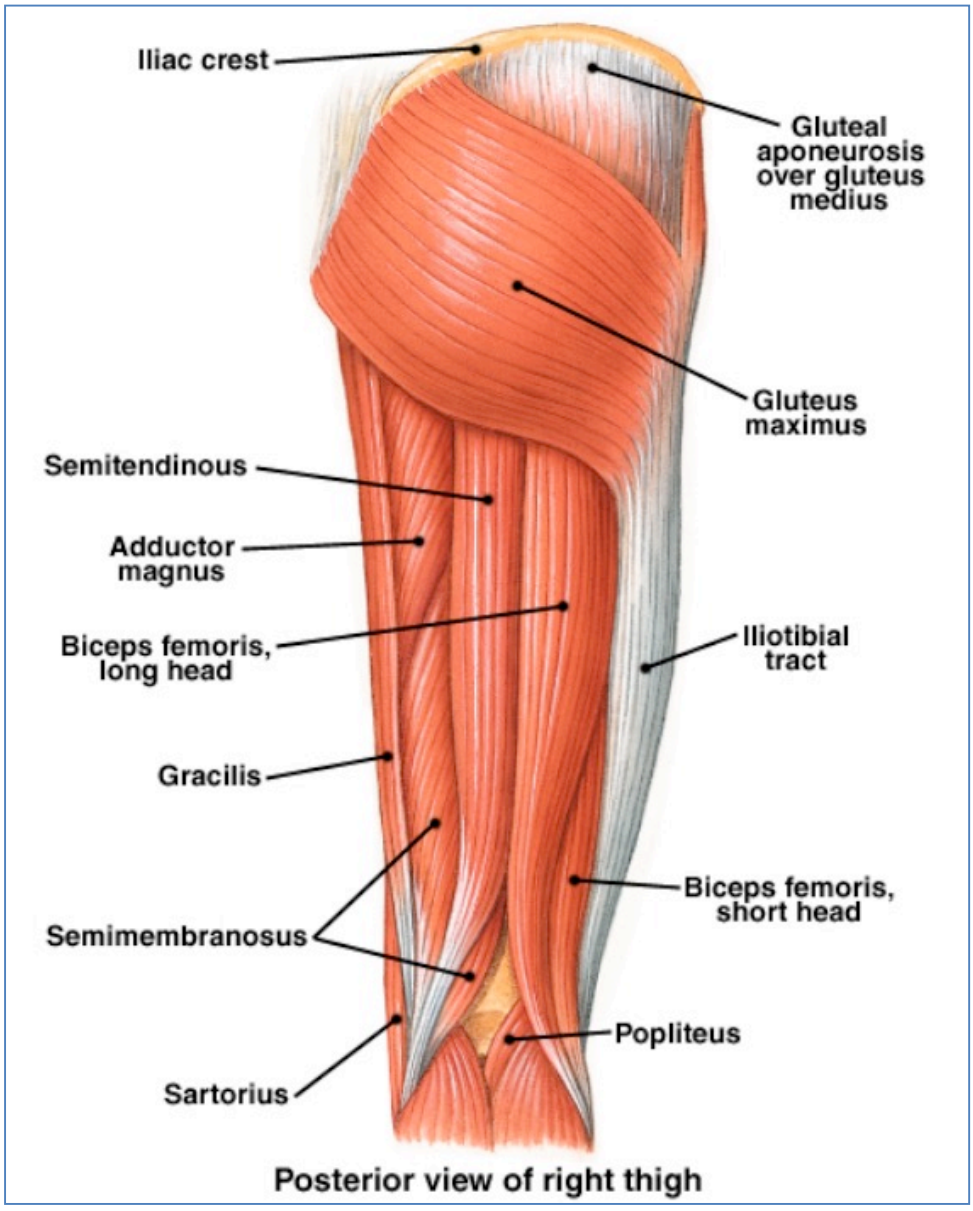


Thigh Medial:

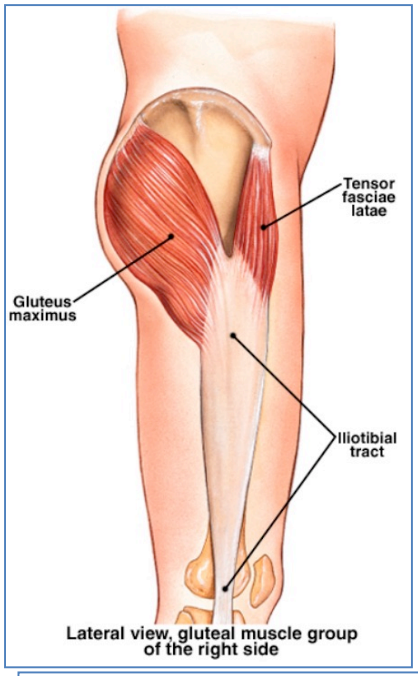
Table 5.3. Medial Thigh Muscles



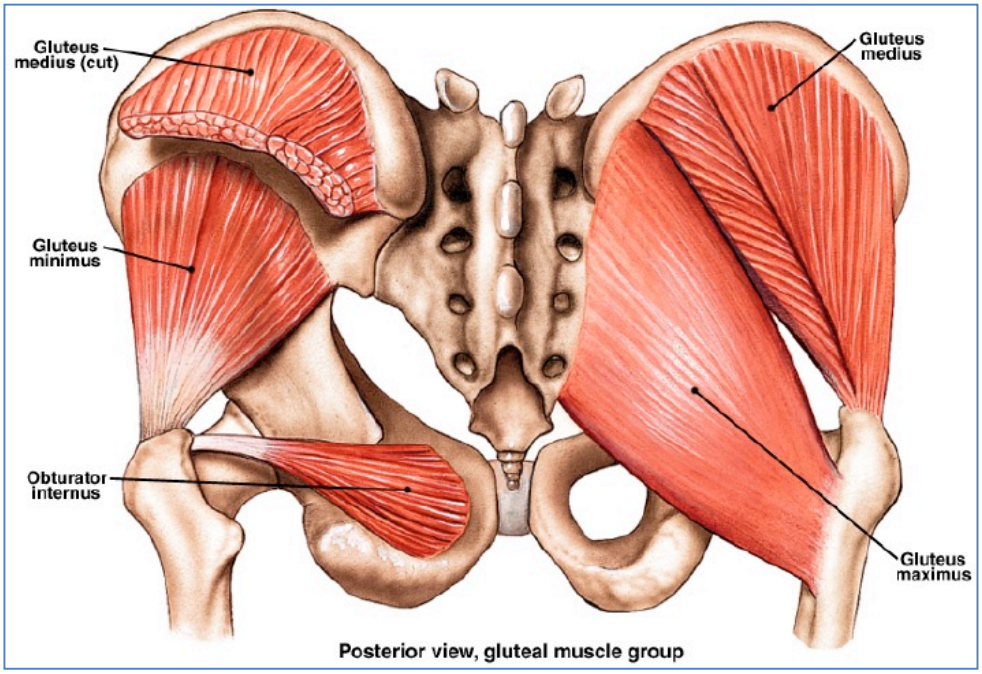
Thigh Posterior:



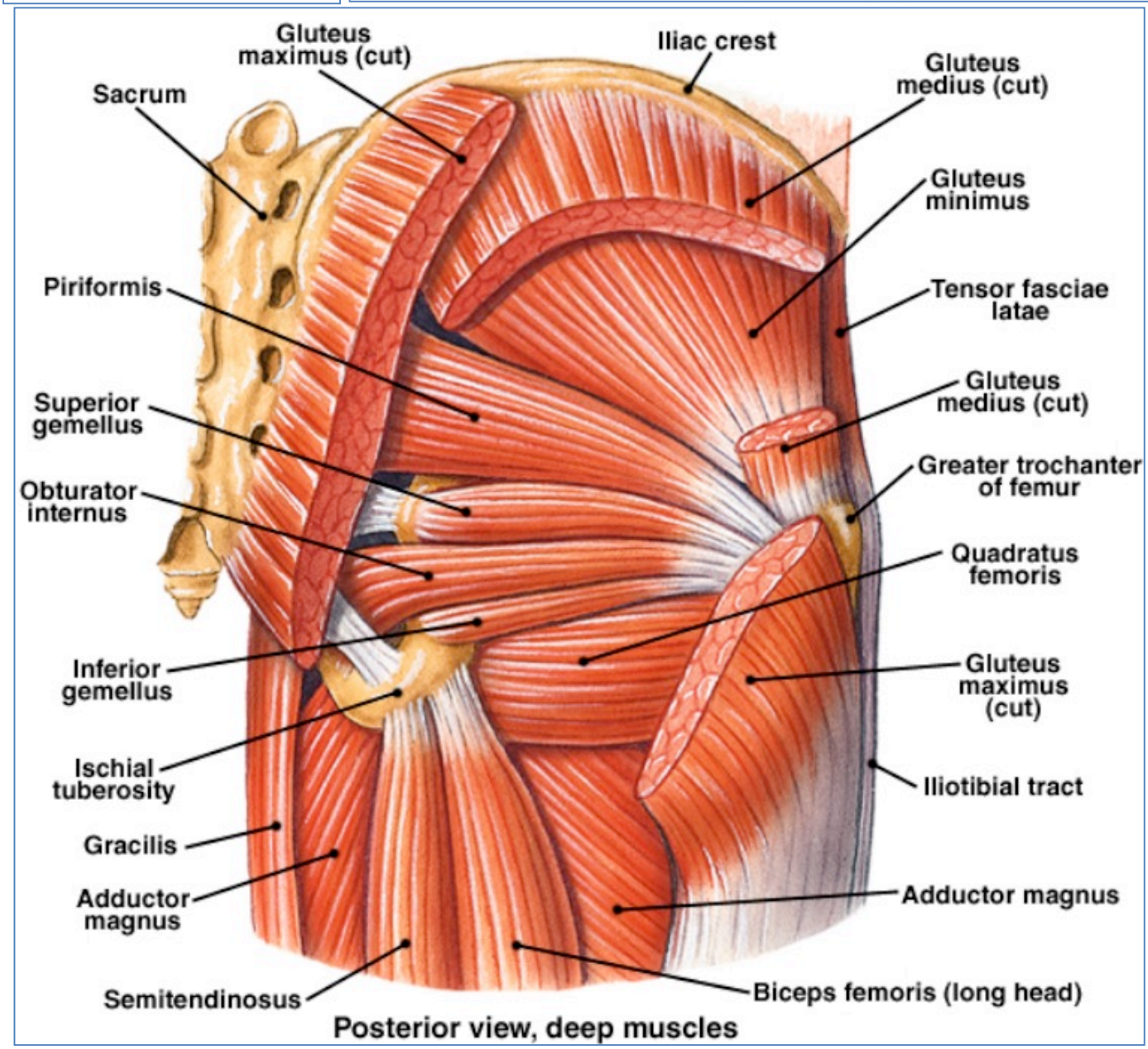
Gluteal Region



Lateral view, gluteal muscle group of the right side



Posterior view, gluteal muscle group



Posterior view, deep muscles

- **Muscles Originating on the Pelvis:**

Muscle	Origins/Insertions	Action
Sartorius *Femoral Nerve*	O – Anterior Superior Iliac Spine I – Medial Aspect of Proximal Tibia	Flexion of Hip Abduction of Hip Lateral Rotation of Thigh Flexion of Knee (weak)
Iliopsoas: **Iliacus** *Femoral Nerve*	O – Iliac Fossa & Crest Lateral Sacrum I – Lesser Trochanter of Femur via Iliopsoas Tendon	Flexion of thigh Doing a 'bow'
Iliopsoas: **Psoas Major** *Ventral Rami* (L_1-L_3)	O – Transverse processes, bodies & discs of Lumbar Vertebrae I – Lesser Trochanter of Femur via Iliopsoas Tendon	Lateral flexion of Vertebral Column Ie. An important 'postural muscle'

- **Thigh Muscles - Medial Compartment:**

Muscle	Origins/Insertions	Action
Gracilis *Obturator Nerve*	O – Inferior Ramus of Pubis I – Medial surface of Tibia inferior to medial condyle.	Adduction of Thigh Flexion of Thigh Medial Rotation of Thigh Flexion of Knee
Pectineus *Femoral Nerve*	O – Pubic Crest I – Between Lesser Trochanter & Linea Aspera of Posterior Femur	Adduction of Thigh Medial Rotation of Thigh Flexion of Thigh
Adductor Brevis *Obturator Nerve*	O – Inferior Ramus of Pubis I – Linea Aspera (above Adductor Longus)	Adduction of Thigh Medial Rotation of Thigh
Adductor Longus *Anterior Division of Obturator Nerve*	O – Pubis near Pubic Symphysis I – Linea Aspera	Adduction of Thigh Flexion of Thigh Medial Rotation of Thigh
Adductor Magnus *Obturator Nerve & Sciatic Nerve*	O – Ischial & Pubic Rami & Ischial Tuberosity (ie. Entire inferior surfaces of Pubis & Ischium) I – Linea Aspera & Adductor Tubercle of Femur	Anterior Part: • Adduction of Thigh • Medial Rotation of Thigh • Flexion of Thigh Posterior Part: • Synergist of Hamstrings in Thigh Extension

- **Thigh Muscles – Anterior Compartment:**

Muscle	Origins/Insertions	Action
Tensor Fasciae Latae *Superior Gluteal Nerve*	O – Anterior Superior Iliac Crest I – Iliotibial Tract*	Adduction of Thigh Flexion of Thigh Medial Rotation of Thigh
Quadriceps Femoris: *All: Femoral Nerve* **Rectus Femoris**	O – Anterior Inferior Iliac Spine Superior Margin of Acetabulum I – Patella & Tibial Tuberosity Via Patellar Ligament	Flexion of Thigh Extension of Knee
Quadriceps Femoris: **Vastus Lateralus**	O – Greater Trochanter of Femur I – Patella & Tibial Tuberosity Via Patellar Ligament	Extension of Knee Stabilises Knee
Quadriceps Femoris: **Vastus Medialis**	O – Linea Aspera & Intertrochanteric Line of Femur I – Patella & Tibial Tuberosity Via Patellar Ligament	Extension of Knee Inferior Fibres Stabilise Patella
Quadriceps Femoris: **Vastus Intermedius**	O – Proximal Femur Shaft (Anterior & Lateral Surfaces) I – Patella & Tibial Tuberosity Via Patellar Ligament	Extension of Knee

***NB: Iliotibial Tract** – Thickened lateral portion of the Fascia Lata (fascia that ensheathes all muscles of the thigh). It extends as a tendinous band from the Iliac Crest to the Knee.

MUSCLE GALLERY TABLE 10.14 Muscles Crossing the Hip and Knee Joints: Movements of the Thigh and Leg (Figures 10.19 and 10.20) *(continued)*

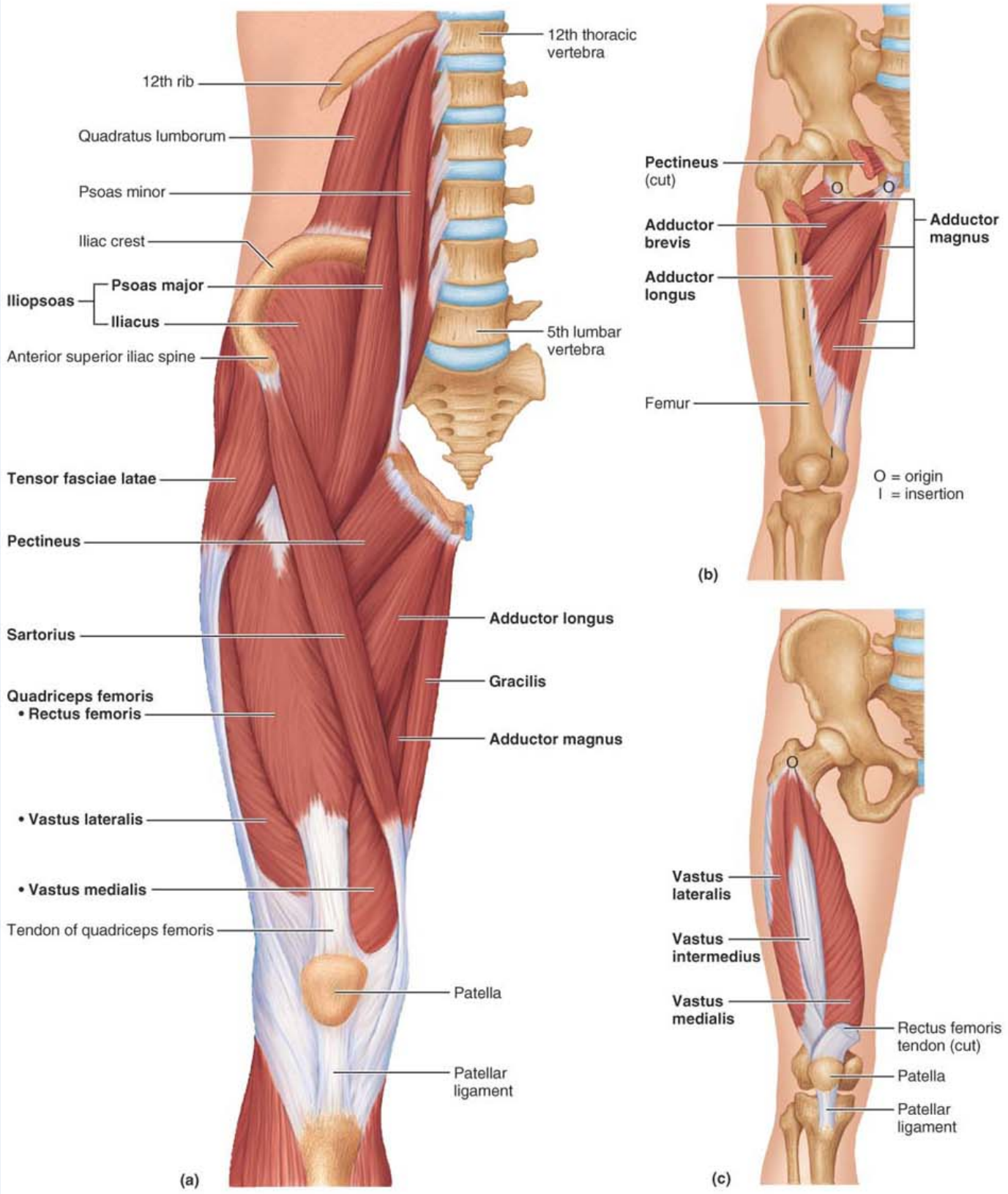


FIGURE 10.19 **Anterior and medial muscles promoting movements of the thigh and leg. (a)** Anterior view of the deep muscles of the pelvis and superficial muscles of the right thigh. (See *A Brief Atlas of the Human Body*, Figure 40.) **(b)** Adductor muscles of the medial compartment of the thigh isolated. **(c)** The vastus muscles of the quadriceps group. The rectus femoris muscle of the quadriceps group and surrounding muscles have been removed.

- **3 Gluteal Muscles:**

Muscle	Origins/Insertions	Action
Gluteus Maximus *Inferior Gluteal Nerve*	O – Dorsal Ilium, Sacrum & Coccyx I – Gluteal Tuberosity (line) of Femur Iliotibial Tract*	Extension of Thigh Lateral Rotation of Thigh Abduction of Thigh
Gluteus Medius *Superior Gluteal Nerve*	O – Lateral Surface of Ilium (between Anterior & Posterior Gluteal Lines) I – Lateral Surface of Greater Trochanter of Femur	Abduction of Thigh Medial Rotation of Thigh -Critical for walking – steadies Pelvis
Gluteus Minimus *Superior Gluteal Nerve*	O – Lateral Surface of Ilium (between Anterior & Inferior Gluteal Lines) I – Anterior aspect of Greater Trochanter of Femur	Abduction of Thigh Medial Rotation of Thigh -Critical for walking – steadies Pelvis

- **Lateral Rotators of Femur:**

Muscle	Origins/Insertions	Action
Piriformus S_1, S_2 & L_5	O – Sacrum (Anterio-Lateral Aspect) I – Greater Trochanter of Femur (superior)	Adduction of Thigh Rotates Extended Thigh Laterally Stabilises Hip Joint
Gemellus Superior L_5 & S_1	O – Ischial Spine I – Greater Trochanter of Femur	Adduction of Thigh Rotates Extended Thigh Laterally Stabilises Hip Joint
Obturator Internus L_5 & S_1	O – Obturator Membrane (Inner Surface) Greater Sciatic Notch (Inner Surface) Margins of Obturator Foramen (Inner) I – Greater Trochanter	Adduction of Thigh Rotates Extended Thigh Laterally Stabilises Hip Joint
Gemellus Inferior L_5 & S_1	O – Ischial Tuberosity I – Greater Trochanter of Femur	Adduction of Thigh Rotates Extended Thigh Laterally Stabilises Hip Joint
Obturator Externus *Obturator Nerve*	O – Obturator Membrane (outer surface) Margins of Obturator Foramen Pubis (Outer Surface) Ischium (Outer Surface) I – Trochanteric Fossa of (posterior) Femur	Adduction of Thigh Rotates Extended Thigh Laterally Stabilises Hip Joint
Quadratus Femoris L_5 & S_1	O – Ischial Tuberosity I – Trochanteric Crest of Femur	Lateral Rotation of Thigh Stabilises Hip Joint

- **Thigh Muscles - Posterior Compartment:**

Muscle	Origins/Insertions	Action
Hamstrings: **Biceps Femoris** *Long Head: Sciatic-Tibial Nerve.* *Short Head: Fibular Nerve*	O – [Long Head] Ischial Tuberosity [Short head] Linea Aspera I – Common Tendon → Head of Fibula & Lateral Condyle of Tibia (Forms Lateral Border of Popliteal Fossa)	Extension of Thigh Flexion of Knee Lateral Rotation of Knee (when flexed)
Hamstrings: **Semitendonosus** *Sciatic-Tibial Nerve*	O – Ischial Tuberosity I – Upper Tibial Shaft (medially)	Extension of Thigh Flexion of Knee Medial Rotation of Knee (leg)
Hamstrings: **Semimembranosus** *Sciatic-Tibial Nerve*	O – Ischial Tuberosity I – Medial Condyle of Tibia (via oblique popliteal ligament)	Extension of Thigh Flexion of Knee Medial Rotation of Knee (leg)

MUSCLE GALLERY TABLE 10.14 *(continued)*

MUSCLE	DESCRIPTION	ORIGIN (O) AND INSERTION (I)	ACTION	NERVE SUPPLY
Obturator externus (ob"tu-ra'tor ek-ster'-nus) (*obturator* = obturator foramen; *externus* = outside)	Flat, triangular muscle deep in superomedial aspect of thigh	O—outer surfaces of obturator membrane, pubis, and ischium, margins of obturator foramen I—by a tendon into trochanteric fossa of posterior femur	As for piriformis	Obturator nerve

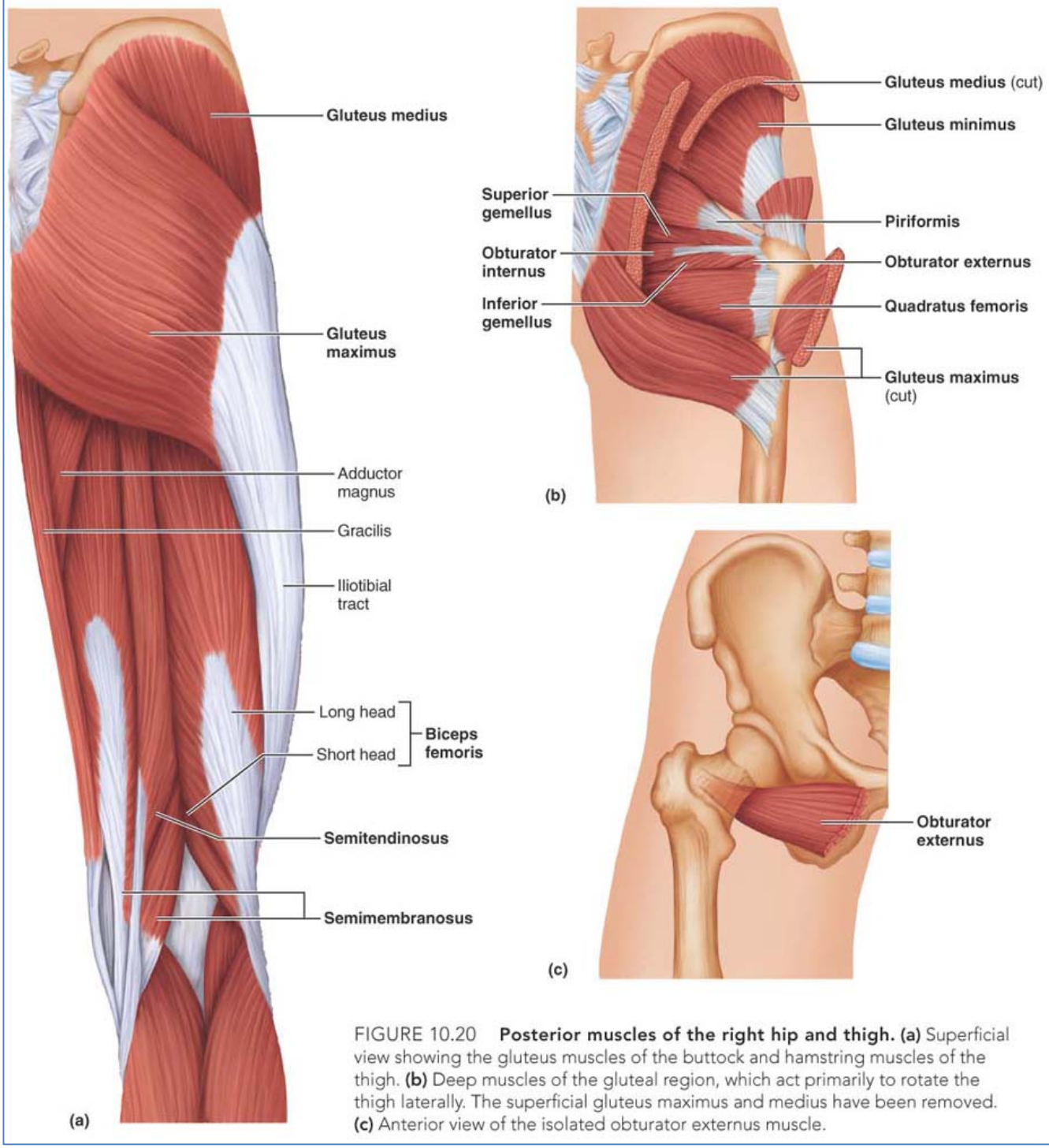
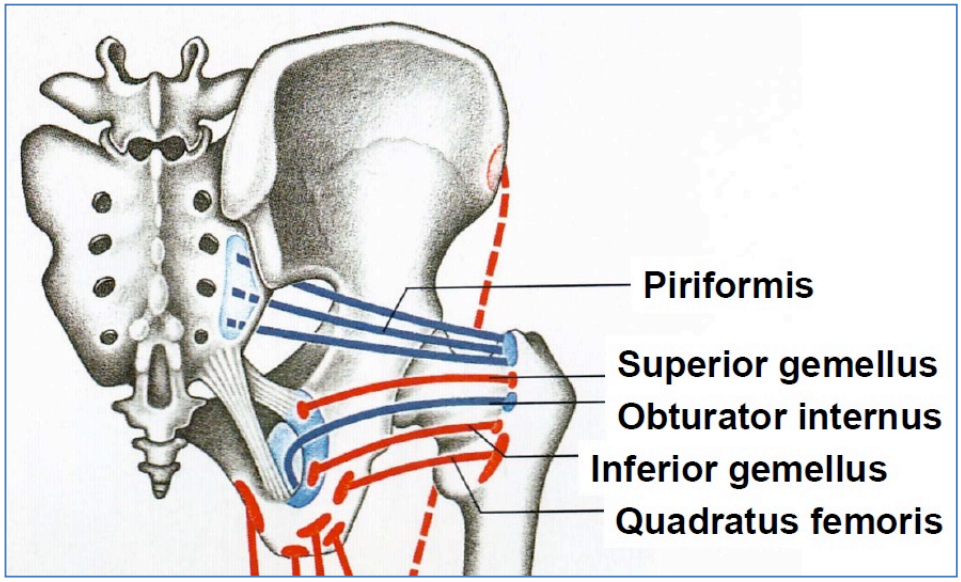
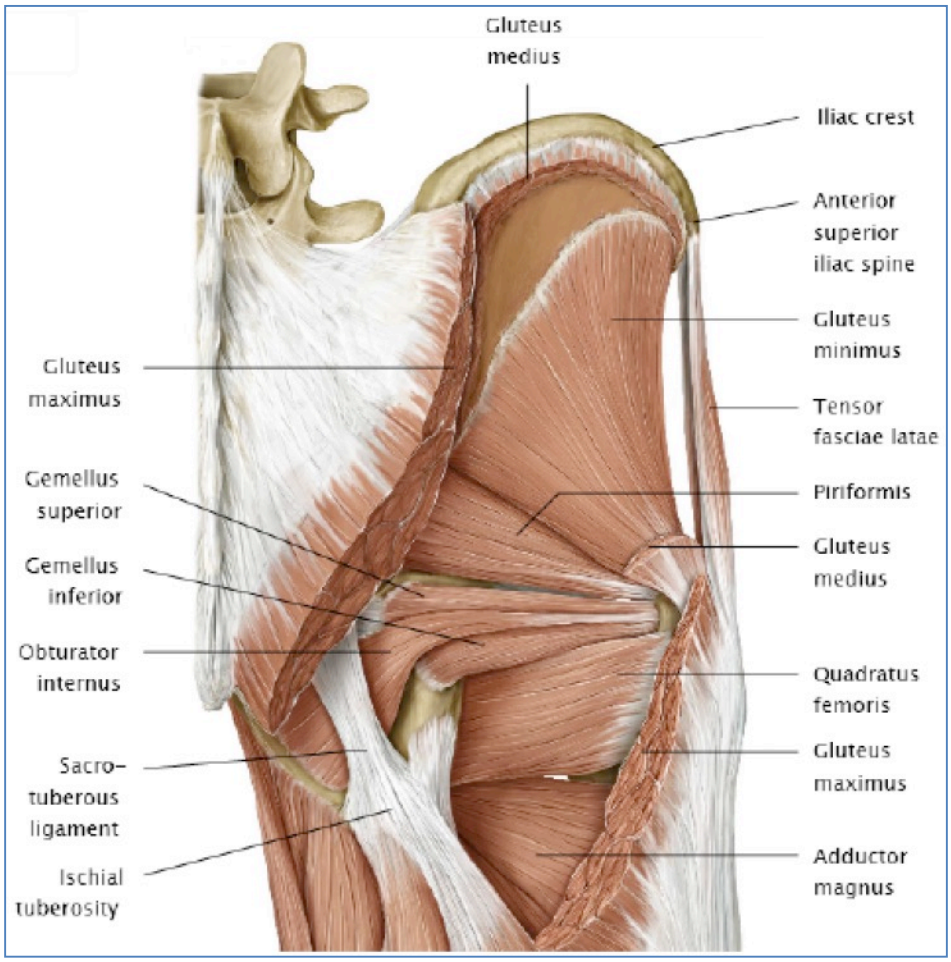


FIGURE 10.20 **Posterior muscles of the right hip and thigh. (a)** Superficial view showing the gluteus muscles of the buttock and hamstring muscles of the thigh. **(b)** Deep muscles of the gluteal region, which act primarily to rotate the thigh laterally. The superficial gluteus maximus and medius have been removed. **(c)** Anterior view of the isolated obturator externus muscle.

Lateral Rotators: Origins & Insertions: Posterior Aspect





The "Femoral Triangle"

Boundaries:

- **Superior:** Inguinal Ligament
- **Lateral:** Sartorius
- **Medial:** Adductor Longus

Corners:

- **Inferior:** Where Sartorius meets Adductor Longus
- **Superior:** Where Sartorius meets Inguinal Ligament
- **Medial:** Where Adductor Longus meets Pectineus

Contents:

- Femoral **N**erve
- Femoral **A**rtery
- Femoral **V**ein
- **E**mpty Space
- Inguinal **L**ymphatics

"NAVEL" →

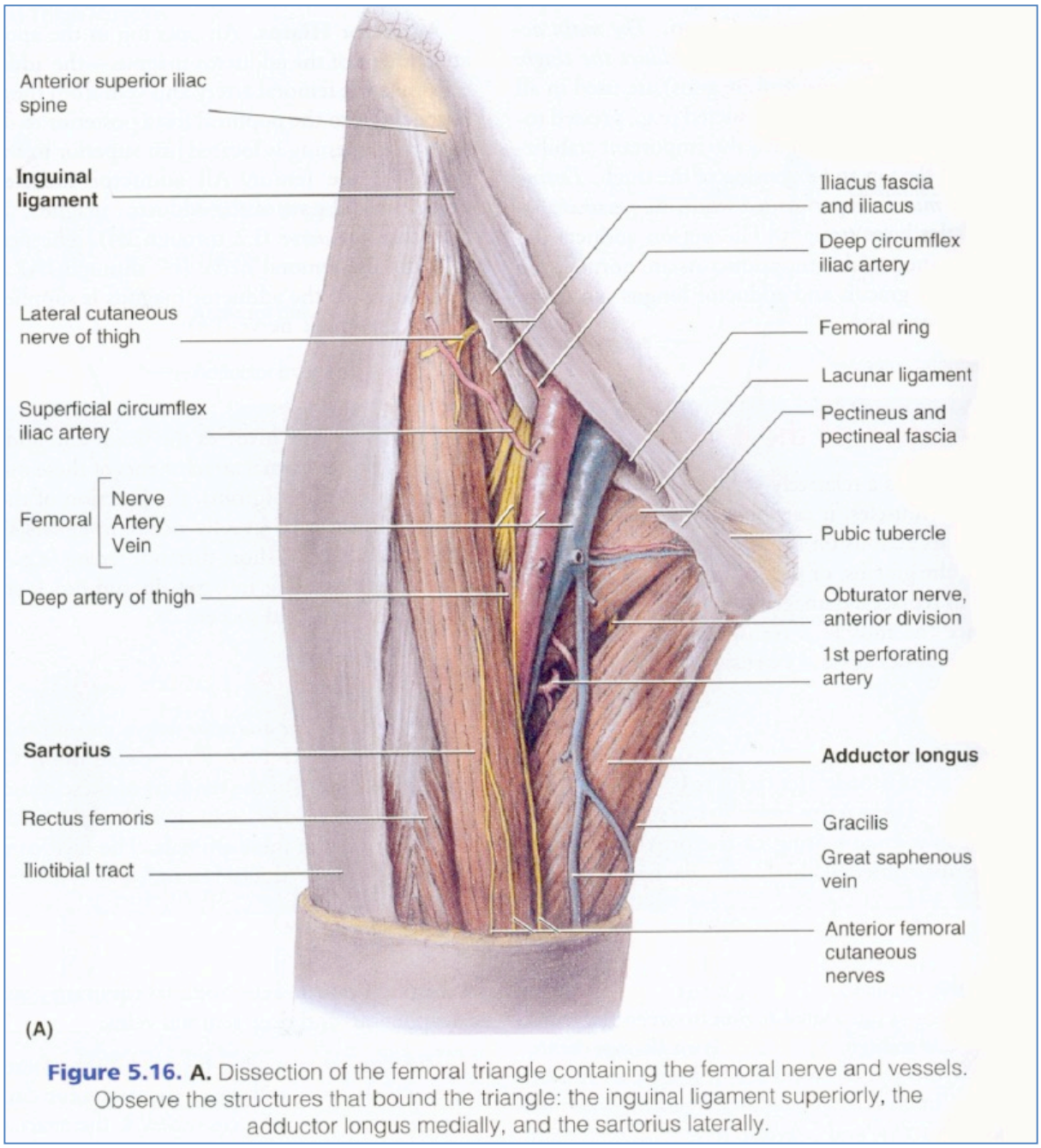
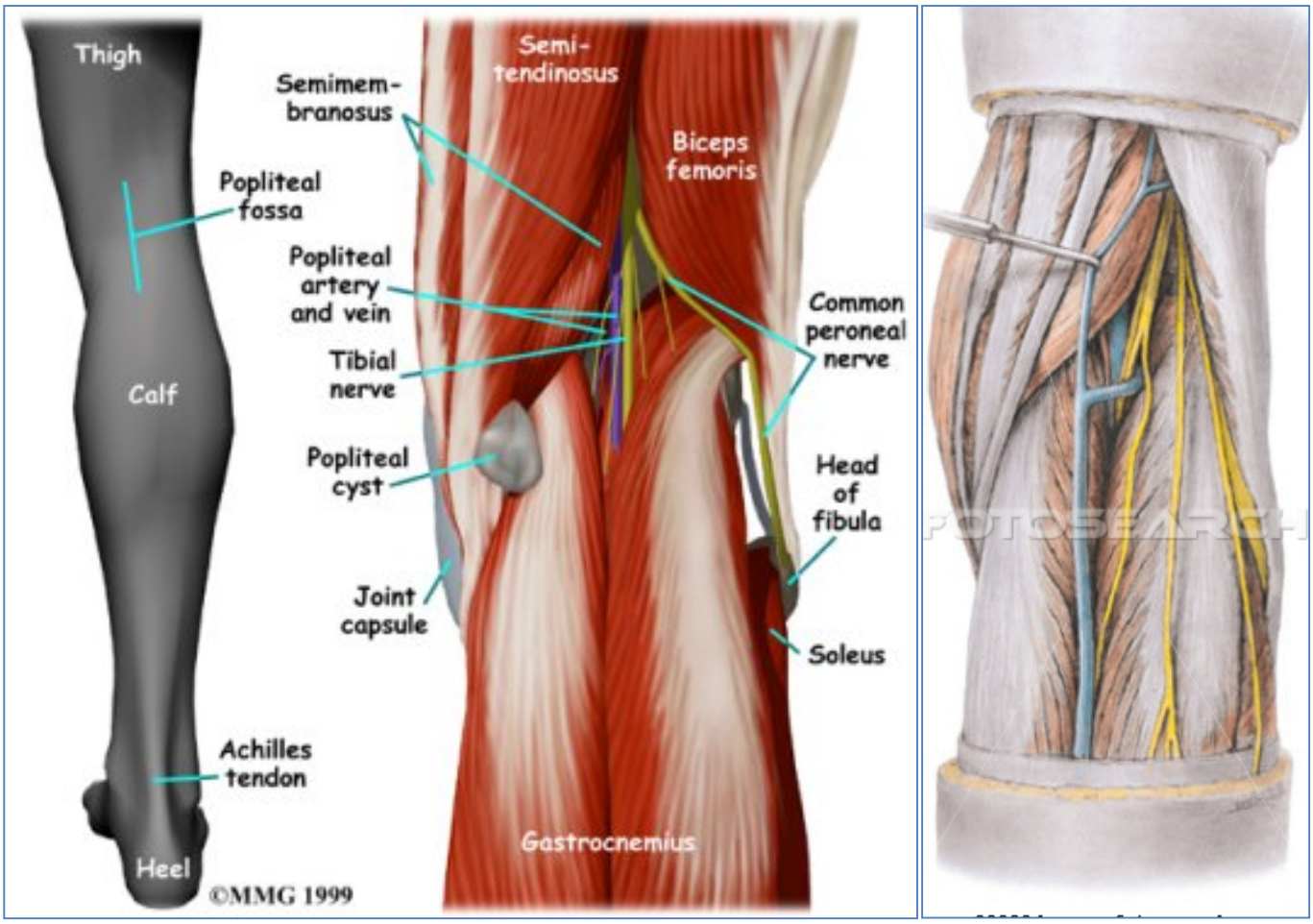


Figure 5.16. A. Dissection of the femoral triangle containing the femoral nerve and vessels. Observe the structures that bound the triangle: the inguinal ligament superiorly, the adductor longus medially, and the sartorius laterally.

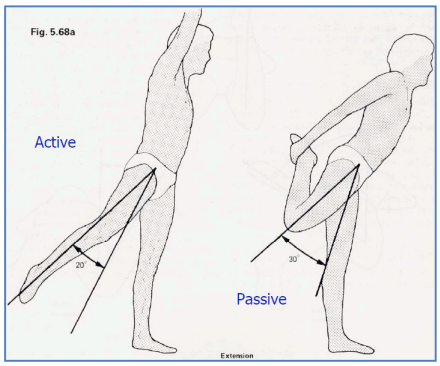
The Popliteal Fossa:

- **General:**
- Posterior Aspect of Knee
- Diamond-shaped
- **Boundaries:**
  - **Superio-Medially:**
    - Semimembranosus
    - Semitendonosus
  - **Superio-Laterally:**
    - Biceps Femoris
  - **Inferior-Medially:**
    - Medial head of Gastrocnemius
  - **Inferior-Laterally:**
    - Lateral Head of Gastrocnemius
- **Contents:**
  - Popliteal Artery
  - Popliteal Vein
  - Tibial Nerve
  - Common Fibular Nerve

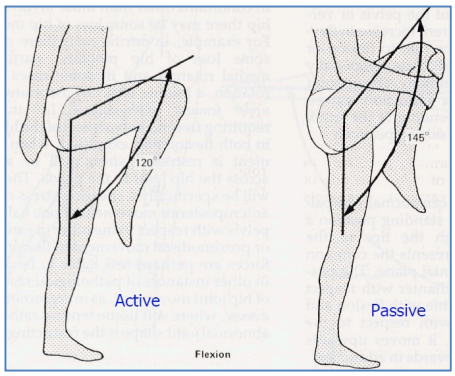


Movements @ the Hip:

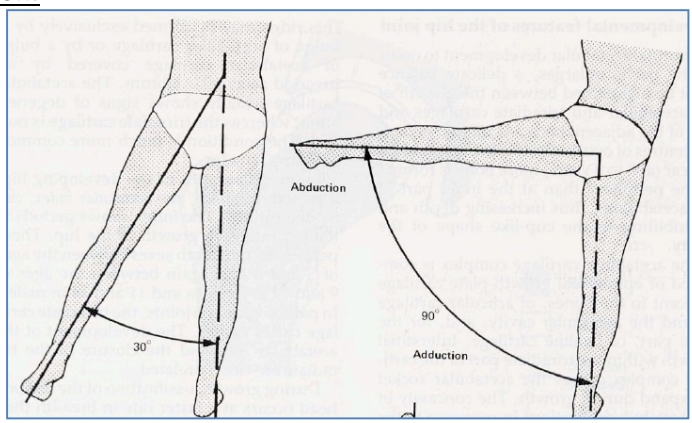
- **Extension:**



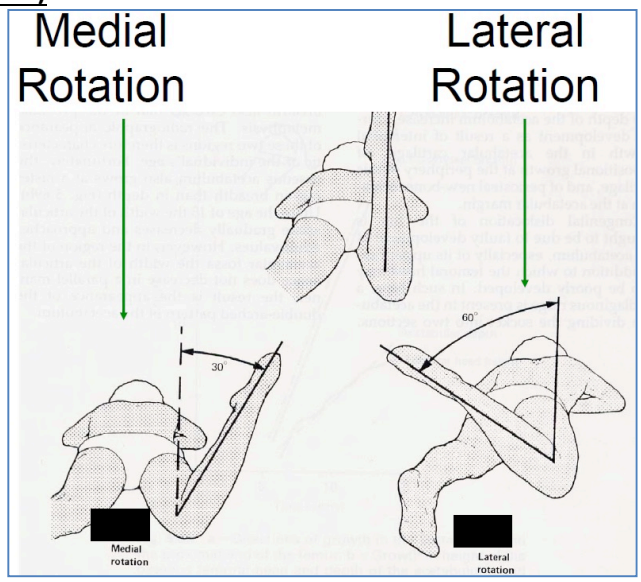
- **Flexion:**



- **Abduction & Adduction:**



- **Rotation (medial & lateral)**



Movements at the Knee:

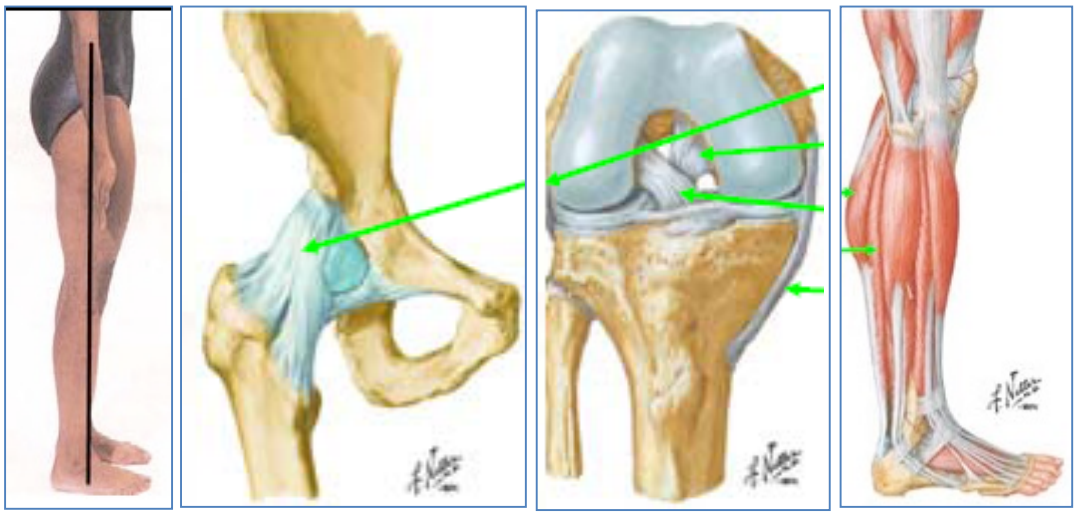
- Flexion
- Extension
- Slight Rotation

Movements at the Ankle:

- Inversion
- Eversion
- Plantar Flexion
- Dorsi Flexion

Gait – The Process of Walking:

- **Standing:**
  - Postural muscles working
  - Very efficient – only consumes 7% more energy than lying down.
  - Knee 'locks' in place
  - All 3 joints (hip, knee & ankle) are in their most stable positions.
  - **Hip:**
    - Neutral/Extended
    - Iliofemoral ligament is taut in this position
    - Centre of Gravity – Posterior to joint
  - **Knee:**
    - Fully Extended
    - Knee ligaments are taut in this position
    - Centre of Gravity – Anterior to joint
  - **Ankle:**
    - Neutral/Slightly Dorsiflexed
    - Centre of Gravity – Anterior to joint
    - No innate stabilisers – stabilised by contraction of Triceps Surae (Gastrocnemius + Soleus)

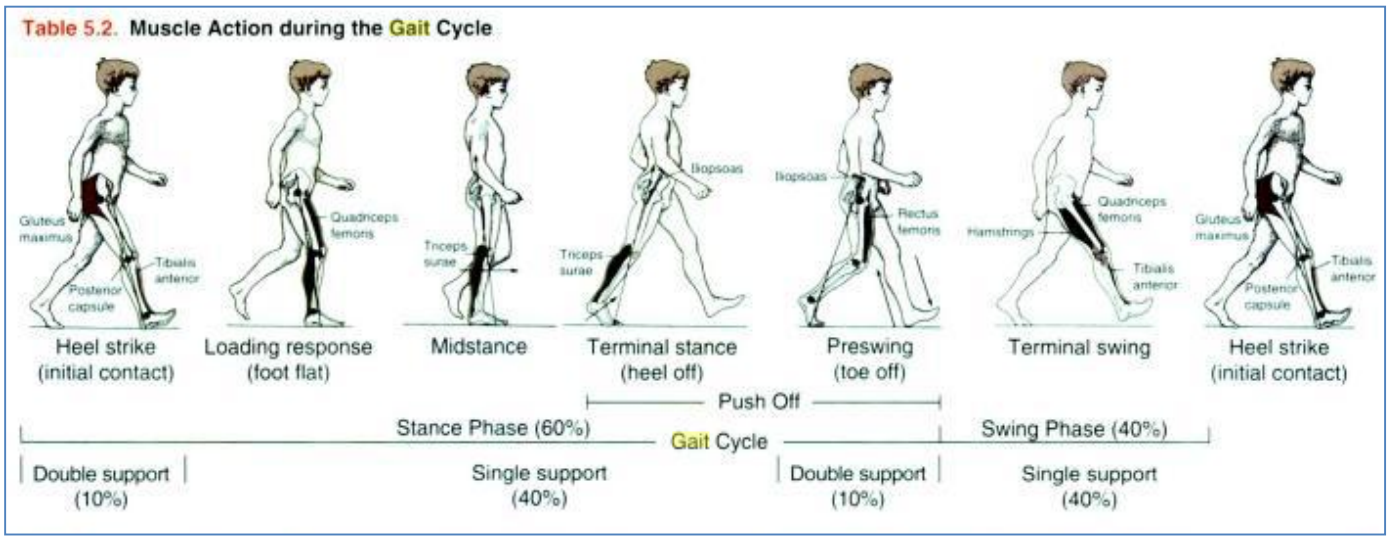


- **Walking:**
  - **Tasks of Gait:**
    - Weight Acceptance
    - Single Limb Support
    - Advancement of Limb
  - **Phases of Walking:**
    - **Stance:** (Foot is on the ground)

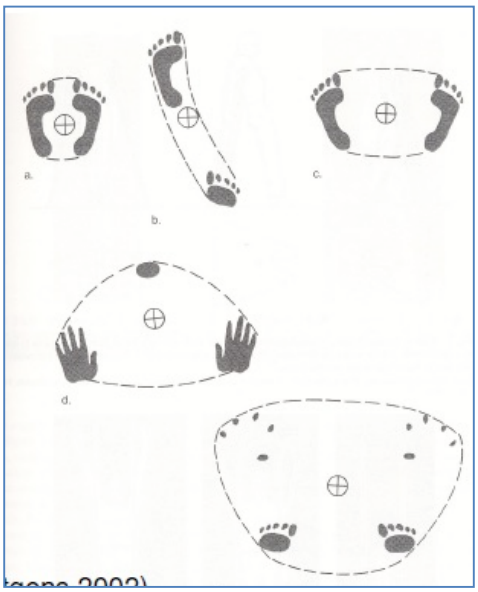
		Hip	Knee	Ankle
Heel Strike	**Position:**	Flexed	Mildly Flexed	Dorsiflexed
	Prime Mover/s:	Psoas Muscle	Gravity	Tibialis Anterior
	Stabiliser/s:	Gluteus Maximus	Iliotibial Tract Quadriceps	Inverters/Everters
Midstance	**Position:**	Flexed →Neutral	Extended	Neutral/Dorsiflexed
	Prime Mover/s:	Gluteus Maximus Hamstrings	-	-
	Stabiliser/s:	Gluteus Medius Gluteus Minimus Tensor Fascia Lata	Quadriceps Femoris Medial Muscles	Intrinsic Foot Muscles
Toe-Off	**Position:**	Neutral → Flexed	Beginning to Flex	Plantar Flexion
	Prime Mover/s:	Gluteus Maximus	-	Triceps Surae
	Stabiliser/s:	-	Quadriceps Femoris	Toe Flexors

- **Swing:** (Foot is off the ground)
  - **Swing:**

		Hip	Knee	Ankle
Swing	**Position:**	Extended→Flexion	Flexed→Extension	Dorsiflexion
	Prime Mover/s:	Iliopsoas Lateral Rotators	Gravity	Tibialis Anterior
	Stabiliser/s:	Antag: Gluteus Maximus	Quadriceps Femoris Antag: Hamstrings	-



- **Features of Gait:**
  - Centre of Gravity Lower = More Stable
  - Base of Support – Larger = More Stable (eg. Zimmer frames/walking sticks)
  - Step Length
  - Velocity
  - Cadence (steps/minute)

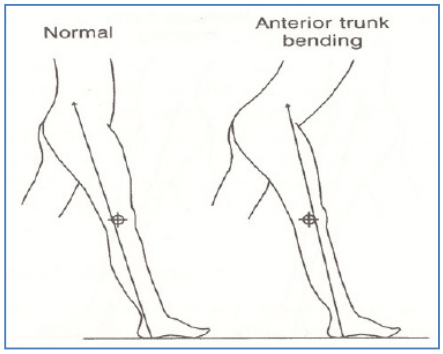


Base of Support

- **Factors Influencing Gait:**
  - Age/Maturation – adult gait patter occurs at ≈10yrs
  - Old age
  - Gender
  - **Pain**
  - **CNS Disorders –** Stroke/MS/Parkinsons/Kennedy's Disease/etc
  - **MSS Impairments –** Injury/Fused Joint/Tendonitis/Arthritis/etc
  - Assistive devices
  - Braces/Orthotics/Taping
  - Habit
  - Terrain
  - Velocity
  - Emotion
  - Height
  - Weight

- **Methods of Gait Analysis:**
  - Visual Method (eg. In the doctor's office)
  - Video Method (eg. Slo-mo camera)
  - Gait Timing (Foot Switches/Sensored Catwalks)

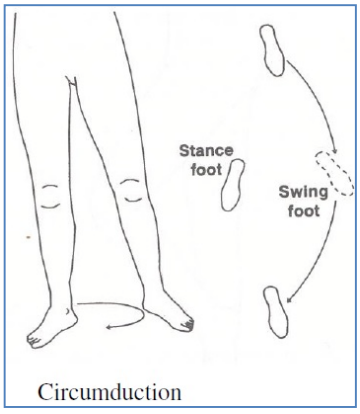
- **Examples of Gait Abnormalities:**
  - Anterior Trunk Bending:
    - Weak knee extensors – need to 'lock' their knee to walk/
    - Fused knee/
    - Tight hip flexors/

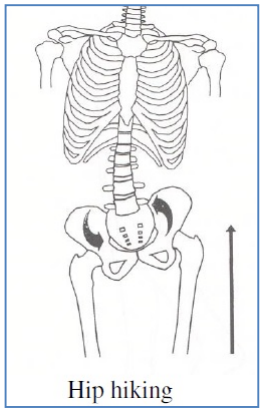


  - Trendelenburg (ie. 'Hip Drop'):
    - Hip-abductor weakness/

  - Leg Length Discrepancy:
    - Anatomical:
      - Actual difference in leg length
    - Functional:
      - Eg. Neurological Muscle imbalance – ie. Stroke/foot-drop/etc.
      - Eg. Musculoskeletal Problems

    - Patients may try to overcome this by:
      - Circumducting the hip
      - Hip Hiking
      - Steppage
      - Vaulting





- Excessive Knee Extension:
    - Ie. Snapping the knee into its 'locked' position midway through stance phase.
    - Due to Weak Knee Flexors.

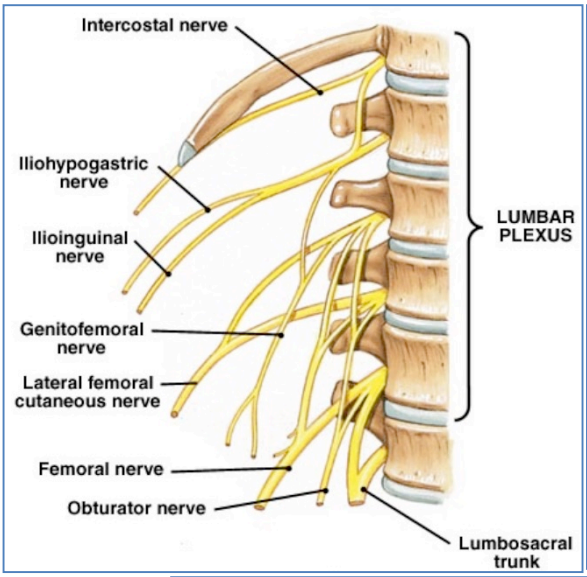
- 'Foot Slap':
    - Ie. Lack of eccentric control of Dorsiflexion → following 'heel strike', the foot slaps the ground.

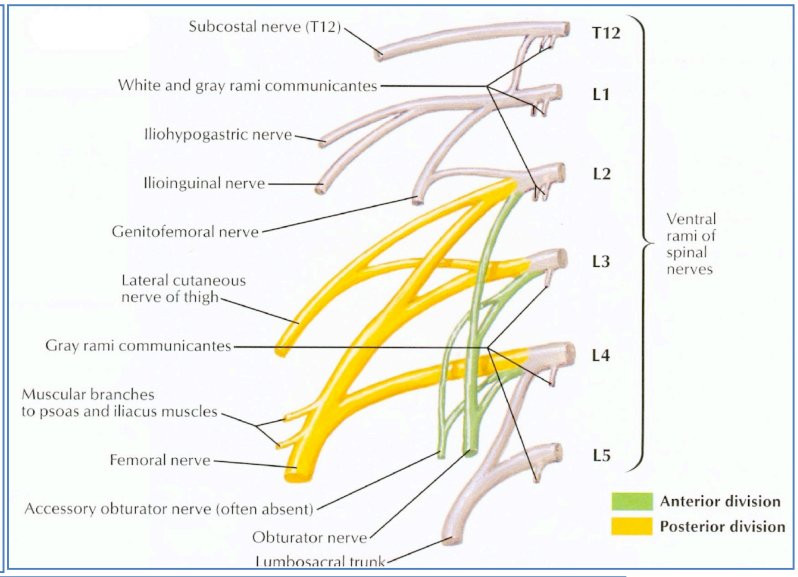
- 'Toe Drag':
    - Ie. Inadequate Dorsiflexion →during Swing Phase, the ankle hangs down in the plantarflexed position → drags along the ground.

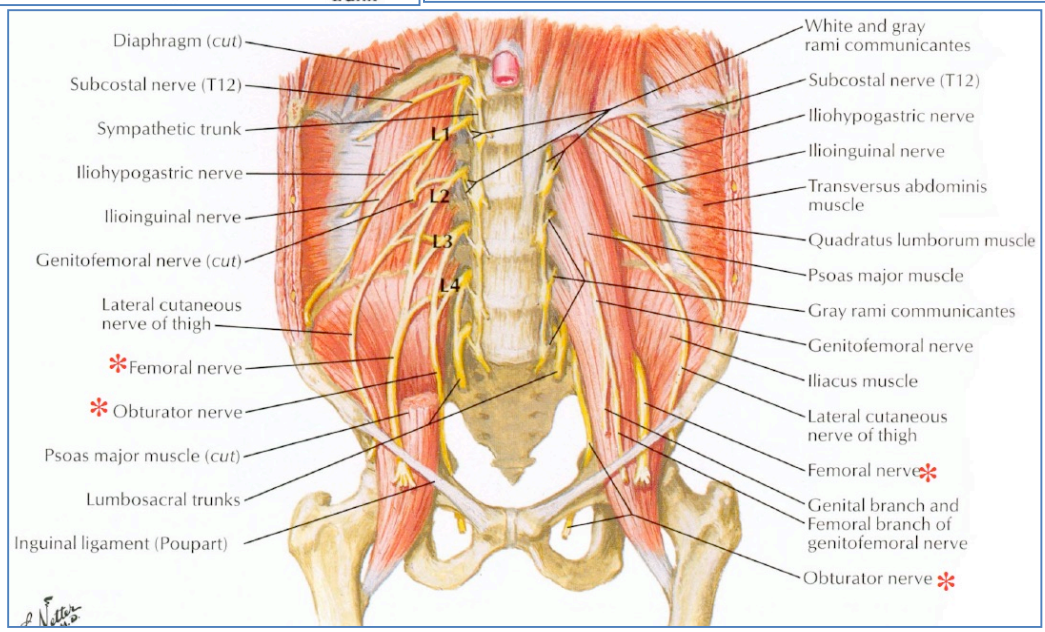
- Insufficient 'Toe-Off':
    - Where the whole foot is lifted off the ground at once (as opposed to pushing off from the toes)
    - Due to:
        - Nerve lesions/
        - Fusion of the ankle/
        - Archilles Tendon Problem (torn/inflamed/etc)
        - Pain in front (ball) of foot

Innervation:

- **Lumbar Plexus:**



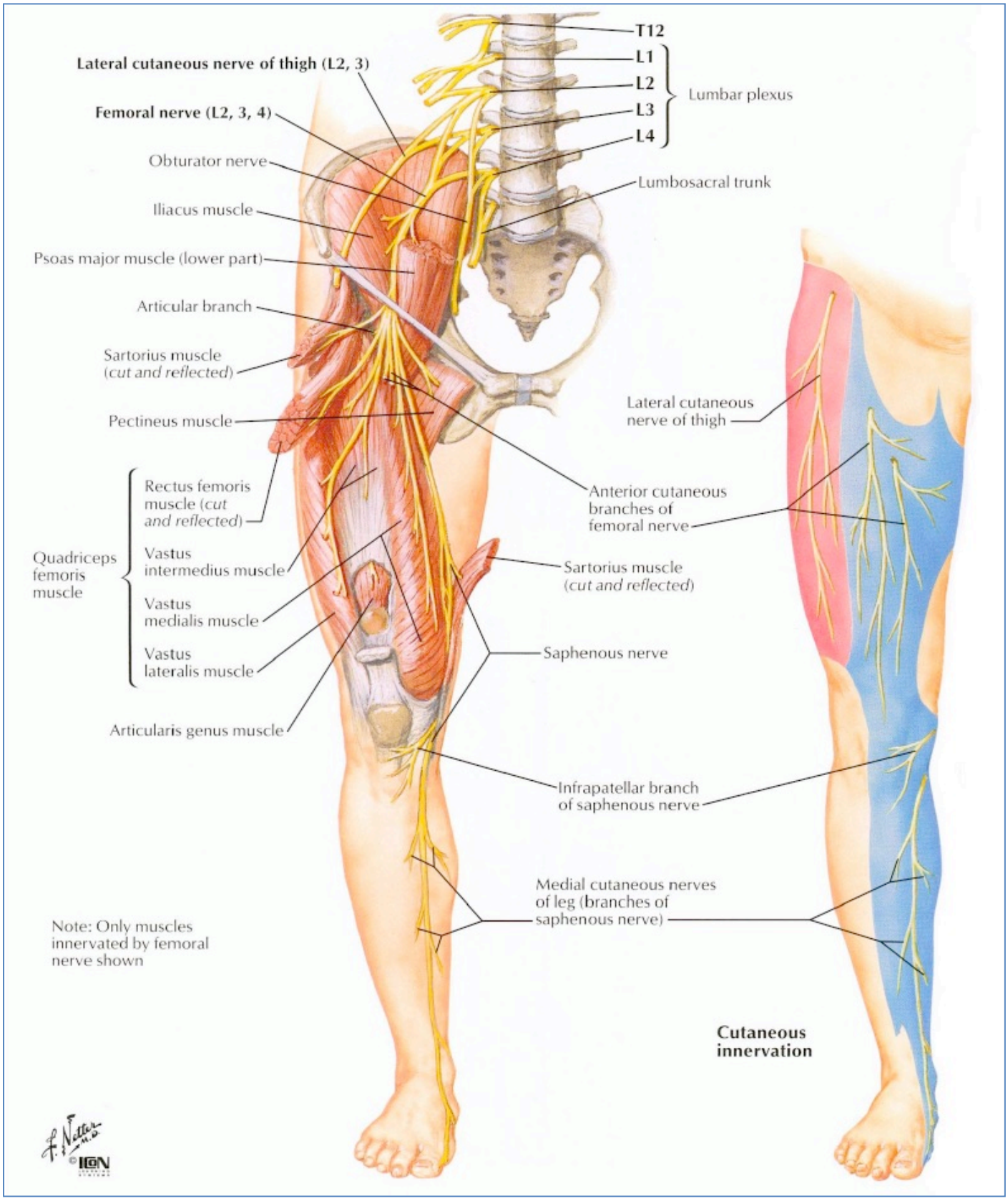




NB: Know:

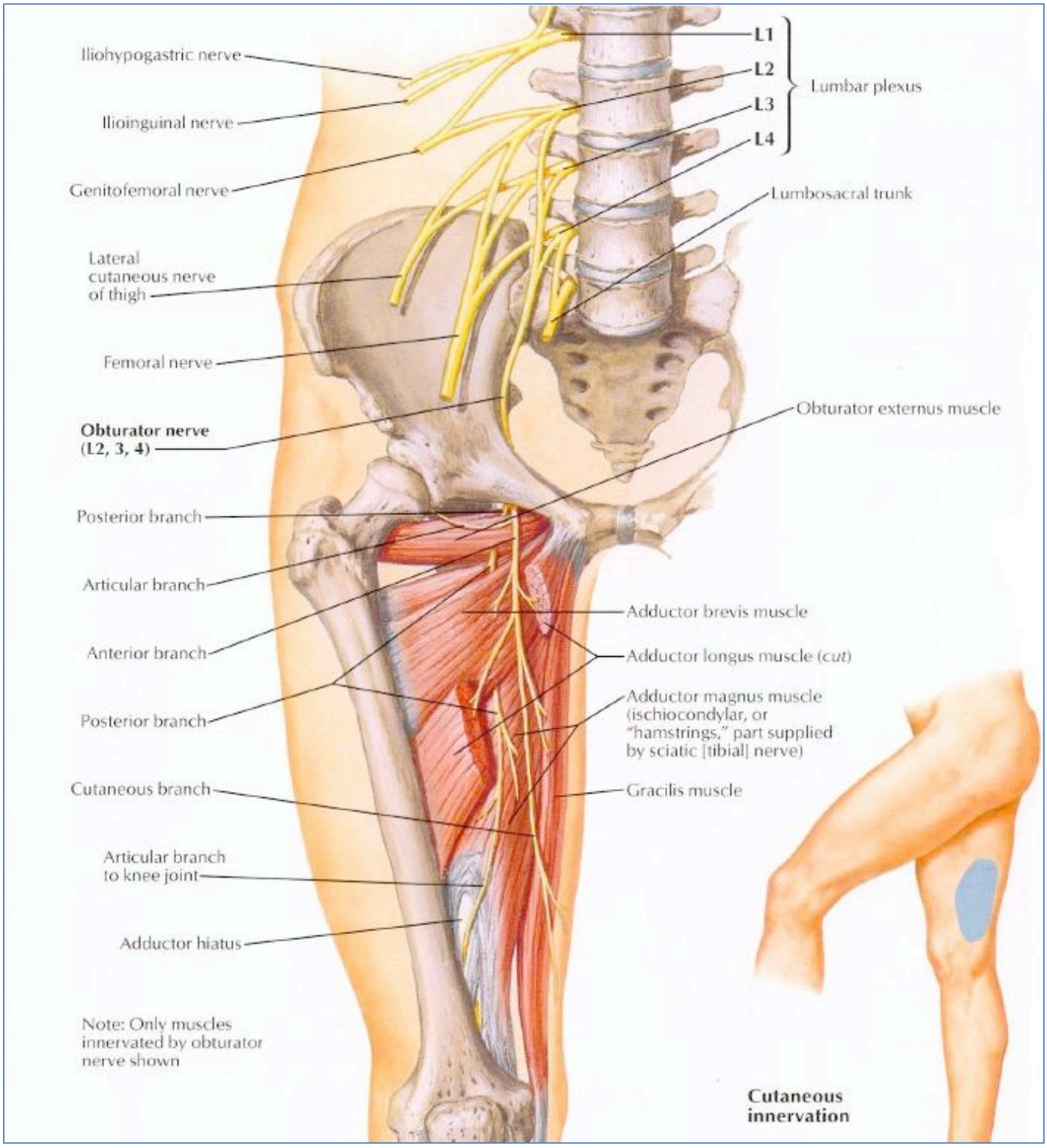
Lumbosacral Trunk – Communicates between Lumbar & Sacral Plexus

- **Femoral Nerve:**
  - Branches off L_2, L_3 & L_4
  - Runs between Psoas Major & Iliacus → beneath the Inguinal Ligament → Thigh → Splits in 2:
    - Anterior Division
      - Cutaneous Branches
      - Muscular Branches → Pectineus & Sartorius
    - Posterior Division
      - Cutaneous Branch – *Saphenous Nerve*
      - Muscular Branches → Quadriceps Femoris
  - Innervates:
    - Pectineus
    - Sartorius
    - Rectus Femoris
    - Vastus Lateralis
    - Vastus Intermedius
    - Vastus Lateralus
    - Skin of Anterio-Medial Thigh & Lower Leg + Medial Aspect of Foot

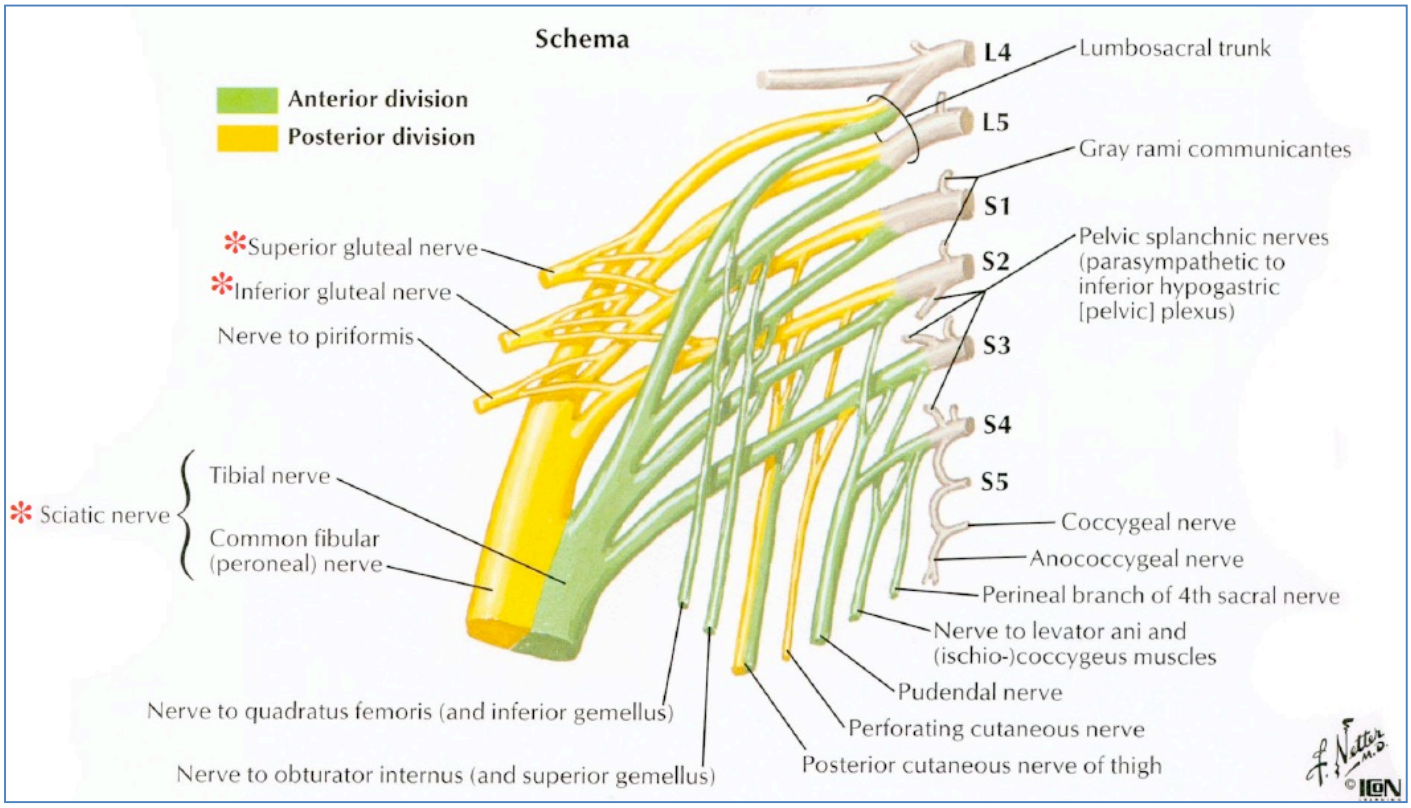


NB: Cutaneous Innervation – In blue

- **Obturator Nerve:**
  - Branches off L_2, L_3 & L_4
  - Runs medial to Psoas Major, down along the inside wall of lesser pelvis → through Obturator Canal (in obturator membrane) through Obturator Foramen → Thigh
  - Innervates:
    - External Obturator
    - Adductor Longus
    - Adductor Brevis
    - Adductor Magnus
    - Gracilis
    - Skin of medial aspect of thigh

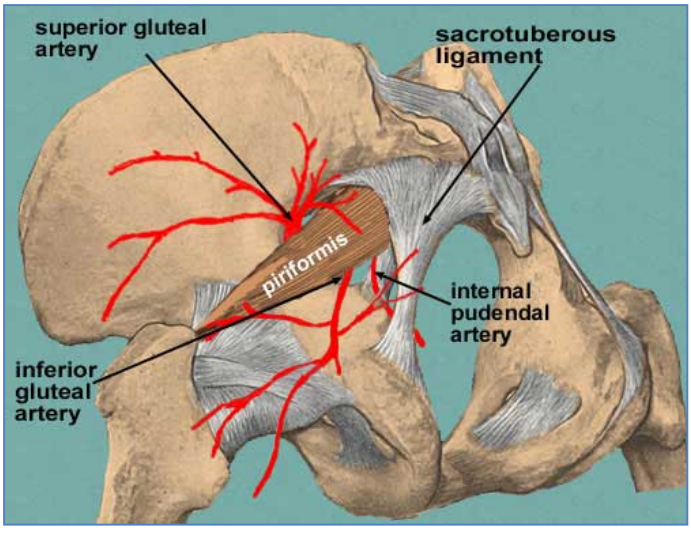


- **Sacral Plexus:**

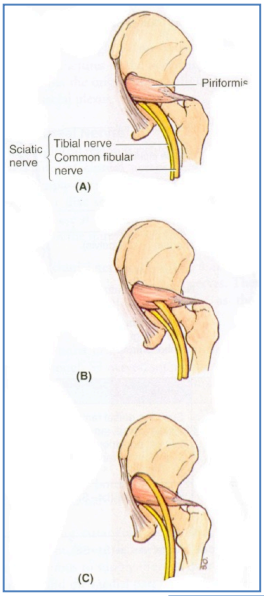


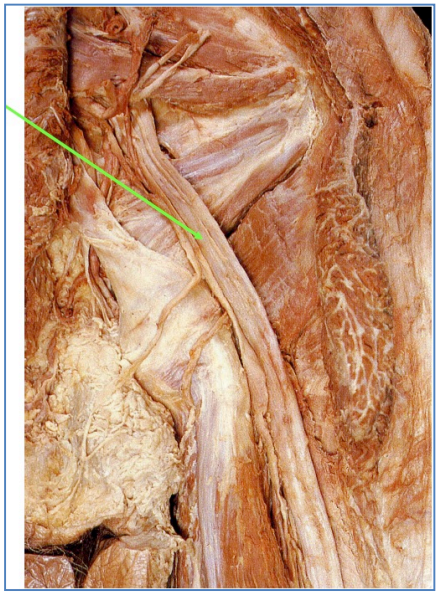
  - **Superior Gluteal Nerve:**
    - Branches off L_4, L_5 & S_1
    - Runs from Dorsal Roots → leaves pelvis through Greater Sciatic Foramen above Piriformis → Gluteus Medius, Gluteus Minimus & Tensor Fasciae Latae.
      - Accompanied by Superior Gluteal Vein & Artery.
    - Innervates:
      - Gluteus Medius
      - Gluteus Mimimus
      - Tensor Fasciae Latae

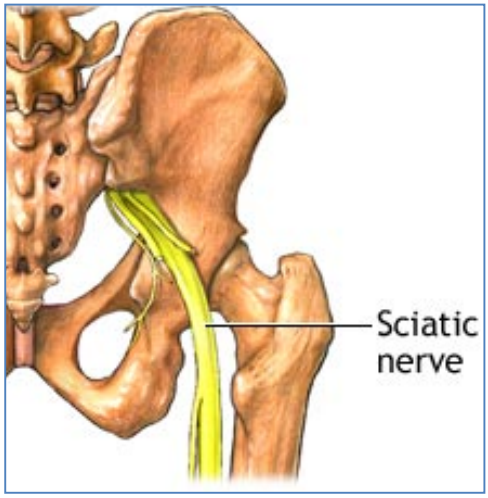
  - **Inferior Gluteal Nerve:**
    - Branches off L_5, S_1 & S_2
    - Runs from Dorsal Roots → leaves pelvis through Greater Sciatic Foramen above Piriformis → Gluteus Maximus.
    - Innervates:
      - Gluteus Maximus

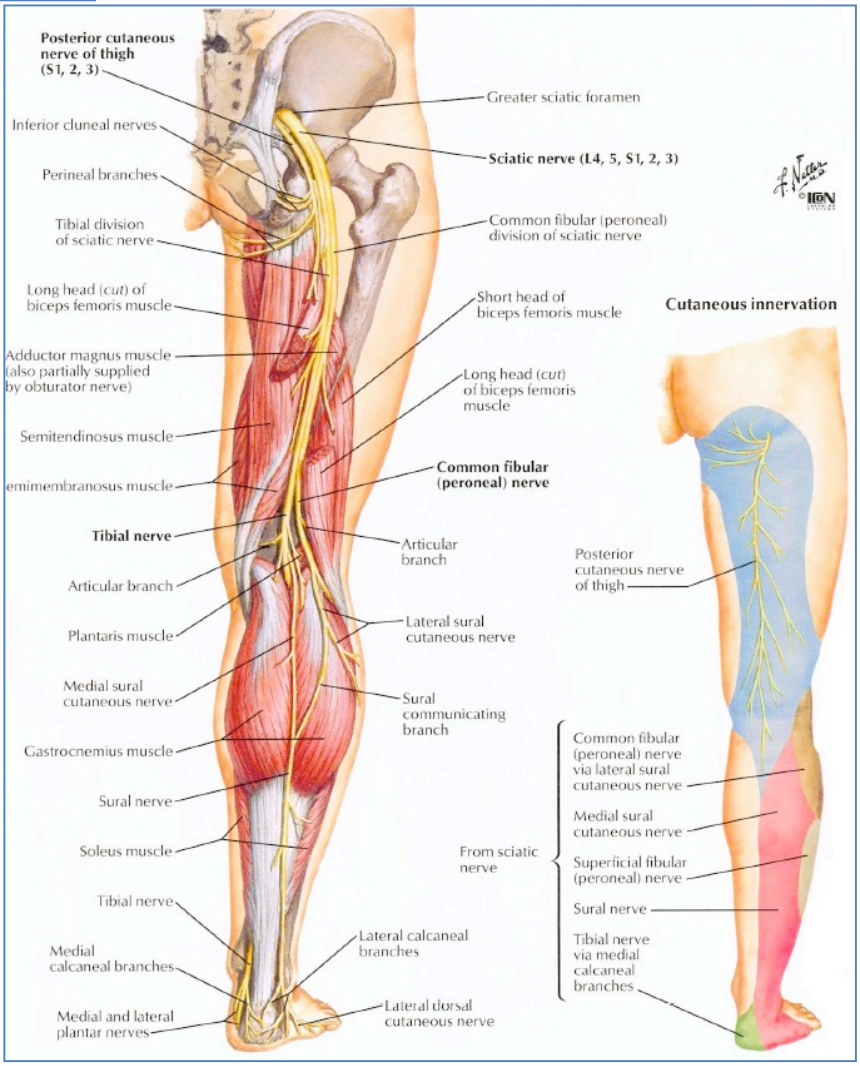


- **Sciatic Nerve:**
  - Branches off L_4, L_5, S_1, S_2 & S_3
  - Runs from inside pelvis → through Greater Sciatic Foramen (below piriformis) → descends along the posterior thigh to about its lower third → ***Divides into 2 Branches: Tibial & Common Fibular Nerves.*** (some variation)
  - Innervates:
    - Hamstrings
    - ½ of Adductor Magnus

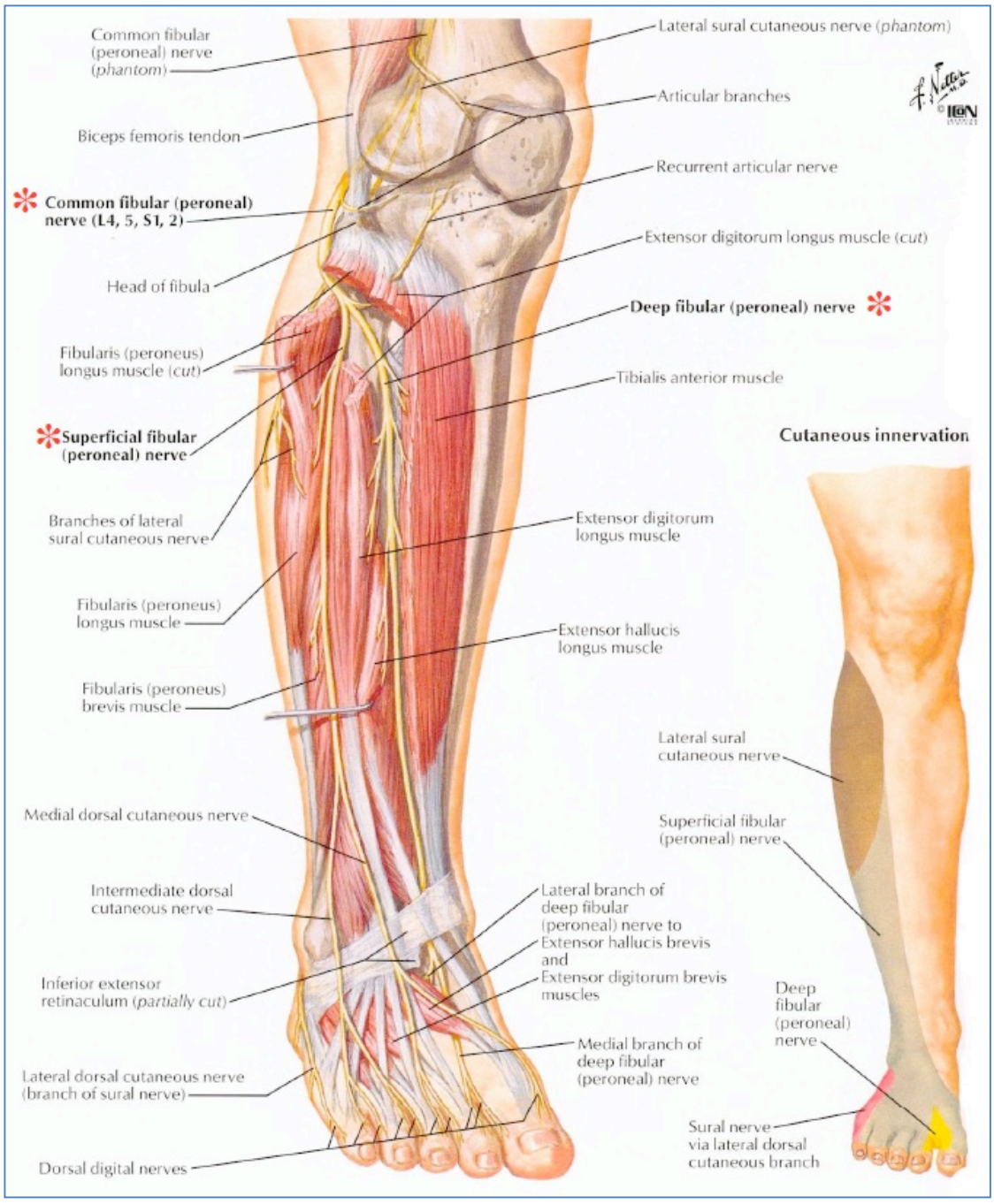




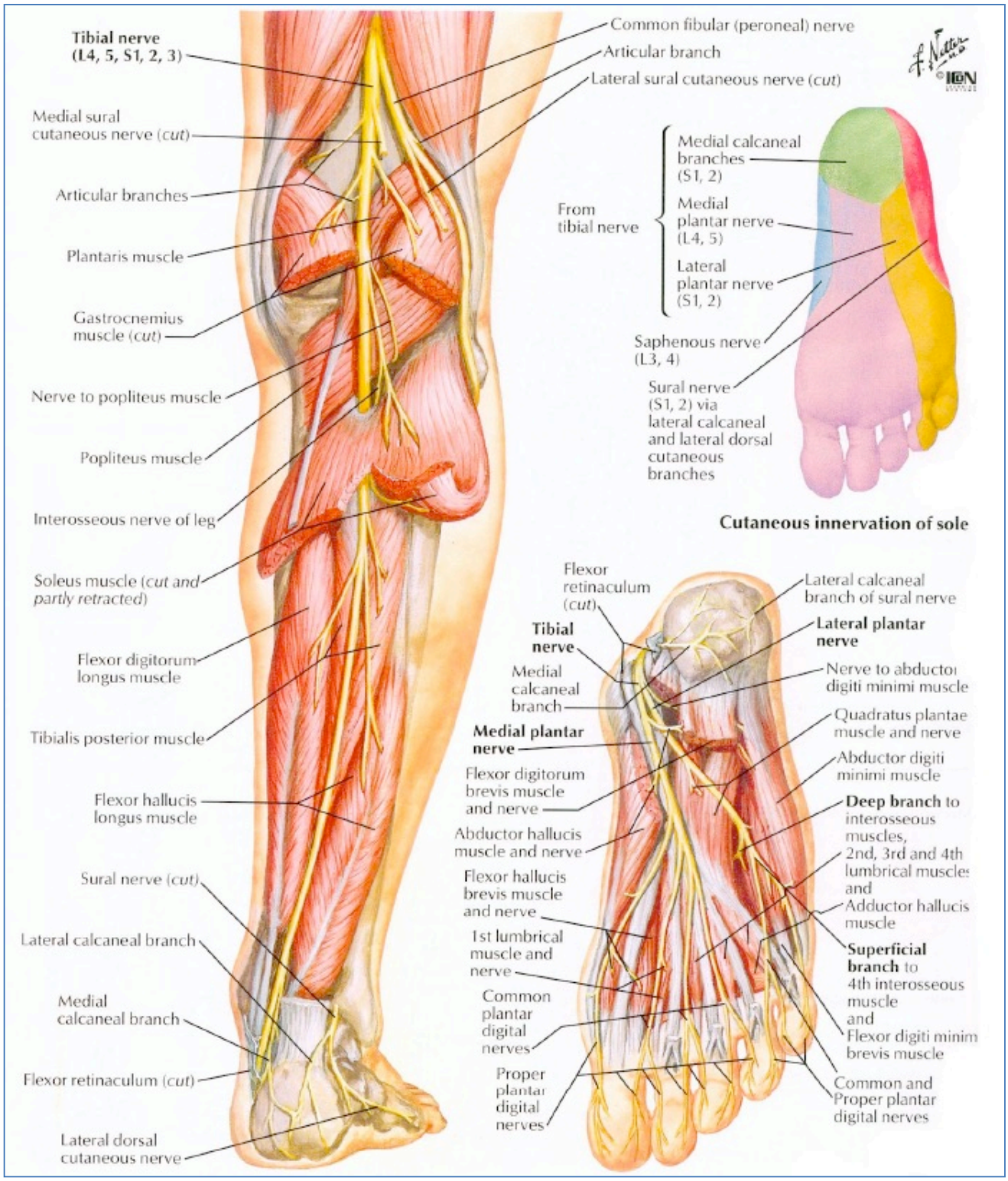


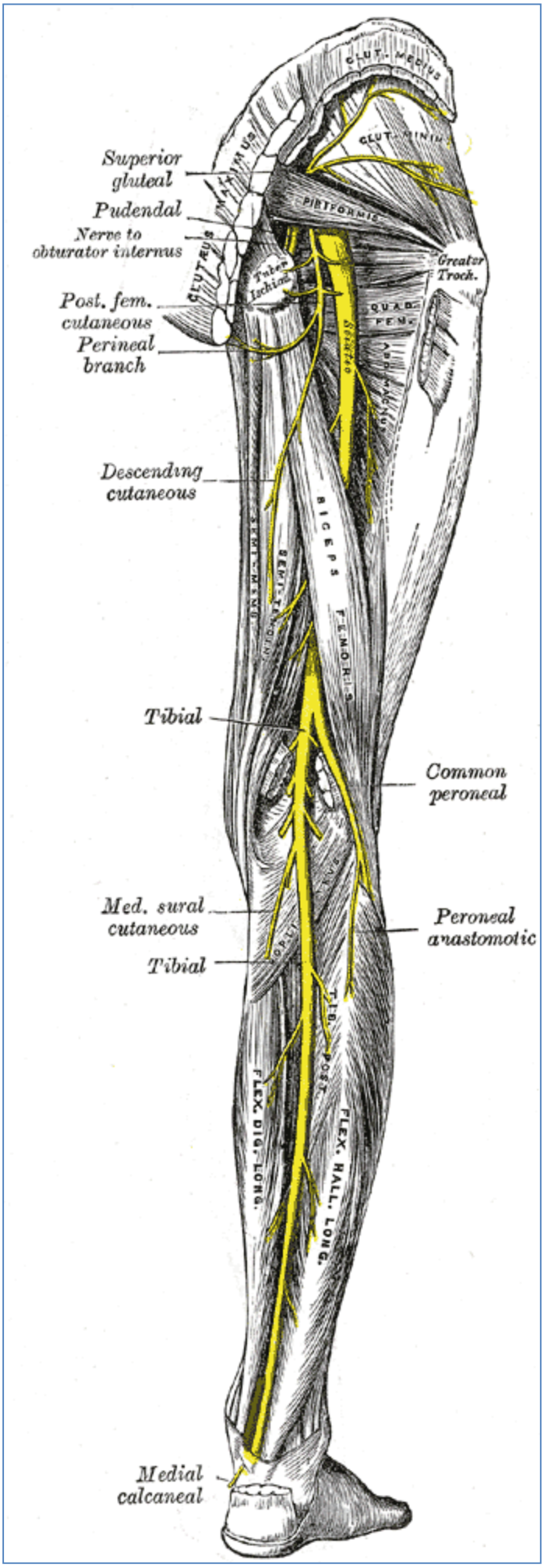


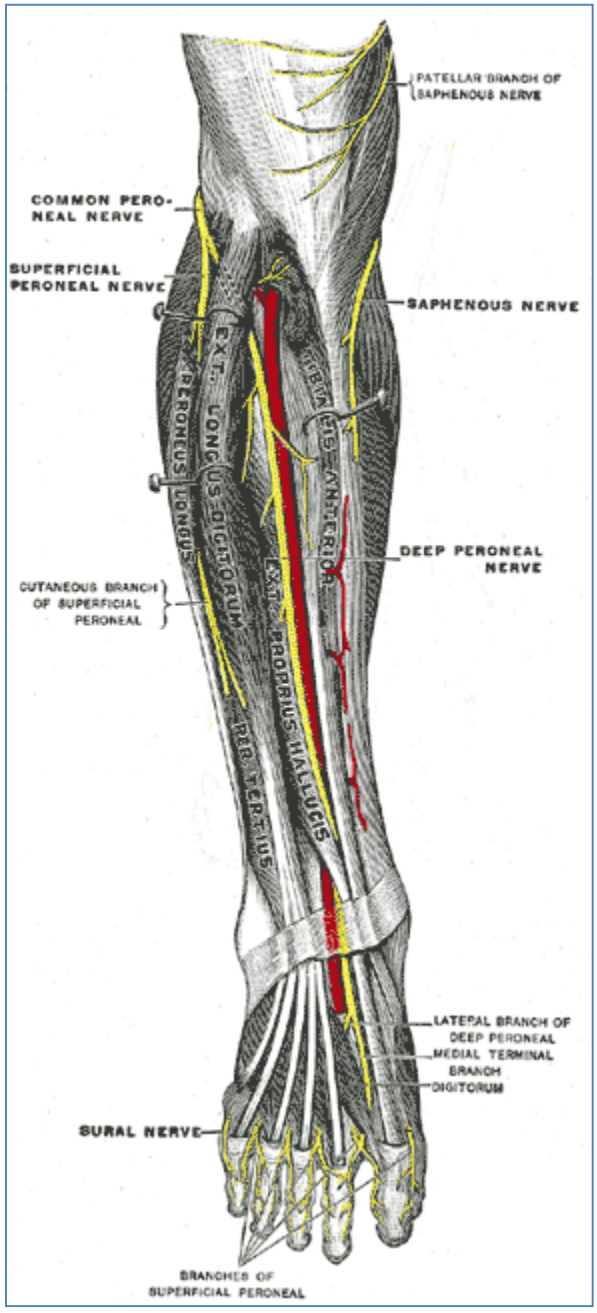
- **Sciatic Nerve: Common Fibular (Peroneal) Nerve:**
  - Branches off Sciatic Nerve
  - Runs obliquely along the lateral side of the Popliteal Fossa → Head of the Fibula Adjacent to the Medial Margin of the Biceps Femoris → Winds around neck of Fibula → **divides into Deep & Superficial Fibular (peroneal) Nerves**
  - Innervates:
    - Skin of Lateral Aspect of Lower Leg
    - Skin of Dorsum of Foot
  - **Deep Fibular Nerve:**
    - Innervates:
      - Tibialis Anterior
      - Extensor Digitorum Longus
      - Fibularis Tertius
      - Extensor Hallucis Longus
  - **Superficial Fibular Nerve:**
    - Innervates:
      - Fibularis Longus
      - Fibularis Brevis



- **Tibial Nerve:**
  - Branches off Sciatic Nerve
  - Runs through Popliteal Fossa → Then follows the Tibia to the ankle → passes into Foot (below medial malleolus) → Terminates as Medial & Lateral Plantar Nerves
  - Innervates:
    - Gastrocnemius
    - Popliteus
    - Soleus
    - Plantaris
    - Tibialis Posterior
    - Flexor Digitorum Longus
    - Flexor Hallucis Longus

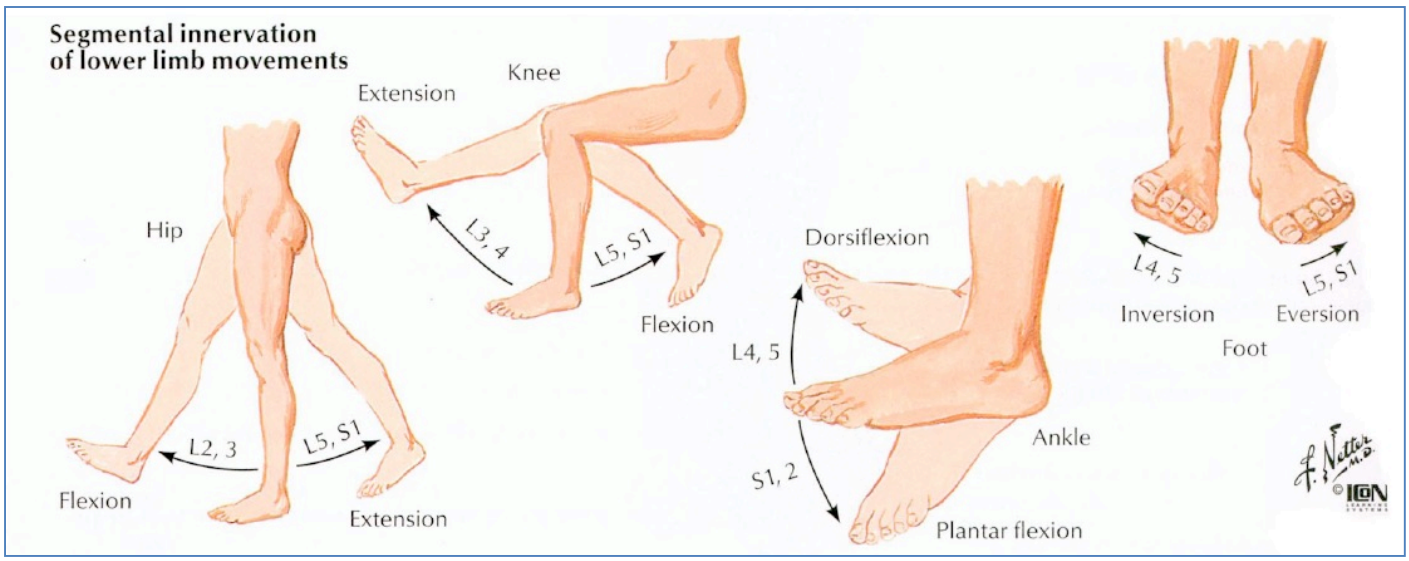






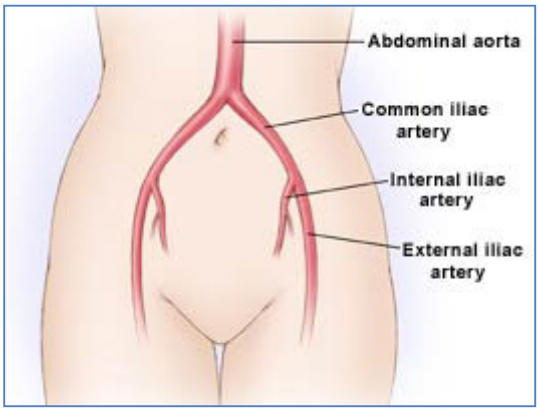
- **Nerve Lesions:**
  - Most are incomplete lesions
  - Can be disabling

  - Eg. Femoral:
    - Loss of Extension of Knee
    - Loss of Flexion of Hip
  - Eg. Obturator:
    - Loss of Adductors of Hip
    - Weird Gait
  - Eg. Tibial:
    - Loss of Plantar Flexion
    - Loss of Movement of Toes
  - Eg. Deep Fibular:
    - Loss of Dorsiflexion → 'foot drop'
    - Loss of Extension of toes
  - Eg. Superficial Fibular:
    - Loss of Eversion

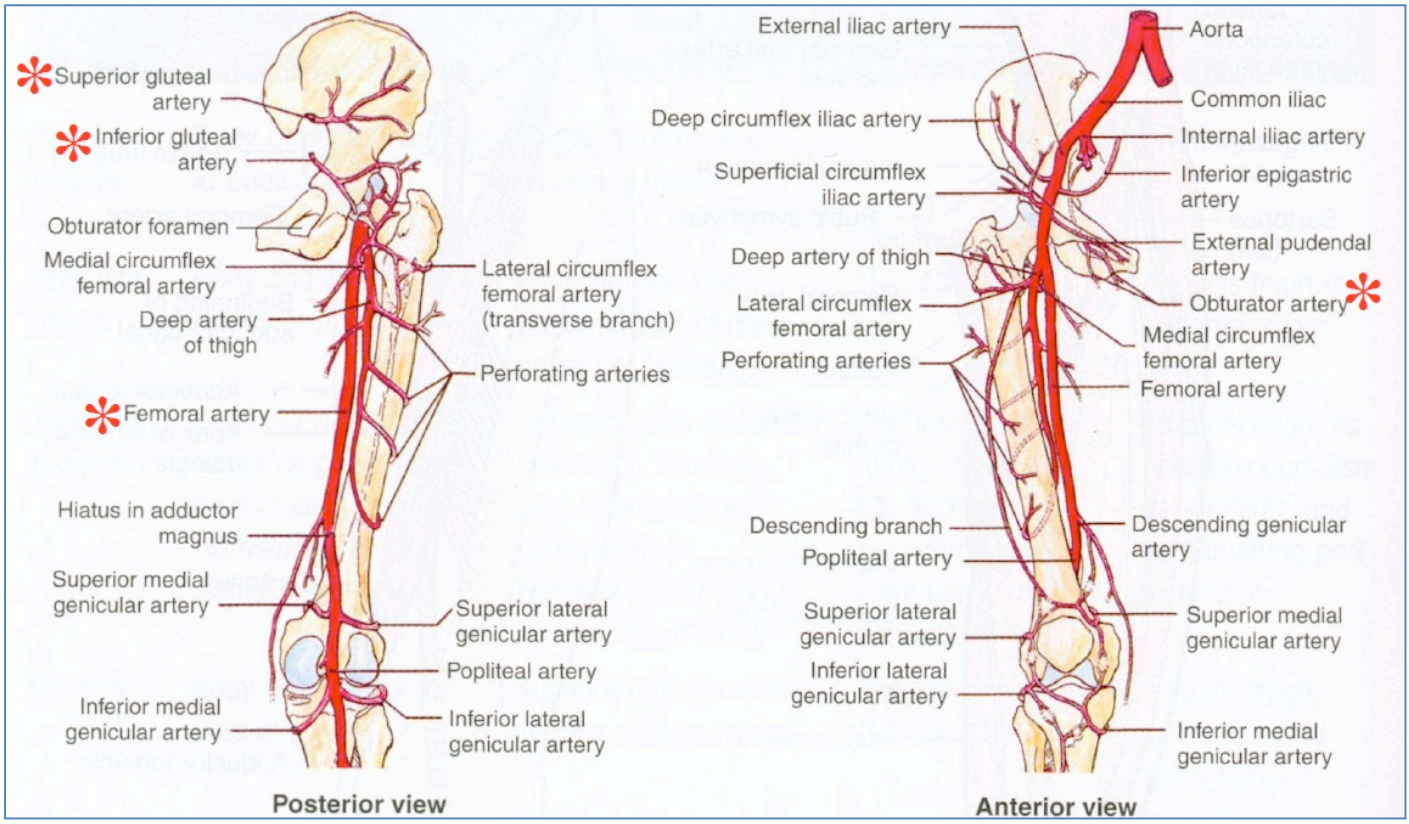


Vasculation:

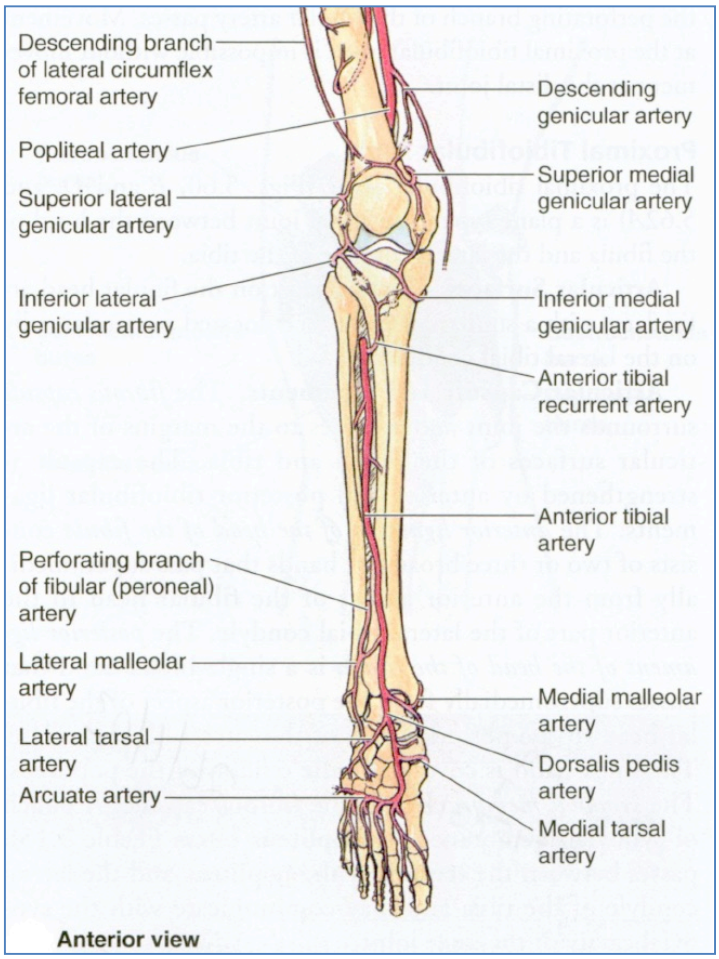
- **Arterial Blood Supply:**
  - **Thoracic:**
    - **Abdominal Aorta →**
  - **Pelvic:**
    - **2 Common Iliac Arteries →**
      - **Internal Iliac Artery →** Pelvic & Reproductive Organs + Buttocks + Medial Thigh
        - **Superior Gluteal Artery**
        - **Inferior Gluteal Artery**
        - **Obturator Artery:** runs down & around the inside of the Pelvic 'bowl', escaping through the *Obturator Canal* (hole) in the *Obturator Membrane* of the *Obturator Foramen*.
      - **External Iliac Artery →** Thigh, Leg, Foot.

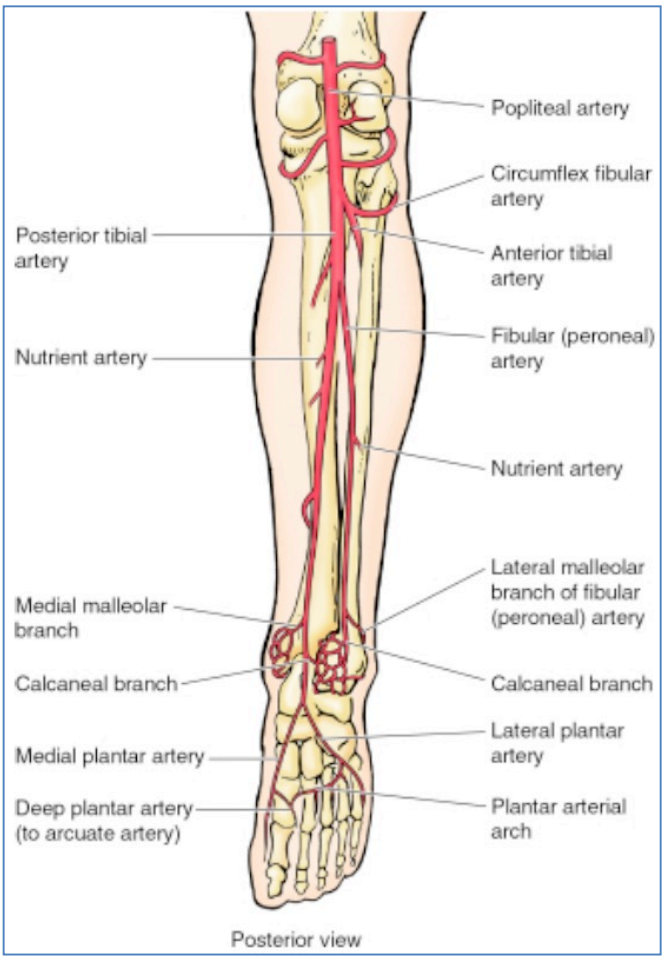


  - **Upper Leg:**
    - **External Iliac Artery →**
      - **Deep Artery of the Thigh →** branches into many perforating arteries
      - **Femoral Artery →** descends the femur, becoming more & more medial + posterior
        - **Popliteal Artery →**



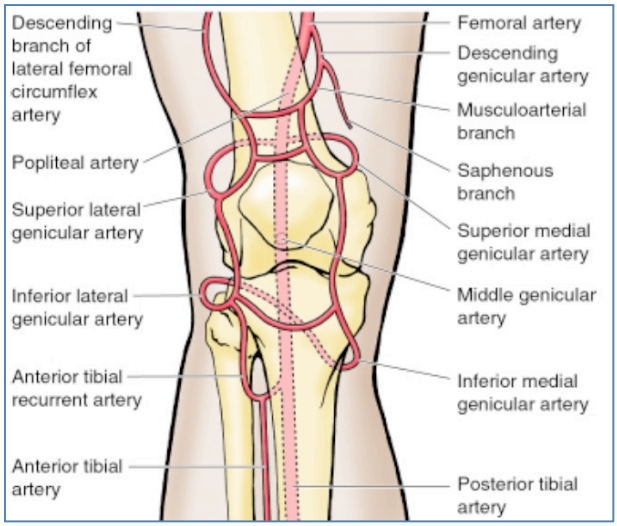
- **Lower Leg:**
  - **Popliteal Artery + Genicular Anastomosis** → Runs down 1/3 of lower leg, then splits into:
    - **Anterior Tibial Artery** -
    - **Posterior Tibial Artery** – Runs down posterior aspect of Tibia → ankle
    - **Fibular Artery** – Runs down posterior aspect of Fibula → ankle
- **Foot:**
  - **Anterior Tibial Artery** →
    - **Dorsalis Pedis Artery**
  - **Posterior Tibial Artery** →
    - **Lateral Plantar Artery**
    - **Medial Plantar Artery**

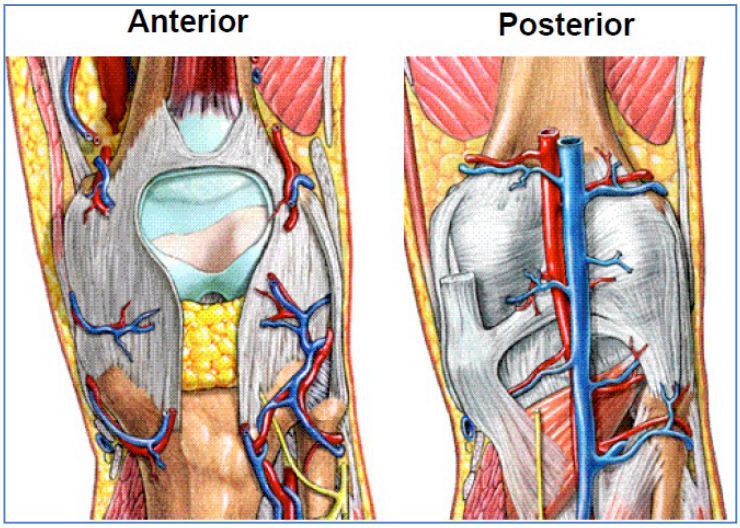




NB: Dorssalis Pedis – Clinical Pulse Site

Anastomoses:





- **Venous Blood Drainage:**
  - **Foot:**
    - **Dorsal Venous Arch →**
      - **Superficial:** Small Saphenous Vein
      - **Deep:** Anterior Tibial Vein
    - **Plantar Venous Arch →**
      - **Superficial:** Great Saphenous Vein
      - **Deep:** Posterior Tibial Vein & Fibular Vein

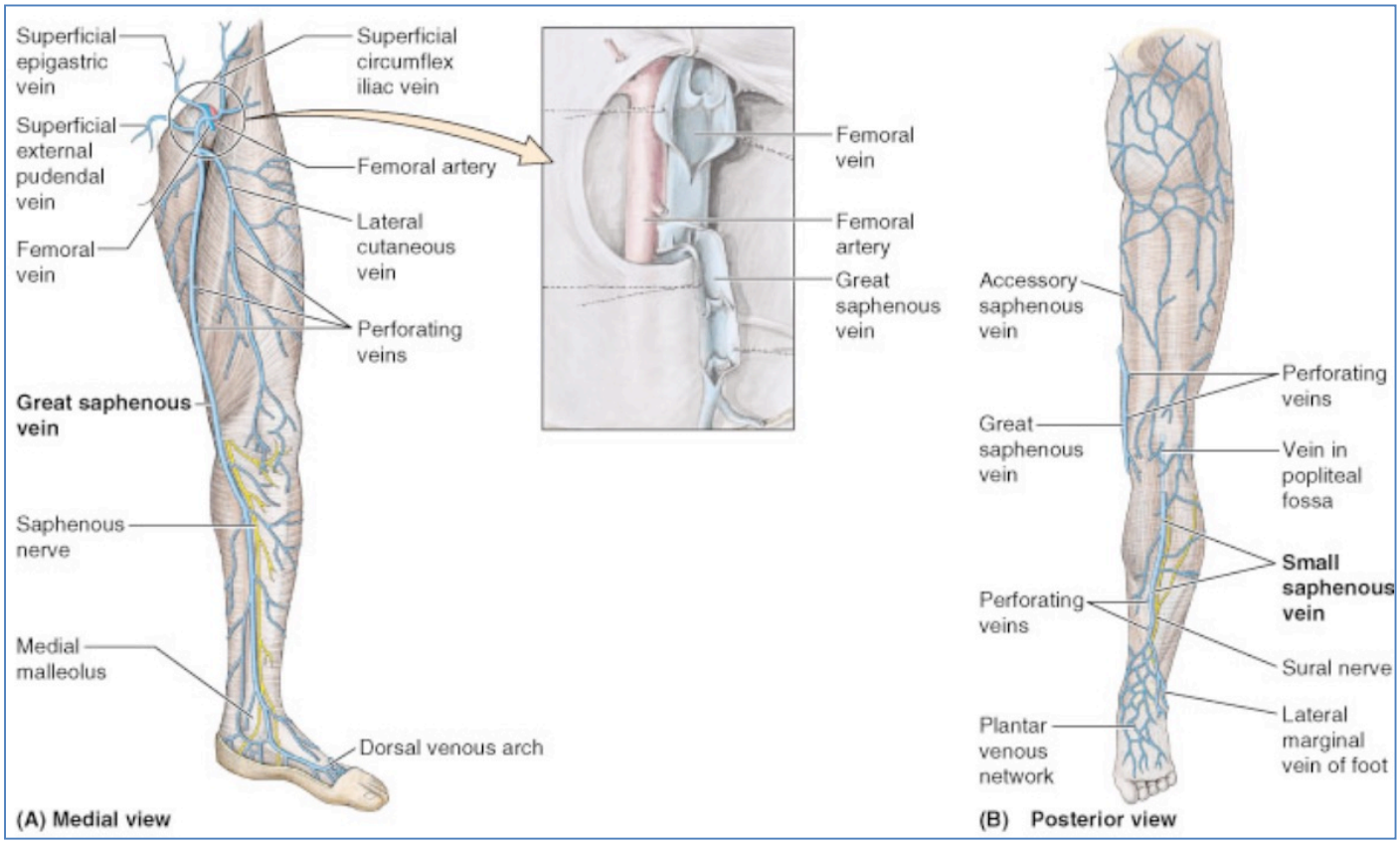
  - **Lower & Upper Leg:**
    - **Superficial:**
      - **Small Saphenous Vein →** Runs up calves (posteriorly), goes deep → **Popliteal Vein**
      - **Great Saphenous Vein →** All the way up the leg (medially) → **Deep Femoral Vein**
    - **Deep:**
      - **Anterior Tibial Vein → Popliteal Vein**
      - **Posterior Tibial Vein → Popliteal Vein**
      - **Fibular Vein → Popliteal Vein**

      - **POPLITEAL VEIN → Deep Femoral Vein**

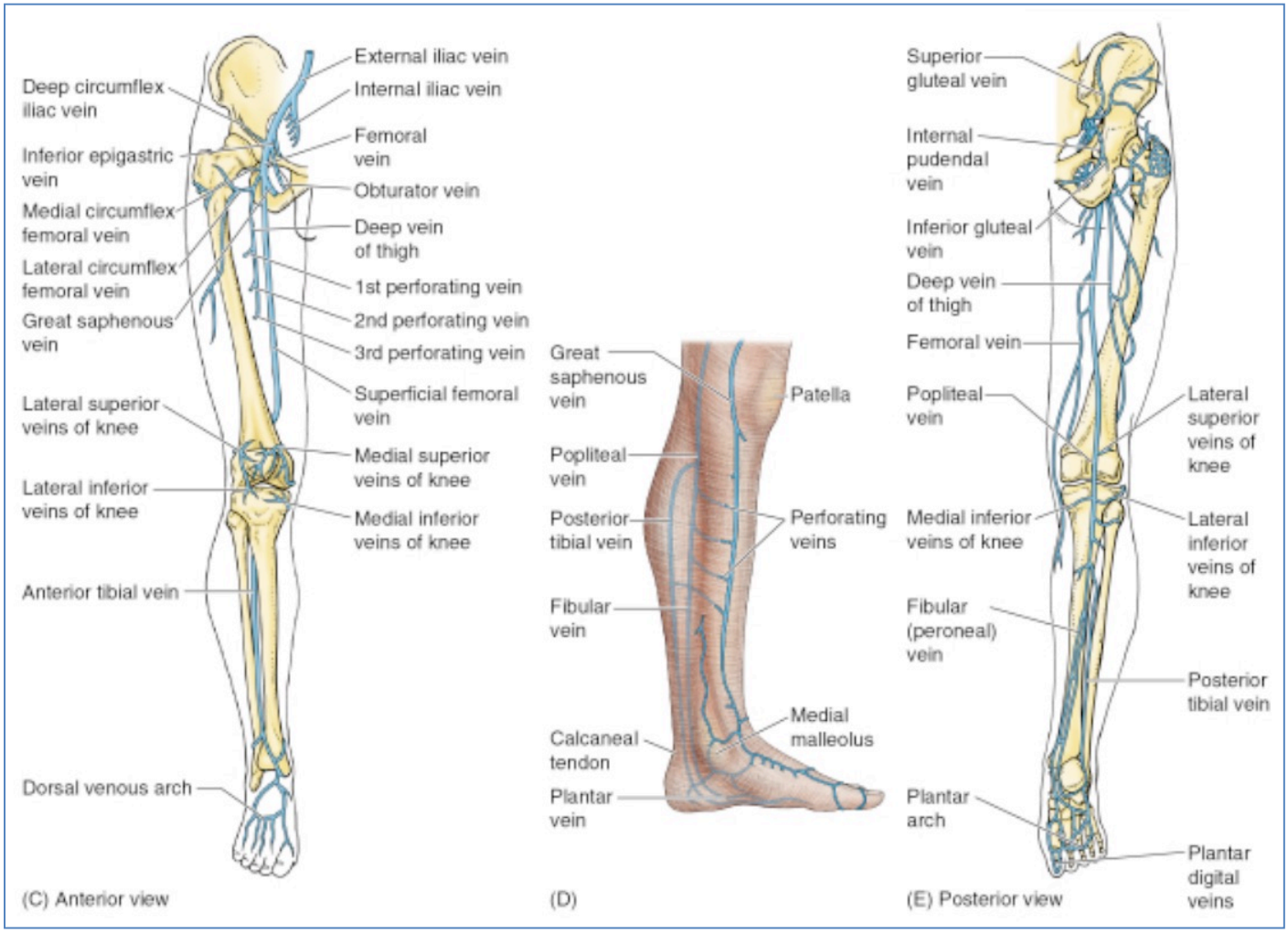
  - **Pelvic:**
    - **Deep Femoral Vein →**
    - **External Iliac Vein**

  - **Thoracic:**
    - **External iliac Vein →**
    - **Inferior Vena Cava**

Superficial Veins of Lower Limb:

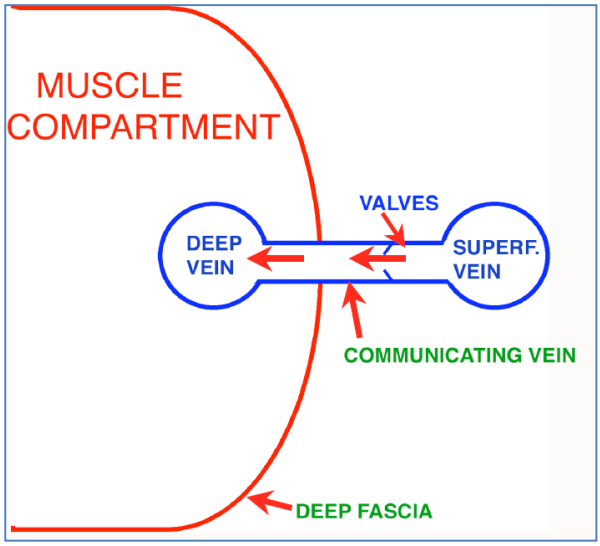


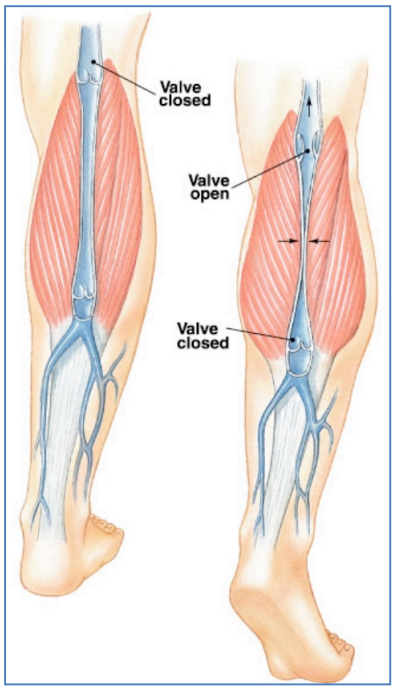
Deep Veins of Lower Limb:



The Muscle Pump Mechanism

- Acts against gravity
- Relies on valves in veins
- Blood is squeezed by contracting muscles from Superficial → Deep via Communicating Veins
- Valves prevent blood from flowing backwards and pooling (varicose veins = failure of valves → pooling)



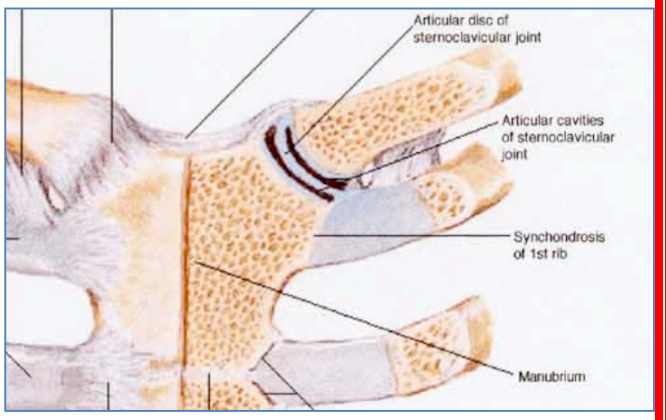


Shoulder Region, Arm & Hand: Bones, Muscles, Nerves, Veins & Arteries.

Shoulder Girdle (Pectorial Girdle):

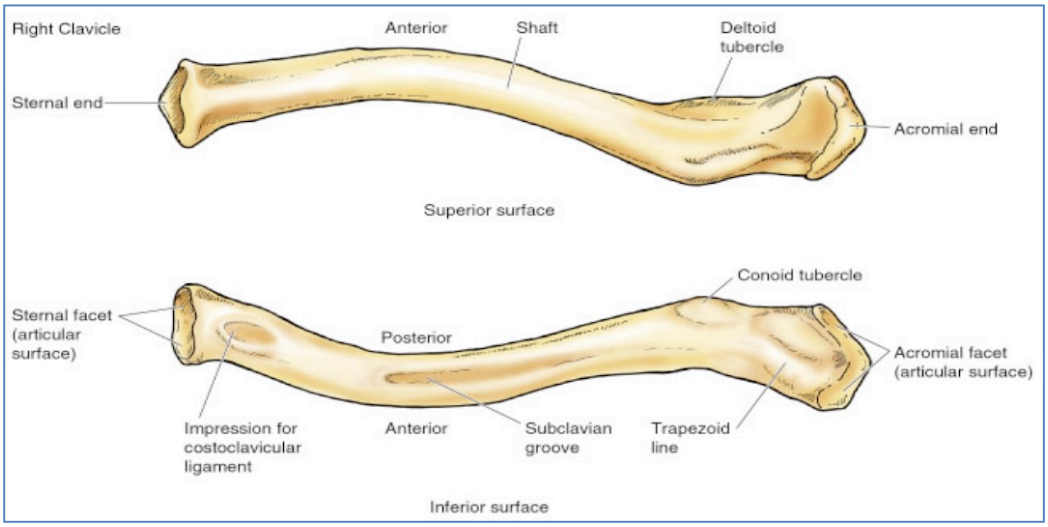
- **Functions:**
  - Manipulation of environment – not locomotion
  - Attaches upper limb to axial skeleton
  - Clavicle acts as 'strut' - transmits force to axial skeleton.
    - Gives upper arm *reach*.
  - **High Mobility, Low Stability.**

Bones & Landmarks:

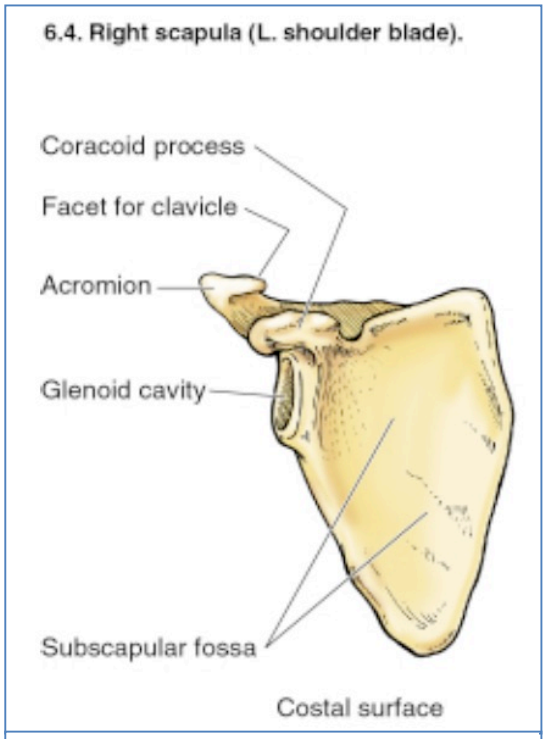


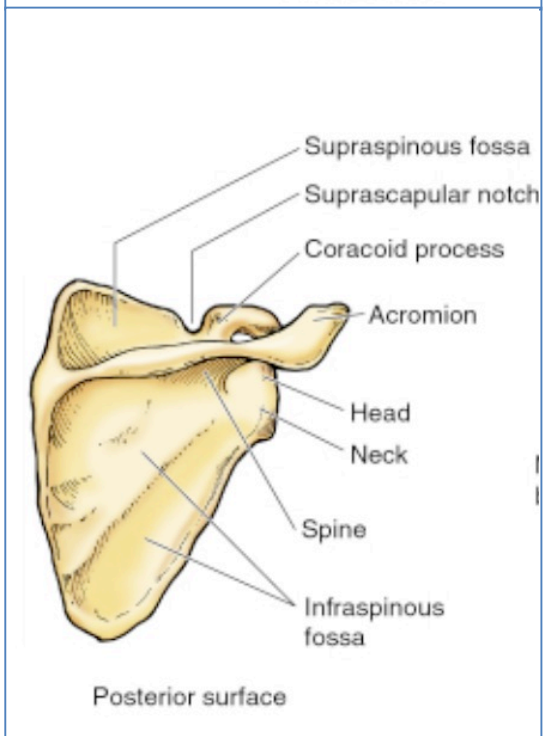
- **Manubrium of Sternum (breastplate)**
  - Flat bone
  - Quadrangular shape
  - **Articulations:**
    - Syncondrosis of 1st rib
    - Sternocostal joint of 2nd rib
  - **Origins/Insertions:**
    - Pectoralis Major
    - One head of the Sternocleidomastoid

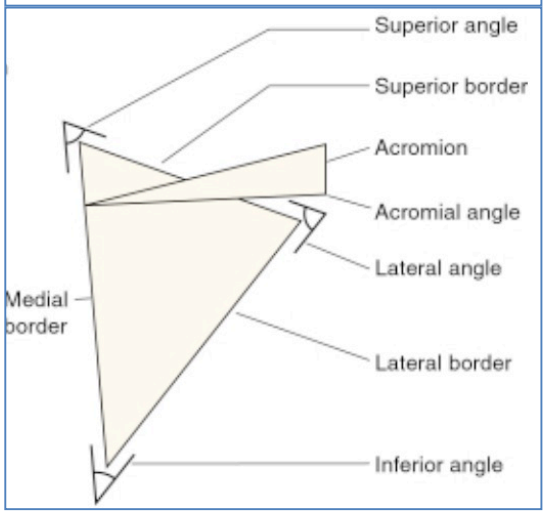
- **Clavicle**
  - Long bone
  - Superior = Smooth, Inferior = Rough
  - S-shaped
  - **Landmarks:**
    - Sternal & Acromial Ends
    - Impression of costoclavicular ligament
    - Deltoid Tubercle
    - Conoid Tubercle
    - Trapezoid line
    - Subclavian Groove
  - **Articulations:**
    - Manubrium of Sternum
    - Acromion of Scapula
  - **Origins/Insertions:**
    - Deltoid — Anteriorly on lateral 3rd
    - Trapezius — Posteriorly on lateral 3rd
    - Subclavius — Subclavian Groove
    - Pectoralis Major — Anteriorly on medial 3rd
    - Sternocleidomastoid — Superiorly on medial 3rd



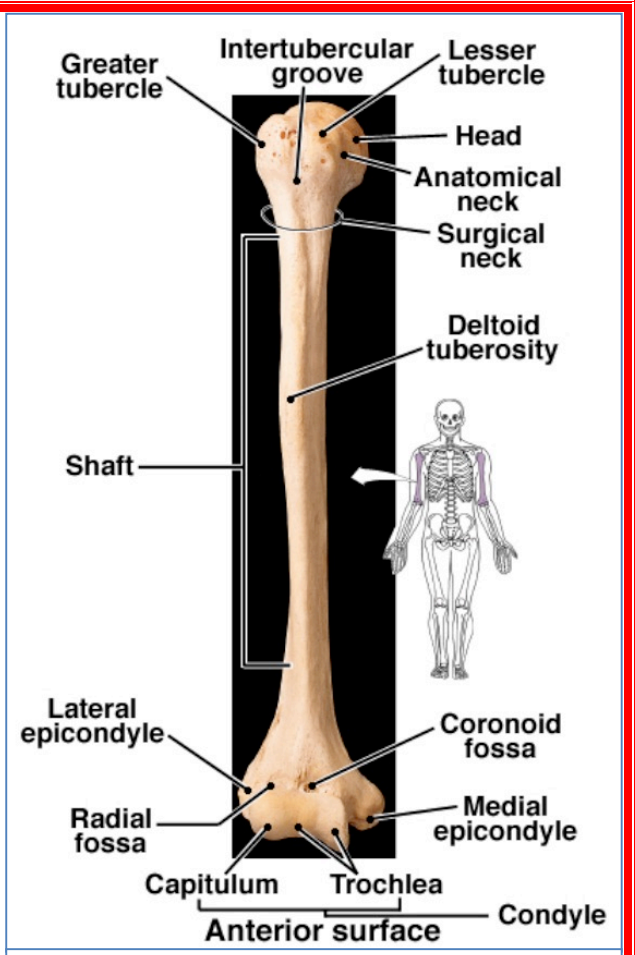
- **Scapula**
  - Irregular bone
  - Connects Humerus → Clavicle
  - **Landmarks:**
    - Lateral Border
    - Medial Border
    - Superior Border
    - Inferior Angle
    - Superior Angle
    - Lateral Angle
    - Spine
    - Acromion
    - Coracoid Process
    - Suprascapular Notch
    - Supraspinous Fossa
    - Infraspinous Fossa
    - Subscapular Fossa
    - Glenoid Cavity
  - **Articulations:**
    - Lateral ends of Clavicle
    - Head of Humerus
  - **Origins/Insertions:**
    - Supraspinatus — Origin
    - Infraspinatus — Origin
    - Subscapularis — Origin
    - Deltoid — Origin
    - Trapezius — Insertion
    - Serratus Anterior — Insertion
    - Rhomboid Major — Insertion
    - Rhomboid Minor — Insertion
    - Levator Scapulae — Insertion
    - Teres Major — Insertion
    - Teres Minor — Insertion
    - Pectoralis Minor — Insertion
    - Long head of Triceps Brachii — Origin
    - Long head of Biceps Brachii — Origin
    - Short head of Biceps Brachii — Origin

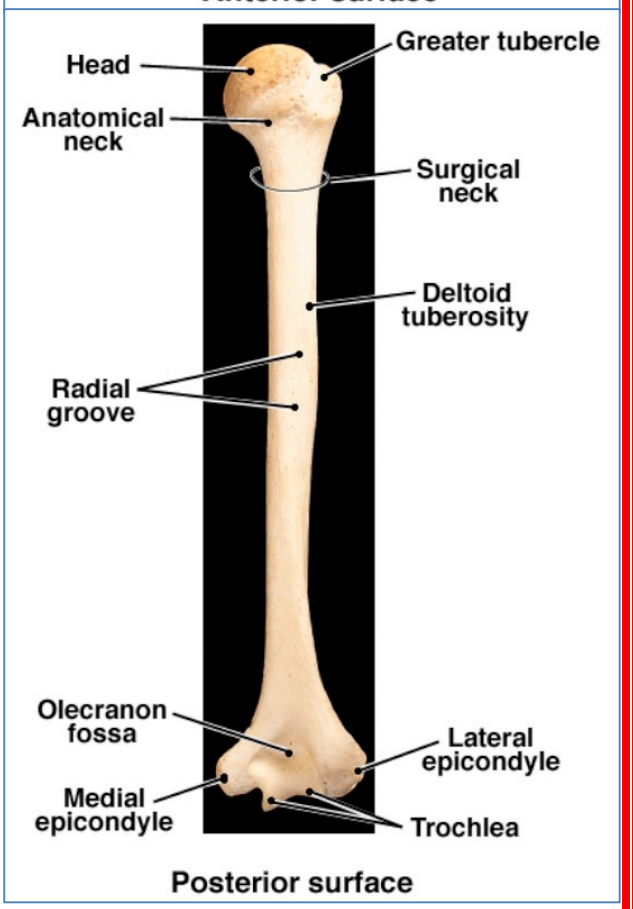






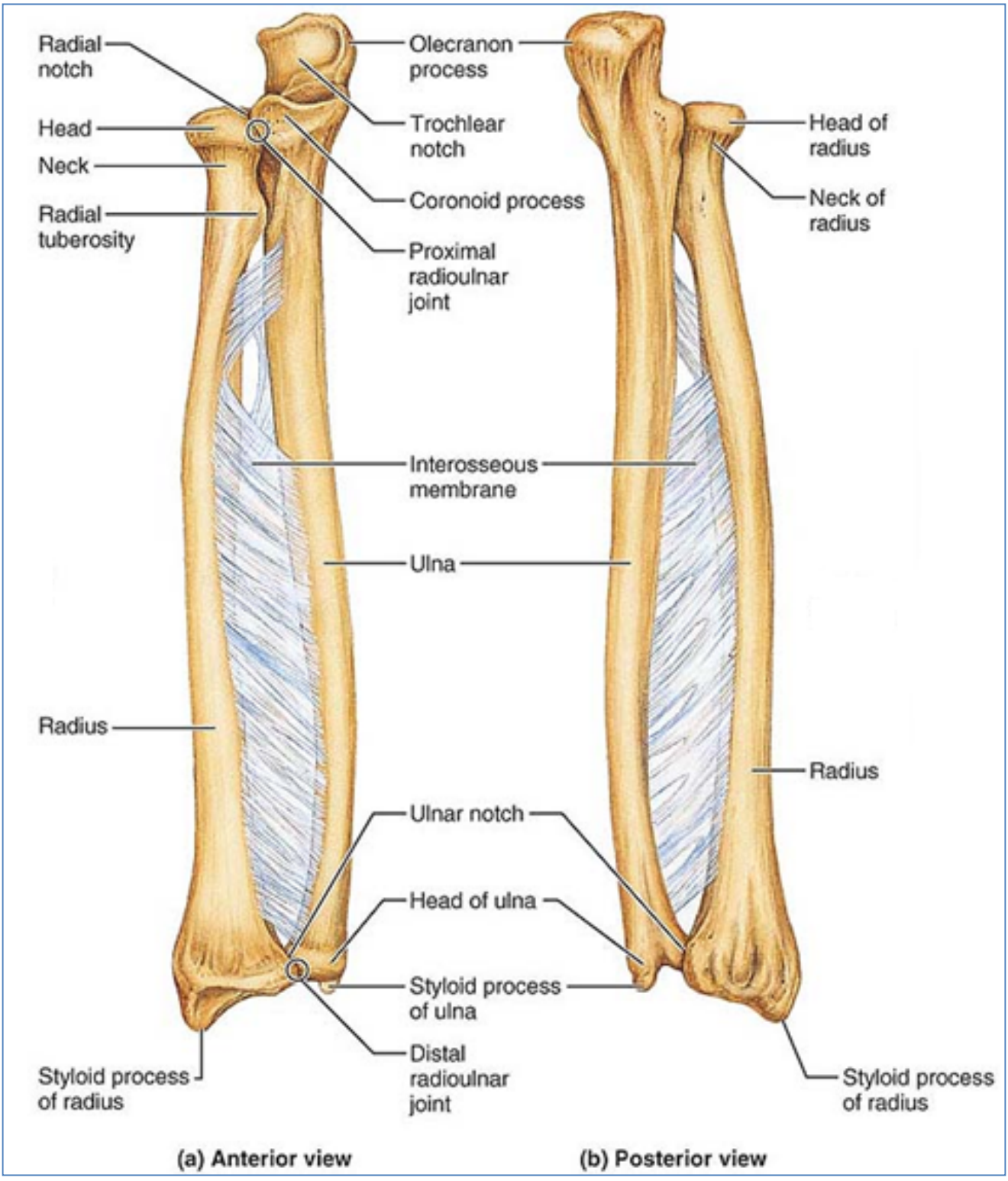
- **Humerus**
  - Long Bone
  - **Landmarks:**
    - Head
    - Greater Tubercle
    - Lesser Tubercle
    - Intertubercular Groove
    - Deltoid Tuberosity
    - Medial Epicondyle
    - Lateral Epicondyle
    - Capitulum
    - Trochlea
    - Radial Groove
    - Olecranon Fossa
  - **Articulations:**
    - Glenoid Process of Scapula
    - Radius
    - Ulnar
  - **Origins/Insertions:**
    - Supraspinatus
    - Subscaplaris
    - Pectoralis Major
    - Latissimus Dorsi
    - Deltoid Muscle
    - Teres Major
    - Teres Minor
    - Coracobrachialis
    - Brachialis
    - Extensor Carpi Radialis Longus
    - Extensor Carpi Radialis Brevis
    - Extensor Digitorum
    - Extensor Digitorum Minimi
    - Extensor Carpi Ulnaris
    - Protonator Teres
    - Flexor Carpi Radialis
    - Palmaris Longus
    - Flexor Carpi Ulnaris
    - Flexor Digitorum Superficialis



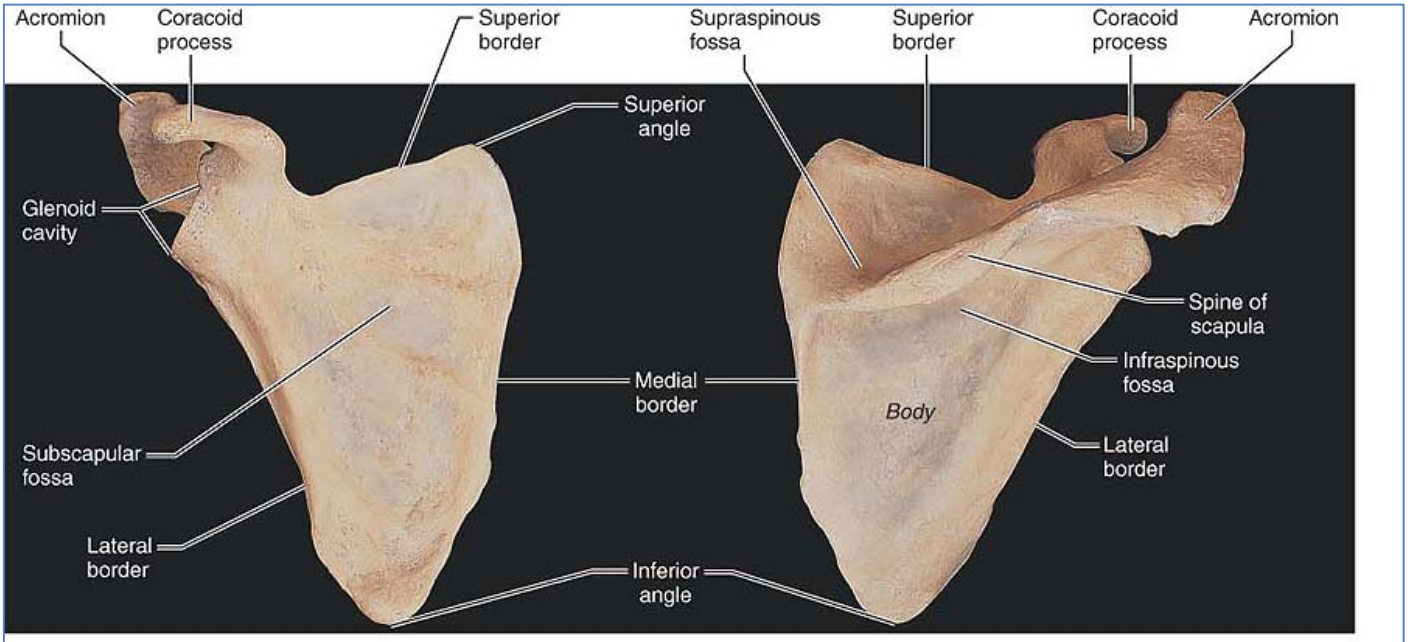


- **Ulna: "Elbow"**
  - 'Little-Finger-Side'
  - Slightly longer than Radius
  - Wide at Proximal End
  - Thin at Distal End
  - Major forearm bone contributing to Elbow Joint
  - **Landmarks:**
    - Coronoid Process (Anterior Proximal)
    - Olecranon Process (Posterior Proximal)
    - Trochlear Notch
    - Radial Notch (Articulates with Head of Radius)
    - Styloid Process of Ulna
    - Head of Ulna (Articulates with Wrist via Disc of Fibrocartilage)
  - **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)
  - **Origins Insertions**
    - Brachialis Insertion
    - Triceps Brachii Insertion
    - Anconeus Insertion
    - Flexor Carpi Ulnaris Origin
    - Flexor Digitorum Superficialis Origin
    - Flexor Digitorum Profundus Origin
    - Pronator Quadratus Origin
    - Pronator Teres Origin
    - Supinator Origin
    - Abductor Pollicis Longus Origin
    - Extensor Pollicis Longus Origin
    - Extensor Pollicis Brevis Origin
    - Extensor Indicis Origin
    - Extensor Carpi Ulnaris Origin

- **Radius: "Rod"**
  - 'Thumb-Side'
  - Thin at Proximal end
  - Wide at Distal end
  - Major forearm bone contributing to Wrist Joint
  - **Landmarks:**
    - Head – concave (Articulates with Capitulum of Humerus)
    - Neck
    - Radial Tuberosity – Anchors Biceps Brachii
    - 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)
  - **Origins Insertions**
    - Pronator Teres Insertion
    - Pronator Quadratus Insertion
    - Supinator Insertion
    - Biceps brachii Insertion
    - Flexor Digitorum Superficialis Origin
    - Flexor Pollicis Longus Origin
    - Brachioradialis Insertion
    - Extensor Pollicis Longus Origin
    - Extensor Pollicis Brevis Origin
    - Abductor Pollicis Longus Origin

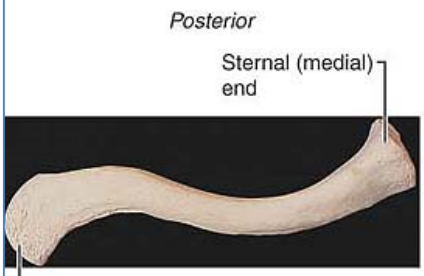


Summary of Shoulder Girdle & Arm Bones & Landmarks

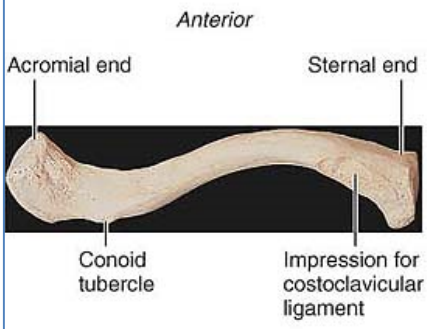


Anterior view **Posterior view**

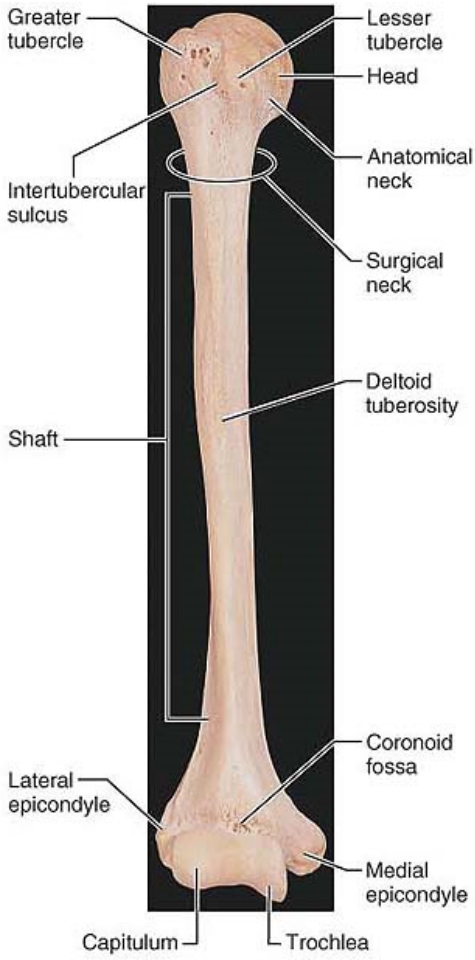
Scapula



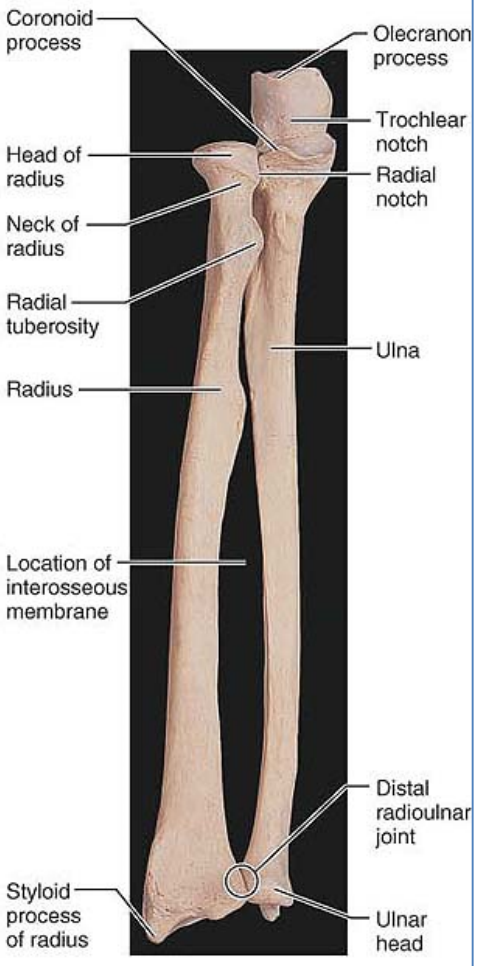
Right clavicle, superior view



Right clavicle, inferior view

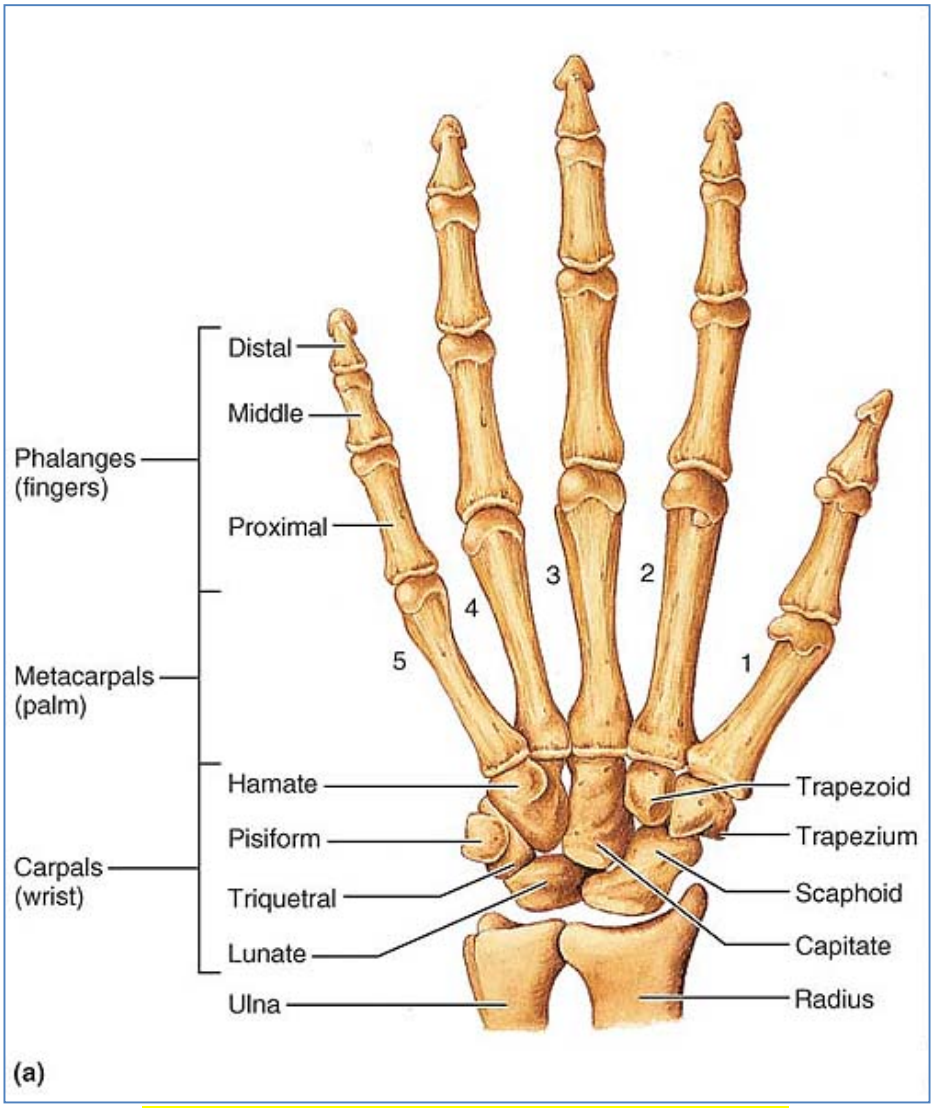


Humerus, anterior view



Radius (left) and ulna (right), anterior view

- **‘Hand’:**
  - **Carpals (“Wrist”):**
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
    - Pisiform
    - Triquetral
    - Lunate
    - Scaphoid
  - **Metacarpals (“Palm”):**
    - Metacarpals # 1-5
  - **Phalanges (“Fingers”):**
    - Distal # 1-5
    - Middle # 1-5
    - Proximal # 1-5

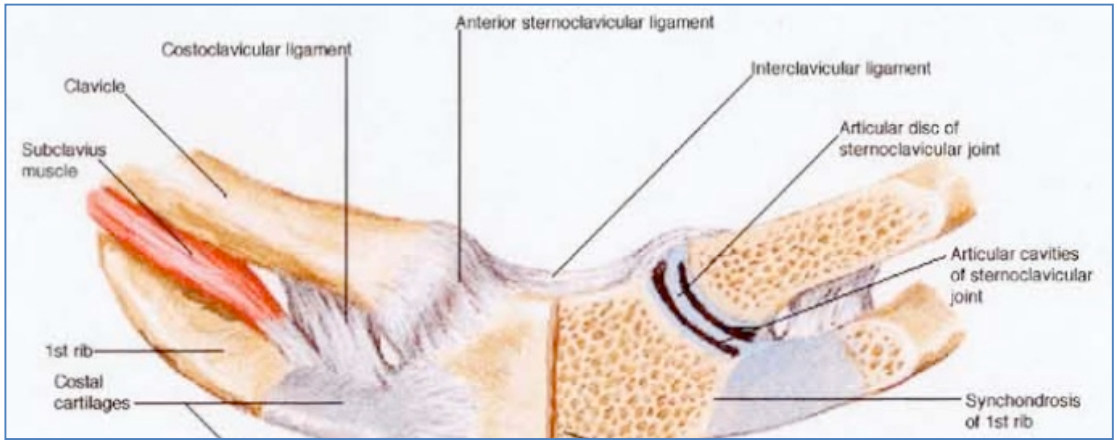


NB: Some **L**overs **T**ry **P**ositions **T**hat **T**hey **C**an’t **H**andle

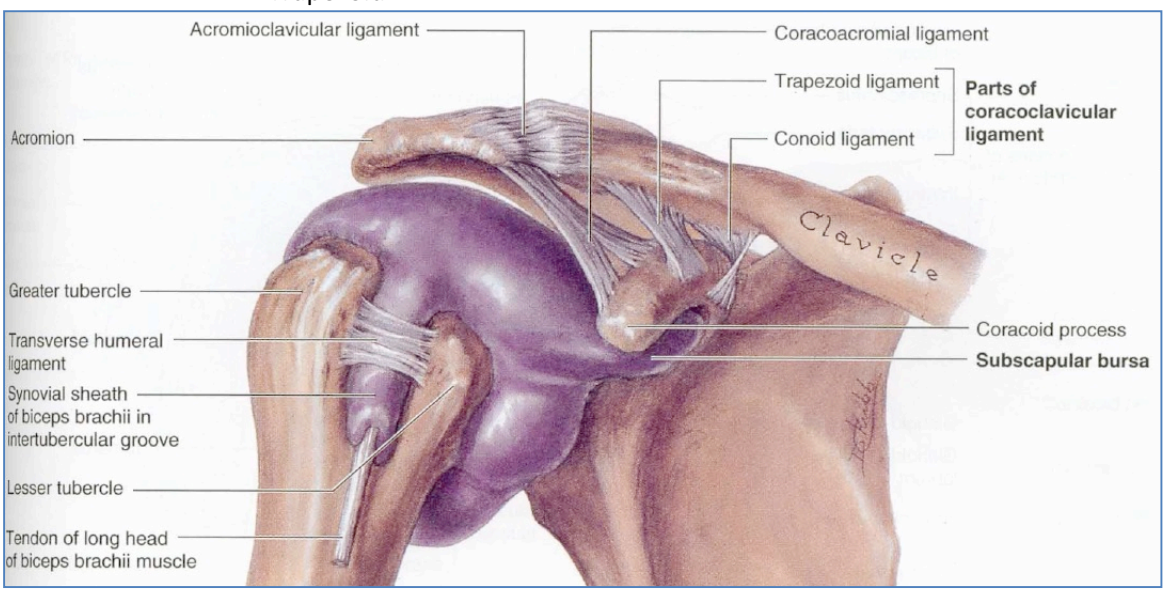
Scaphoid, Lunate, Triquetrium, Pisiform, Trapezium, Trapezoid, Capitate, Hamate.

Joints & Ligaments:

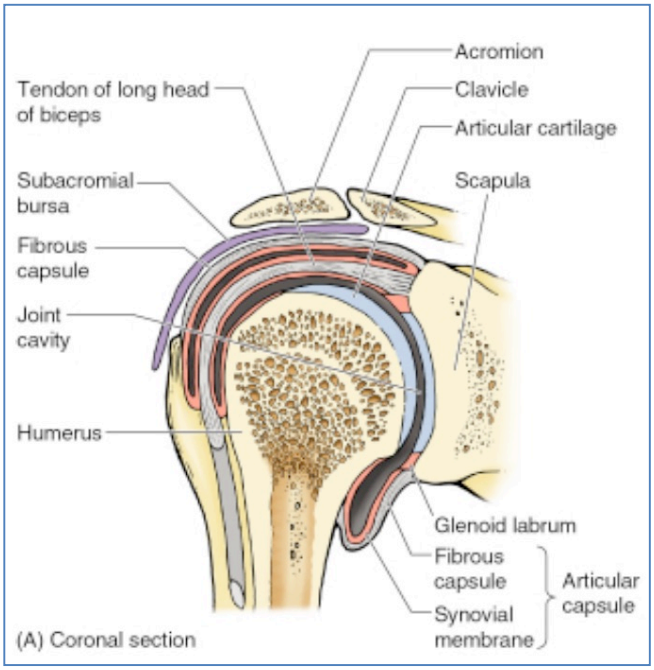
- **SternoClavicular Joint:**
  - **Features:**
    - The only joint that joins limb to axial skeleton.
    - Synovial Saddle Joint
    - Has an 'Articular Disc'(oval plate of fibrocartilage) – for congruence between bones.
  - **Bones:**
    - Manubrium of Sternum (superior lateral borders)
    - Clavicle (medial end)
  - **Ligaments:**
    - SternoClavicular Ligament
    - InterClavicular Ligament
    - CostoClavicular Ligament
      - (also the origin of the SubClavius Muscle)

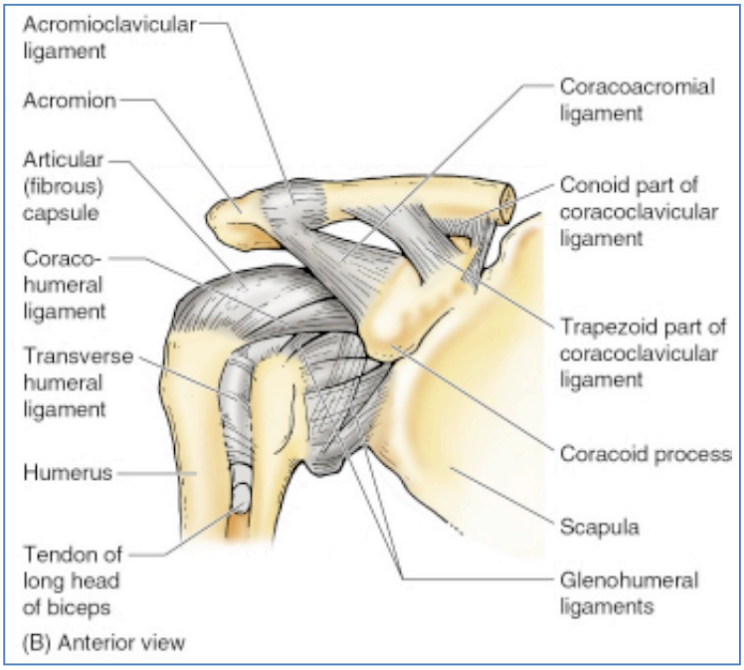


- **AcromioClavicular Joint:**
  - **Features:**
    - Joins the Clavicle to the Acromion
    - Synovial Plane
    - Has an 'Articular Disc'(oval plate of fibrocartilage) – for congruence between bones.
  - **Bones:**
    - Clavicle
    - Acromion of Scapula
  - **Ligaments:**
    - Coracoacromial
    - 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





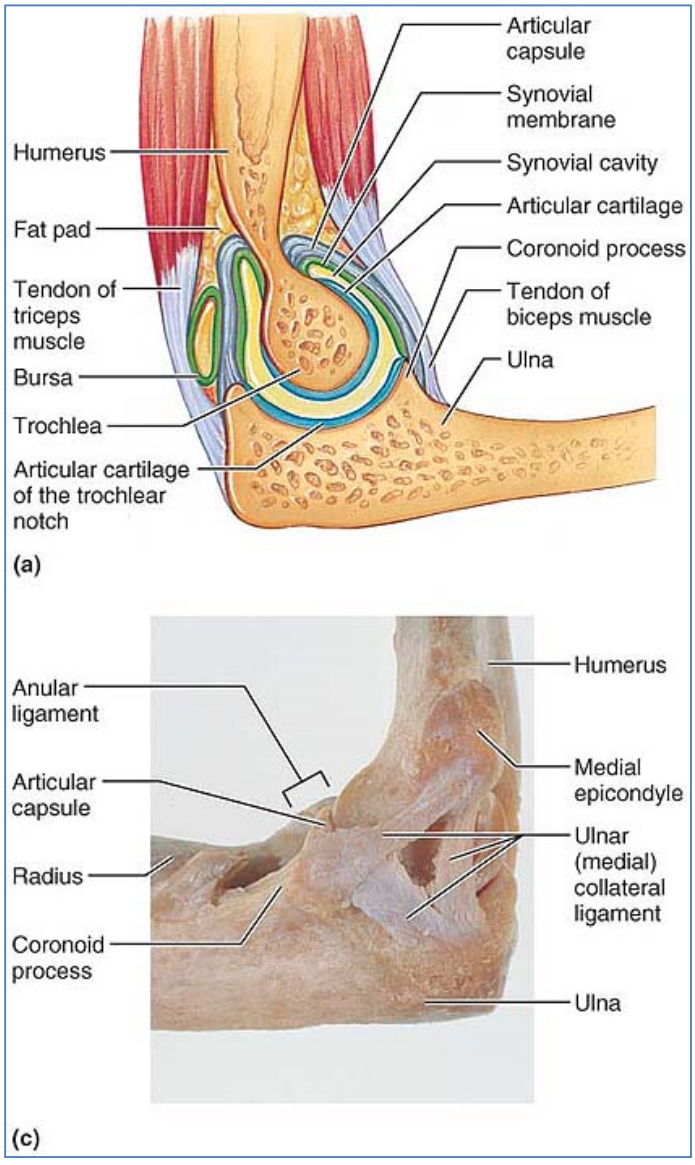
- **Elbow Joint**
  - **HumeroUlnar Joint:**
    - **Features:**
      - Joins Distal Humerus to Proximal Ulna
      - Synovial Hinge Joint
      - Uniaxial – Flexion & Extension Only
      - Very Stable – Due to Bony Congruency
        - & Ligaments
    - **Bones:**
      - Humerus
        - Medial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

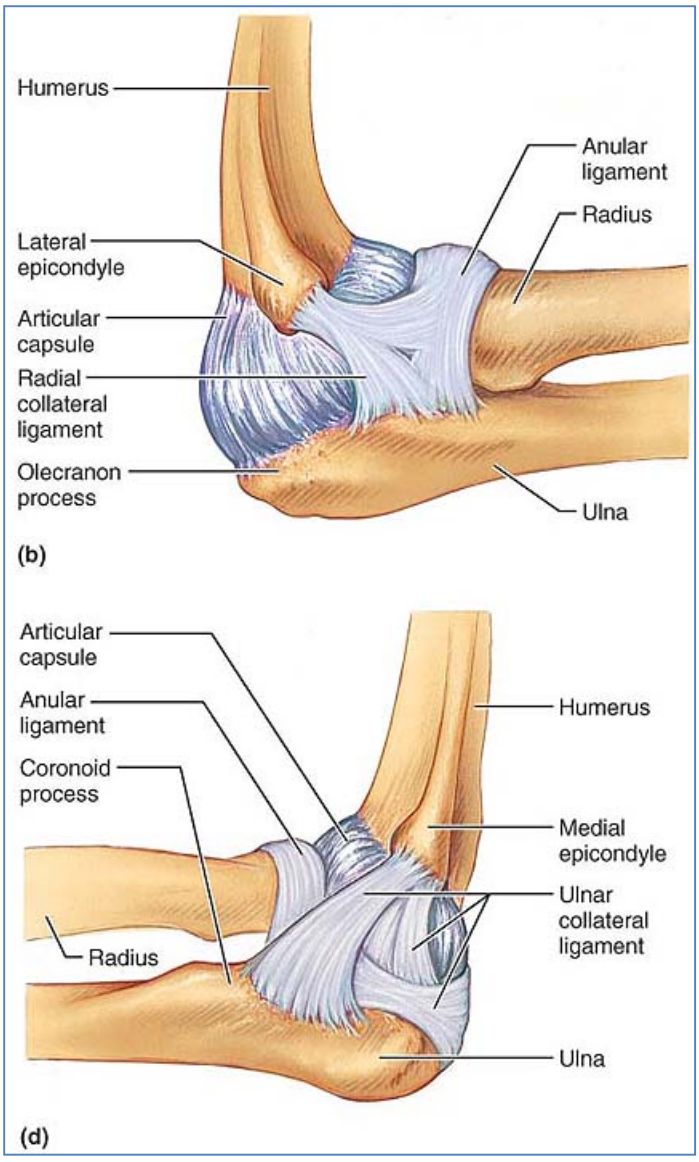
Elbow flexion

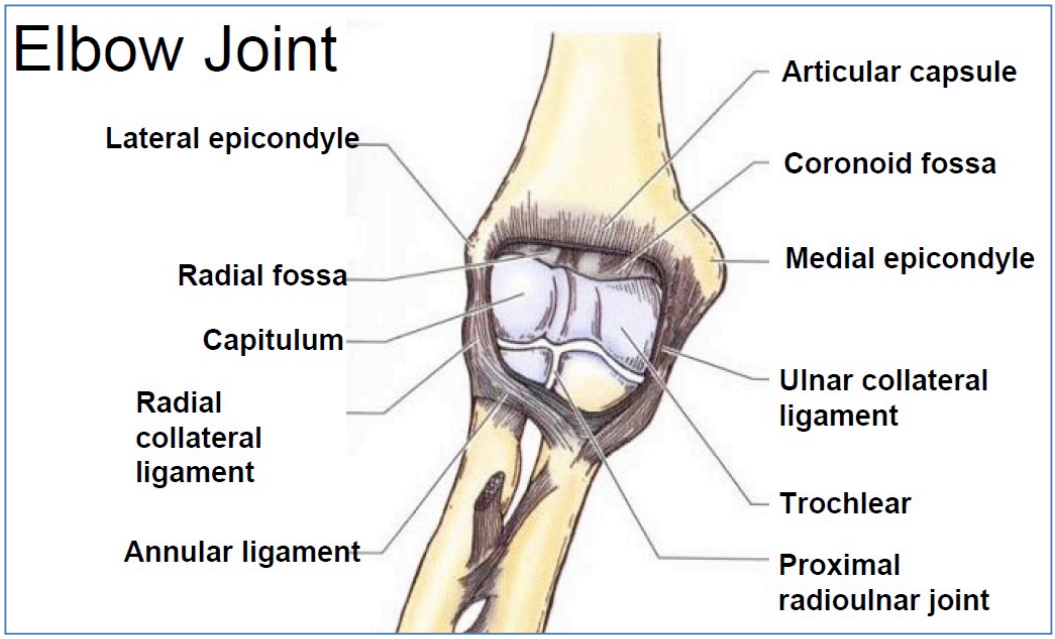
- C5, C6
- Anterior compartment (arm)
  - Brachialis
  - Biceps brachii
    - *Musculocutaneous nerve*
- Posterior compartment (forearm)
  - Brachioradialis
    - *Radial nerve*

Elbow Extension

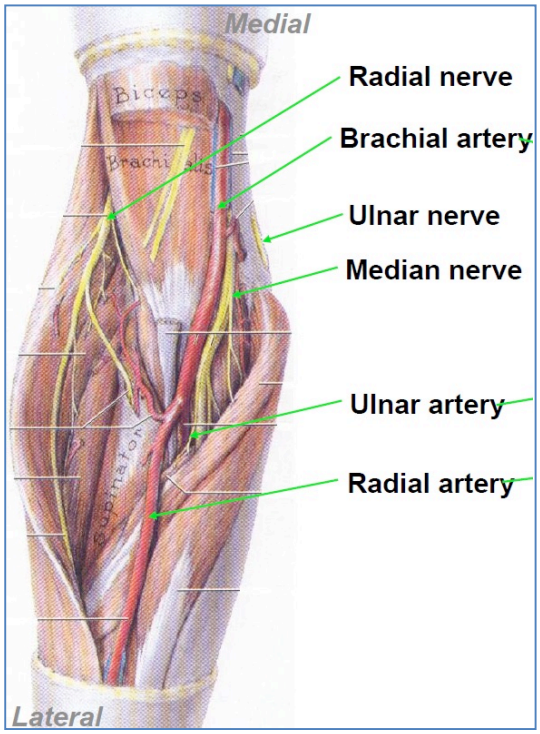
- C7 and C8
- Posterior compartment (arm)
  - Triceps brachii
  - Aconeus

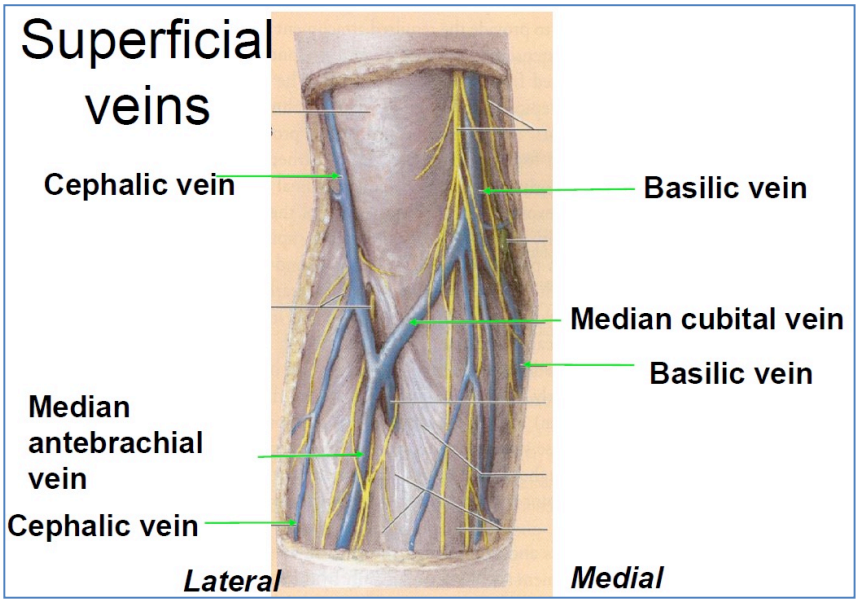




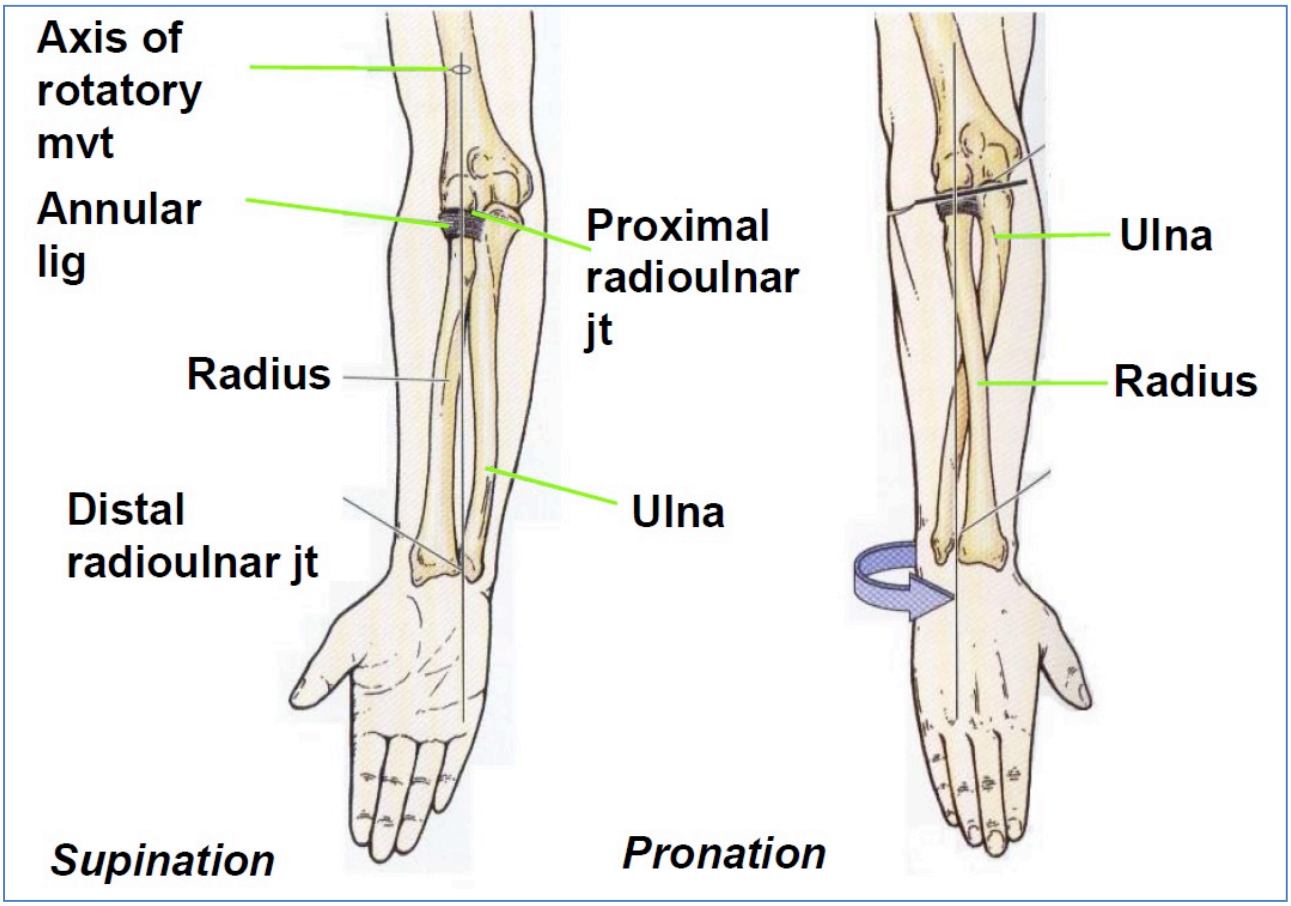


- **Cubital Fossa**

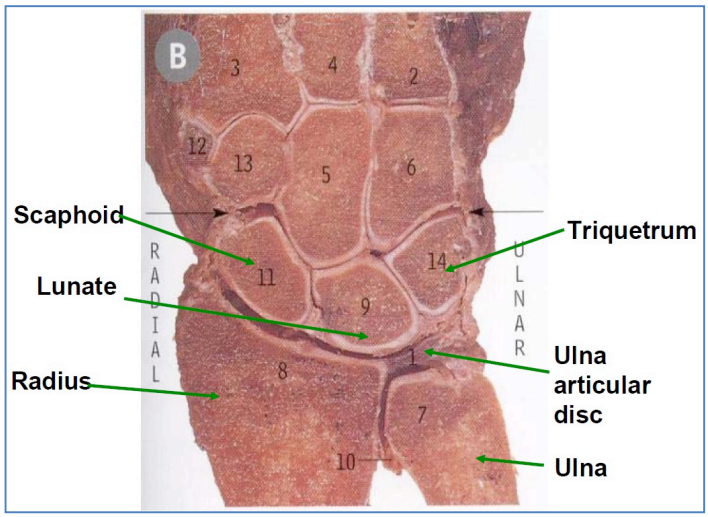


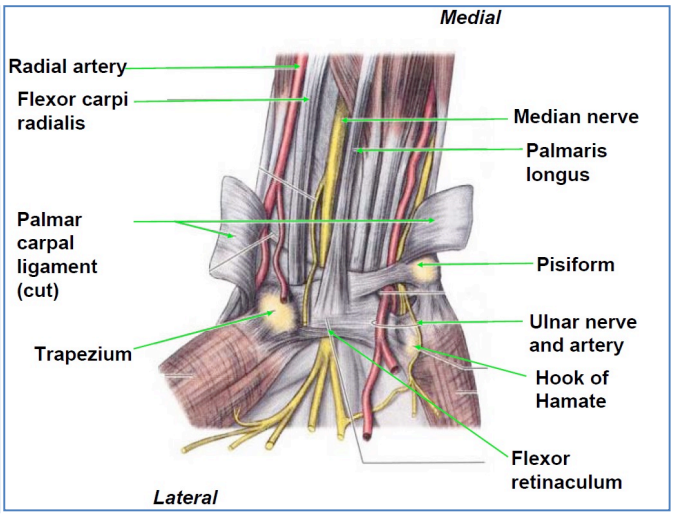


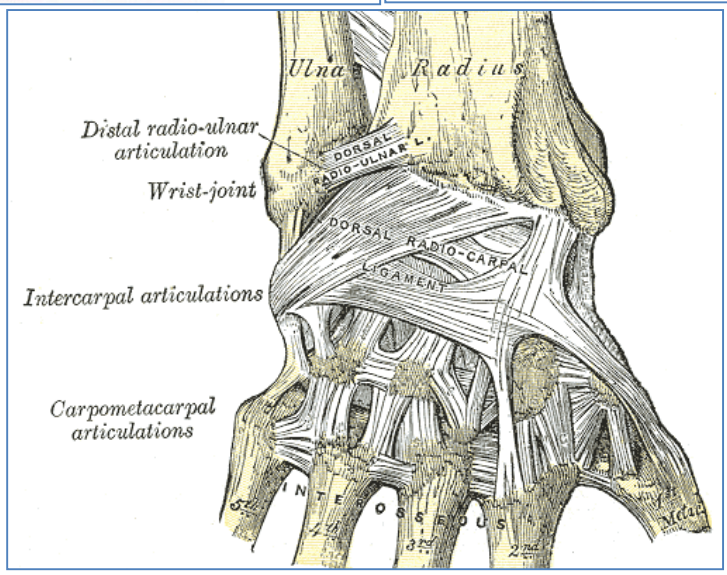
- **RadioUlnar Joint:**
  - **Proximal:**
    - **Features:**
      - Joins Radius & Ulna
      - Synovial Pivot Joint
      - Uniaxial – Pronation & Supination Only
    - **Bones:**
      - Radius
      - Ulna
    - **Ligaments:**
      - Annular Ligament
  - **Distal:**
    - **Features:**
      - Joins Radius & Ulna
      - Synovial Pivot + Articular Disc
      - Uniaxial – Pronation & Supination Only
    - **Bones:**
      - Radius
      - Ulna
    - **Ligaments:**
      - Dorsal RadioUlnar Ligament
      - Volar RadioUlnar Ligament



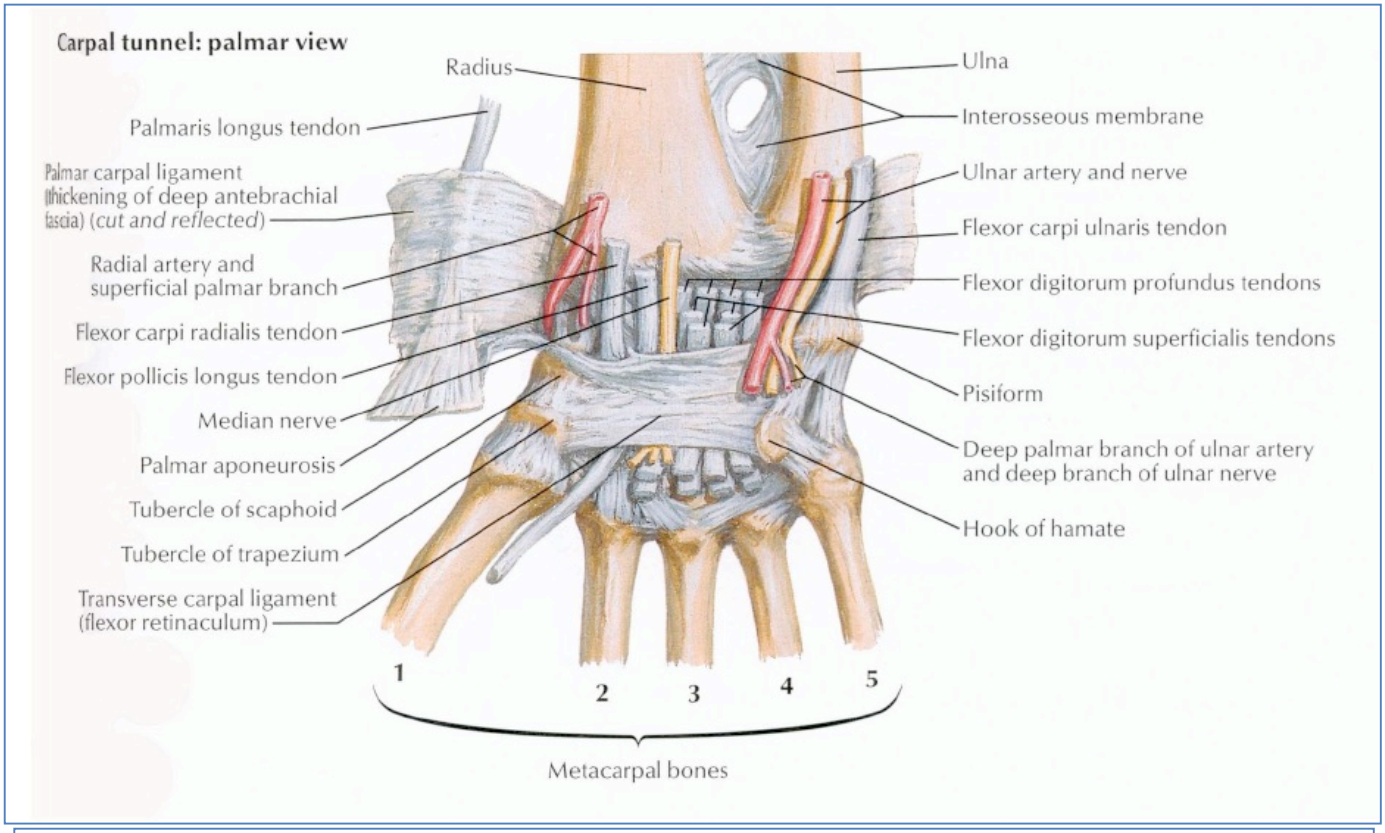
- **Wrist Joint:**
  - **CarpiRadialis Joint:**
    - **Features:**
      - Joins Radius & Proximal Carpals
      - Synovial Condyloid
      - Biaxial: Flexion/Extension + Abduciton/Adduction = Circumduction
    - **Movement (C6 + C7):**
      - **Flexion:**
        - Flexor Carpi Radialis
        - Flexor Carpi Ulnaris
      - **Extension:**
        - Extensor Carpi Radialis – Longus & Brevis
        - Extensor Carpi Ulnaris
      - **Abduction:**
        - Extensor Pollicis Longus
        - Flexor Carpi Radialis + Extensor Carpi Radialis (Longus & Brevis)
      - **Adduction:**
        - Extensor Carpi Ulnaris + Flexor Carpi Ulnaris
    - **Bones:**
      - Radius
      - Proximal Carpals
    - **Ligaments:**
      - Palmar Carpal Ligament
      - Flexor Retinaculum (Transverse Carpal Ligament) – Roof of Carpal Tunnel
      - Dorsal RadioCarpal Ligament

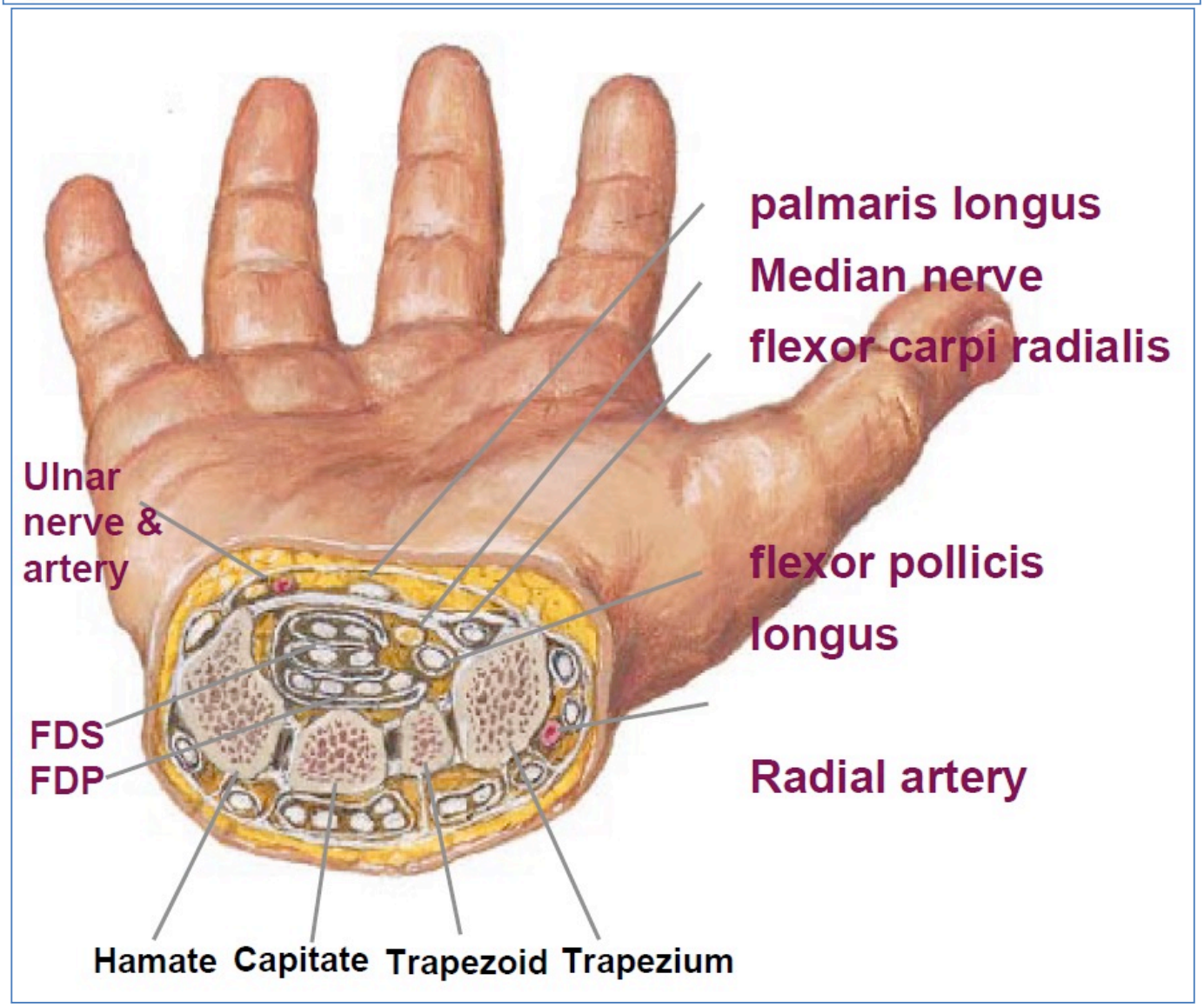




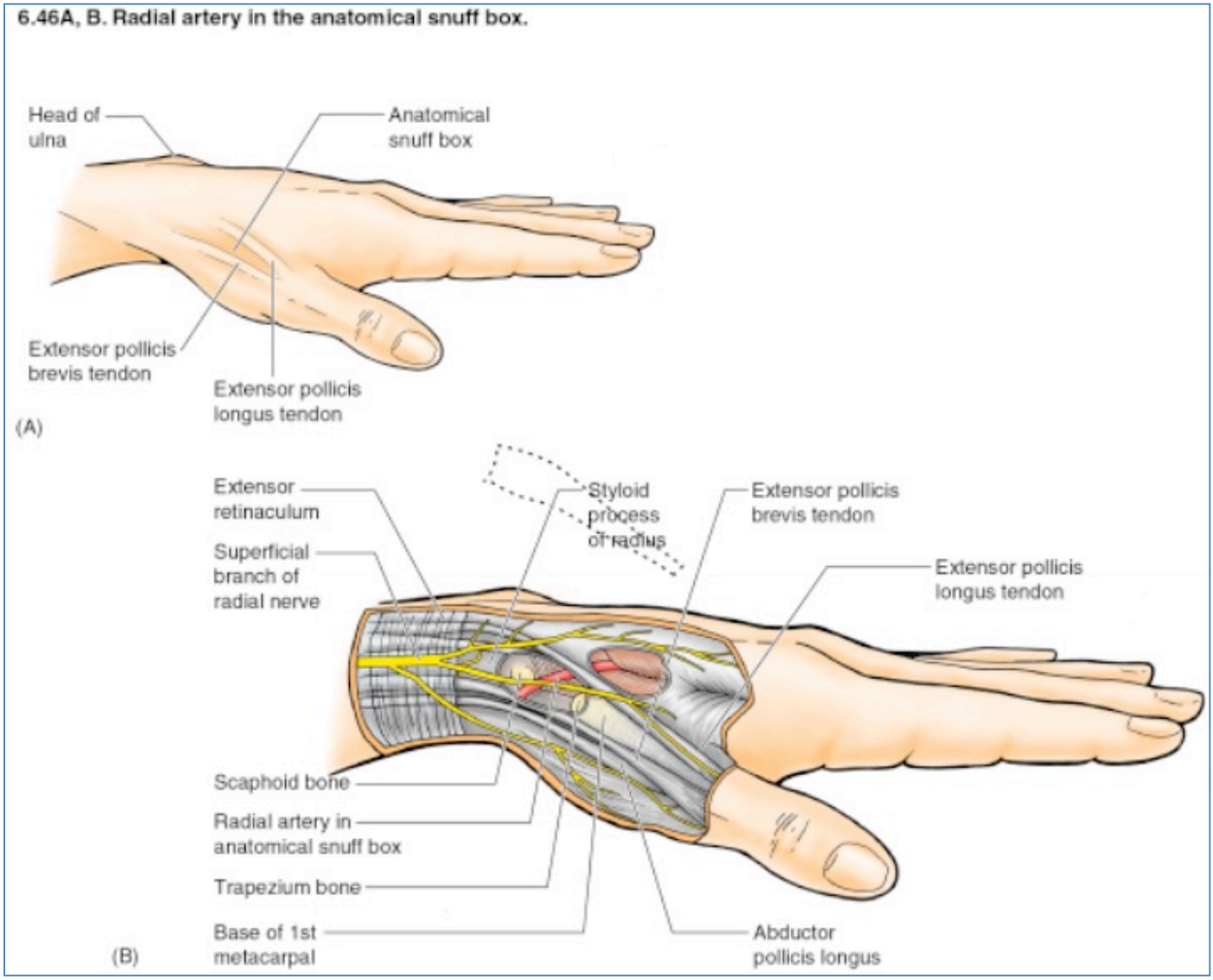


- **Carpal Tunnel (Anterior Aspect)**





- **Anatomical Snuff Box**



- **InterCarpal Joints:**
  - **Features:**
    - Joins Adjacent Carpals
    - Synovial Plan
  - **Bones:**
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
    - Pisiform
    - Triquetral
    - Lunate
    - Scaphoid
  - **Ligaments:**
    - The various Palmar Intercarpal Ligaments

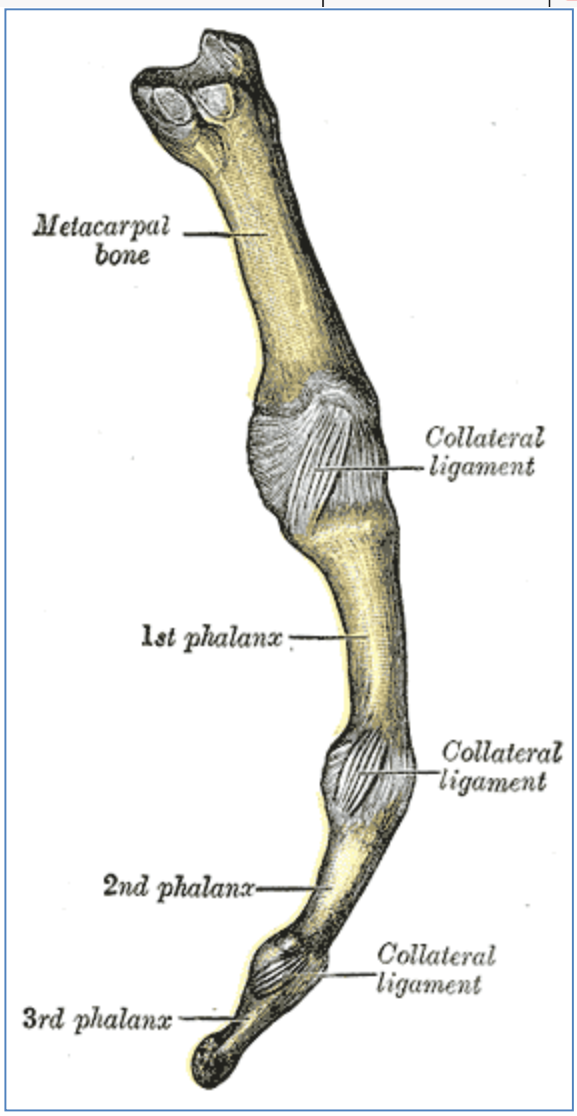
- **CarpoMetacarpal Joints:**
  - **Digit 1 (Thumb):**
    - **Features:**
      - Joins Trapezium & Metacarpal 1
      - Synovial Saddle
      - Biaxial: Flexion/Extension + Abduction/Adduction = Circumduction + Opposition
    - **Bones:**
      - Carpal: Trapezium
      - Metacarpal #1: Thumb
    - **Ligaments:**
  - **Digits 2-5:**
    - **Features:**
      - Joins Distal Carpals & Metacarpals 2-5
      - Synovial Plane
    - **Bones:**
      - Trapezoid
      - Capitate
      - Hamate

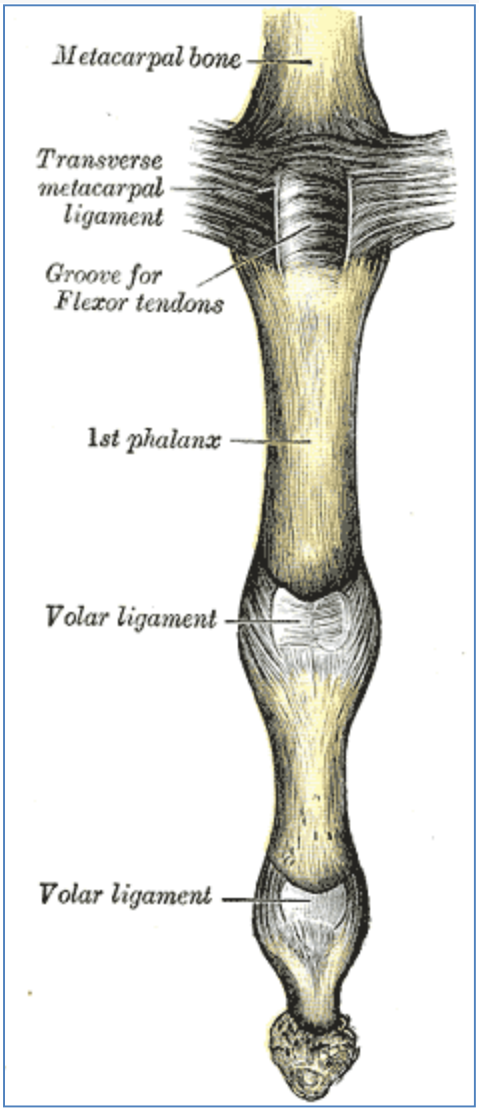
      &
      - Metacarpals 2-5
    - **Ligaments:**
      - The various CarpoMetacarpal Ligaments

- **Metacarpo-Phalangeal Joints (Knuckes):**
  - **Features:**
    - Joins Metacarpals & Phalanges
    - Synovial Condyloid
    - Biaxial: Flexion/Extension + Abduciton/Adduction = Circumduction
  - **Bones:**
    - Metacarpals 1-5
    - Phalanges 1-5
  - **Ligaments:**
    - Collateral Ligaments
    - Transverse Metacarpal Ligament
    - Joint Capsules

- **InterPhalangeal Joints (Fingers):**
  - **Features:**
    - Joins adjacent Phalanges
    - Synovial Hinge
    - Uniaxial – Flexion/Extension Only
  - **Bones:**
    - Proximal, Middle & Distal Phalanges 1-5
  - **Ligaments:**
    - Collateral Ligaments
    - Joint Capsules

Joint	Synovial type	Movements
Intercarpal	plane	gliding
1st Carpometacarpal	saddle	Extension, flexion, abduction, adduction, circumduction, oppositon
2nd to 5th Carpometacarpal	plane	gliding
Metacarpophalangeal	Condyloid	Extension, flexion, abduction, adduction, circumduction
Interphalangeal	Hinge	Extension, flexion





Muscles:

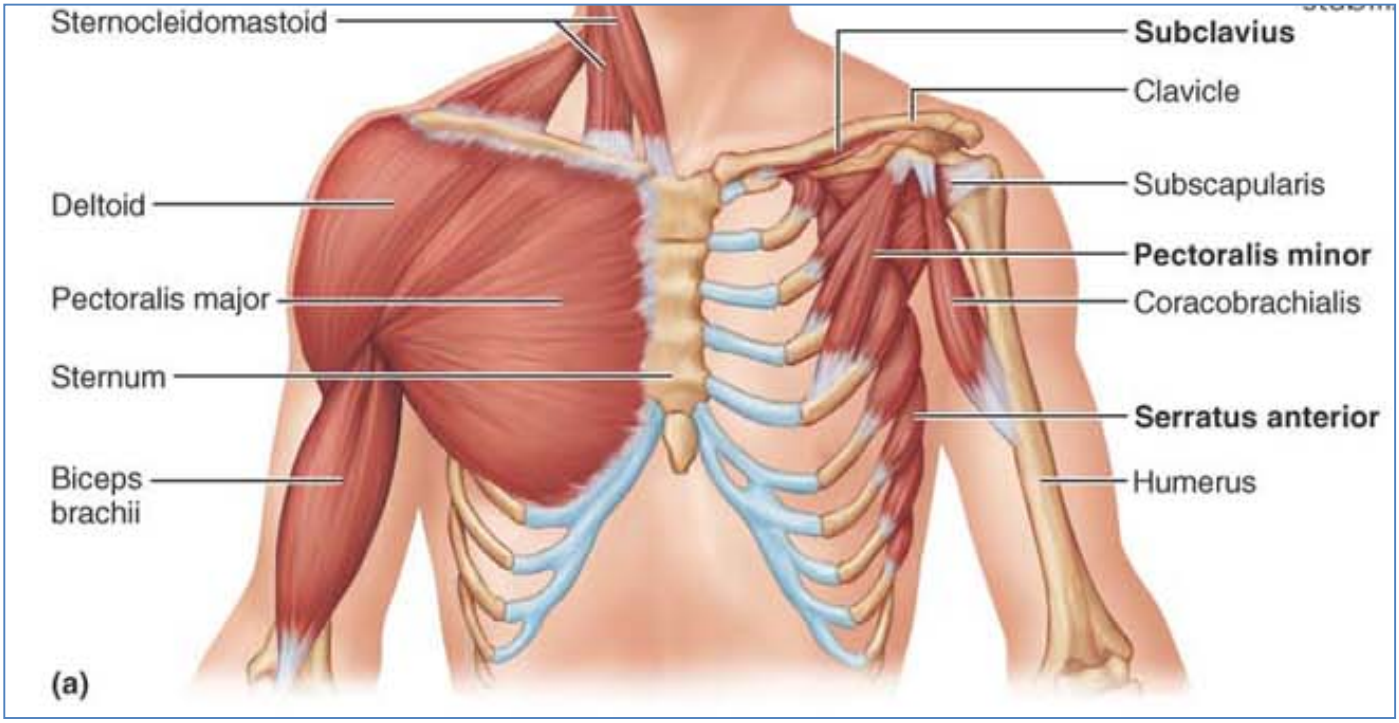
- **Move Pectoral Girdle (Clavicle & Scapula):**

Muscle	Origins/Insertions	Action
Trapezius	O – Occipital bone → Thoracic Vertebrae I – Spine of Scapula, Acromion & Lateral Clavicle	Superior Fibres – Elevate Scapula Middle Fibres – Retract Scapula Inferior Fibres – Depress Scapula
SubClavius	O – Costal Cartilage of Rib 1 I – Groove on inferior surface of Clavicle	Stabilises & Depresses Pectoral Girdle
Rhomboid Major	O – Spinous Processes of T_2 → T_5 I – Lower Medial Border of Scapula	Retracts Scapula Medial Rotation of Scapula
Rhomboid Minor	O – Spinous Processes of C_7 → T_1 I – Upper Medial Border of Scapula	Retracts Scapula Medial Rotation of Scapula
Levator Scapulae	O – Transverse Processes of C_1 → C_4 I – High Medial Border of Scapula	Elevates Scapula Medial Rotation of Scapula Flexes Neck to same side.
Pectoralis Minor	O – Anterior Surface of Ribs 3→5 I – Coracoid Process of Scapula	Draws Scapula forwards & downwards
Serratus Anterior	O – Ribs 1→8 I – Anterior Surface of Medial Border of Scapula	Protraction of Scapula Any Horizontal Arm Movements (pushing/punching)

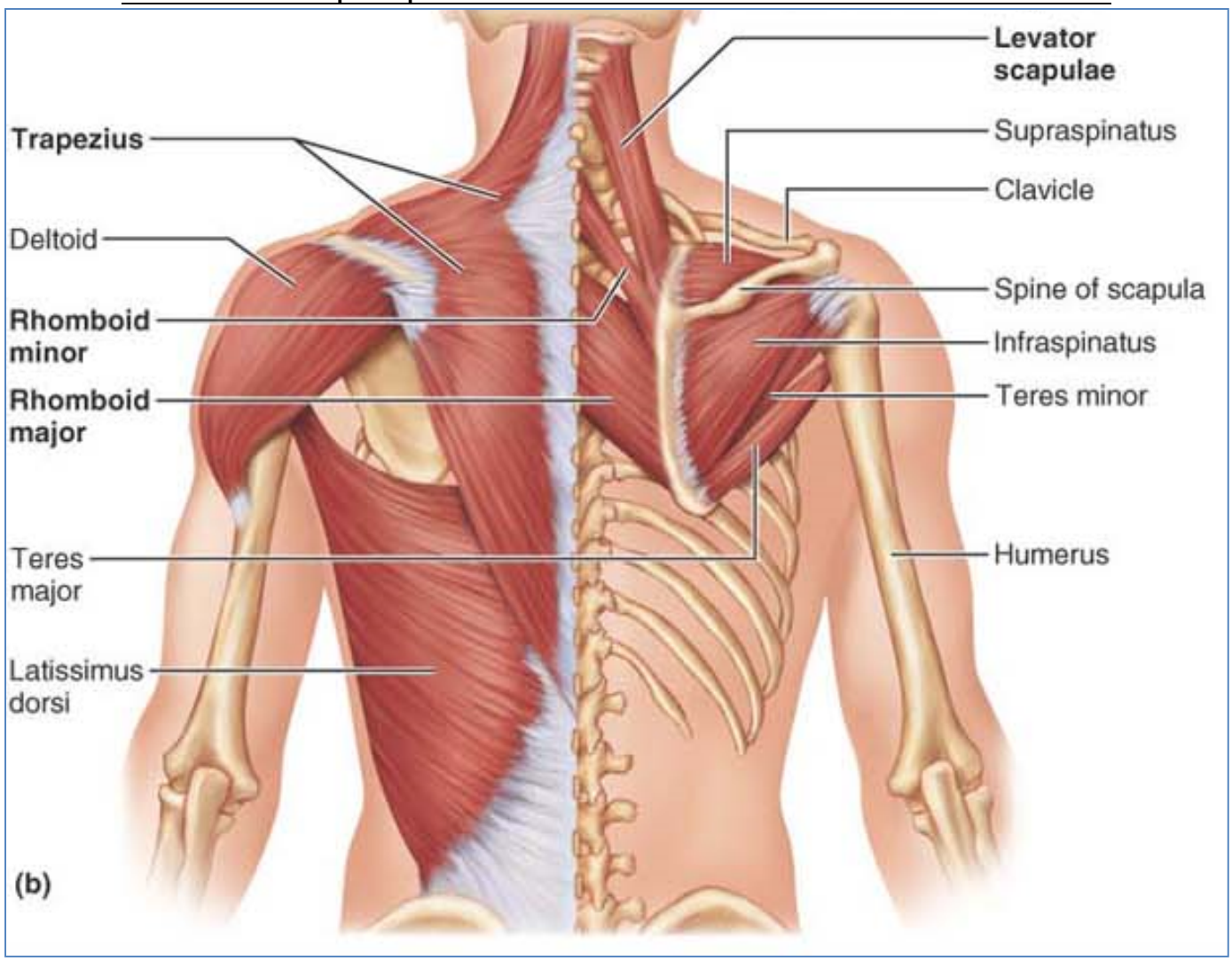
- **Move Humerus (Shoulder Joint):**

Muscle	Origins/Insertions	Action
(RC) Supraspinatus	O – Supraspinous Fossa of Scapula I – Greater Tubercle of Humerus	Abduction of Humerus Helps prevent downward dislocation of Humerus
(RC) Infraspinatus	O – Infraspinous Fossa of Scapula I – Greater Tubercle of Humerus	Lateral Rotation of Humerus Stabilises Shoulder Joint
(RC) Subscapularus	O – Subscapular Fossa of Scapula I – Lesser Tubercle of Humerus	Medial Rotation of Humerus Stabilises Shoulder Joint
(RC) Teres Minor	O – Lateral Border of Scapula I – Greater Tubercle of Humerus	Lateral Rotation of Humerus Stabilises Shoulder Joint
Deltoid	O – Lateral 3rd of Clavicle, Acromion & Spine of Scapula I – Deltoid Tuberosity of Humerus	Abduction of Humerus Flexion & Medial Rotation of Humerus Extension & Lateral Rotation of Humerus
Teres Major	O – Inferior Angle of Scapula I – Intertubercular Sulcus of Humerus	Adduction of Humerus Medial Rotation of Humerus Posterio-Medial Extension
Latissimus Dorsi	O – Spines of lower 6 Thoracic Vertebrae, Lower 3-4 Ribs, Lumbar Vertebrae & Iliac Crest of Pelvis. I – Intertubercular Sulcus of Humerus	Arm Extension Adduction of Humerus Medial Rotation Depression of Scapula
Pectoralis Major	O – Sternal end of Clavicle, Sternum, Aponeurosis of External Oblique Muscle & Ribs 1-6 I – Greater Tubercle of Humerus	Arm Extension Medial Rotation of Humerus Adduction of Humerus

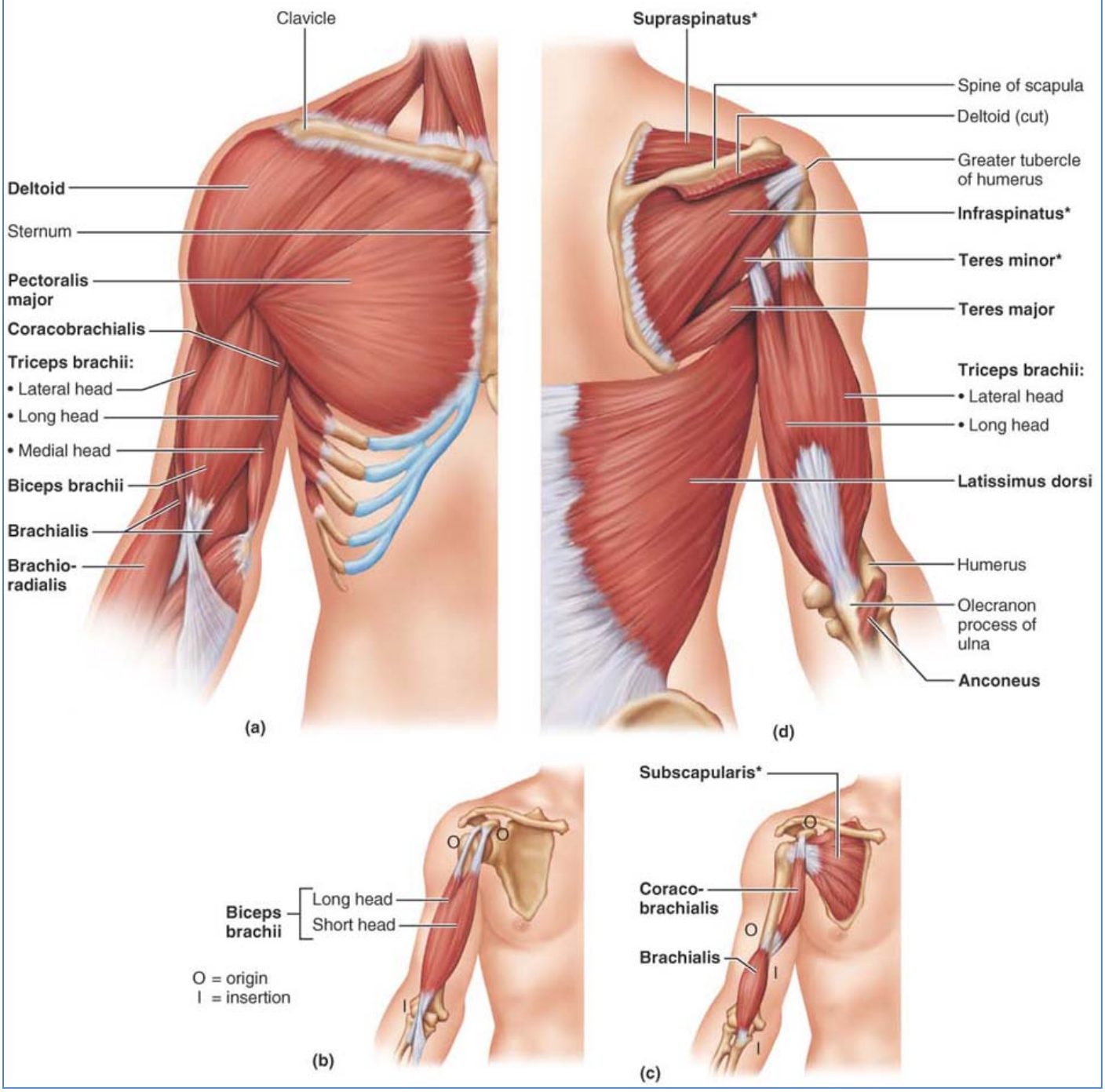
Anterior View: Deep & Superficial Muscles of The Pectoral Girdle & The Glenohumeral Joint



Posterior View: Deep & Superficial Movers of The Pectoral Girdle & The Glenohumeral Joint



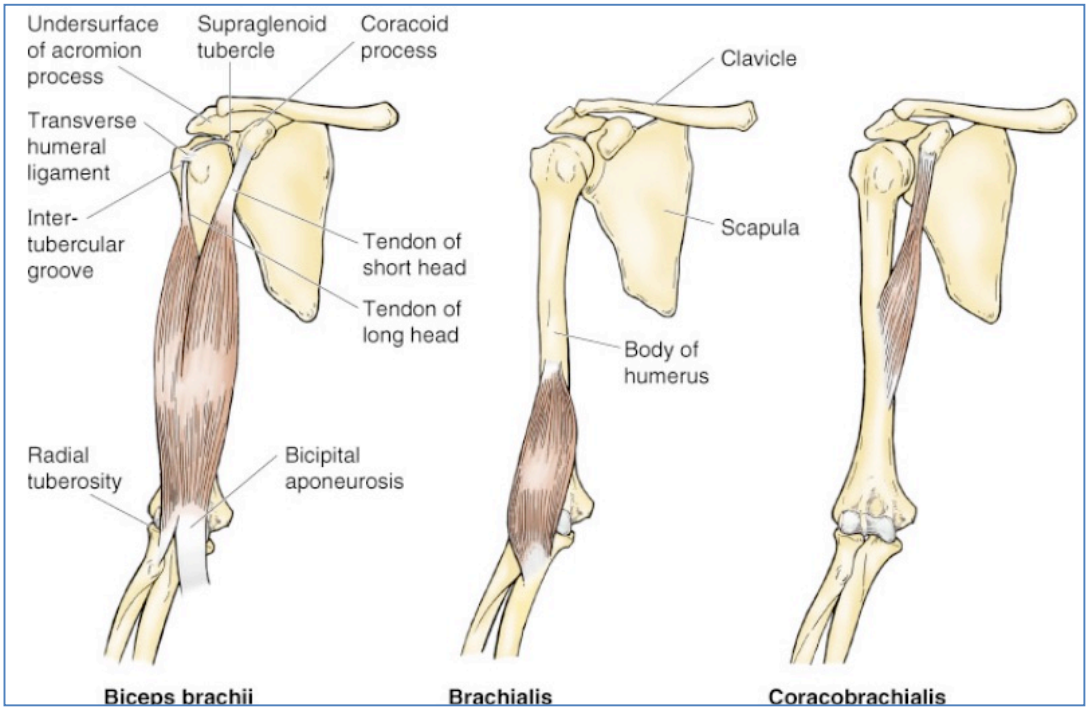
MUSCLE GALLERY TABLE 10.9 Muscles Crossing the Shoulder Joint: Movements of the Arm (Figure 10.14) *(continued)*



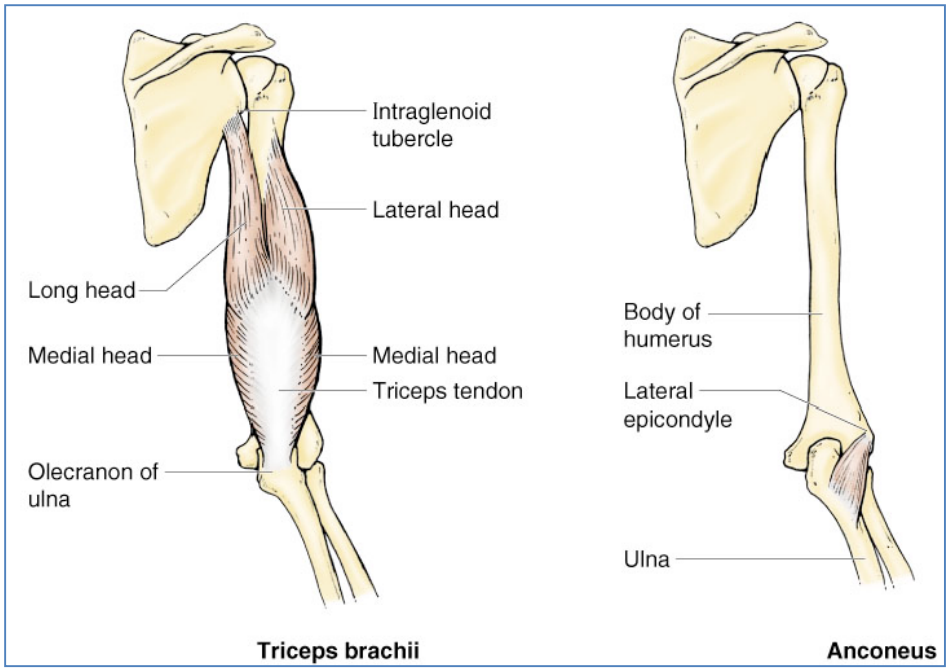
- **Muscles of Upper Arm:**

Muscle	Origins/Insertions	Action
(Ant) Biceps Brachii	O – Long Head: SupraGlenoid Tubercle Short Head: Coracoid Process I – Radial Tuberosity	Flexion of the Elbow Joint Supinates the Forearm
(Ant) Brachialis	O – Distal 1/3 of Anterior Humerus I – Coronoid Process of Ulna	Flexion of the Elbow Joint (synergist of Biceps.B)
(Ant) Coracobrachialis	O – Coracoid Process of Scapula I – Medial surface of Humerus Shaft	Flexion of Humerus Adduction of Humerus
(Post) Triceps Brachii	O – Long Head: InfraGlenoid Tubercle of Scapula. Lateral Head: Posterior Proximal Shaft of Humerus. Medial Head: Posterior Distal Shaft of Humerus. I – Olecranon Process of Ulna	Extension of Elbow Joint (Long head tendon assists in adduction of arm)
(Post) Anconeus	O – Lateral Epicondyle of Humerus I – Lateral side of Olecranon Process of Ulna	Extension of Elbow Joint Abduction of Ulna

Upper Arm – Anterior Compartment



Upper Arm – Posterior Compartment

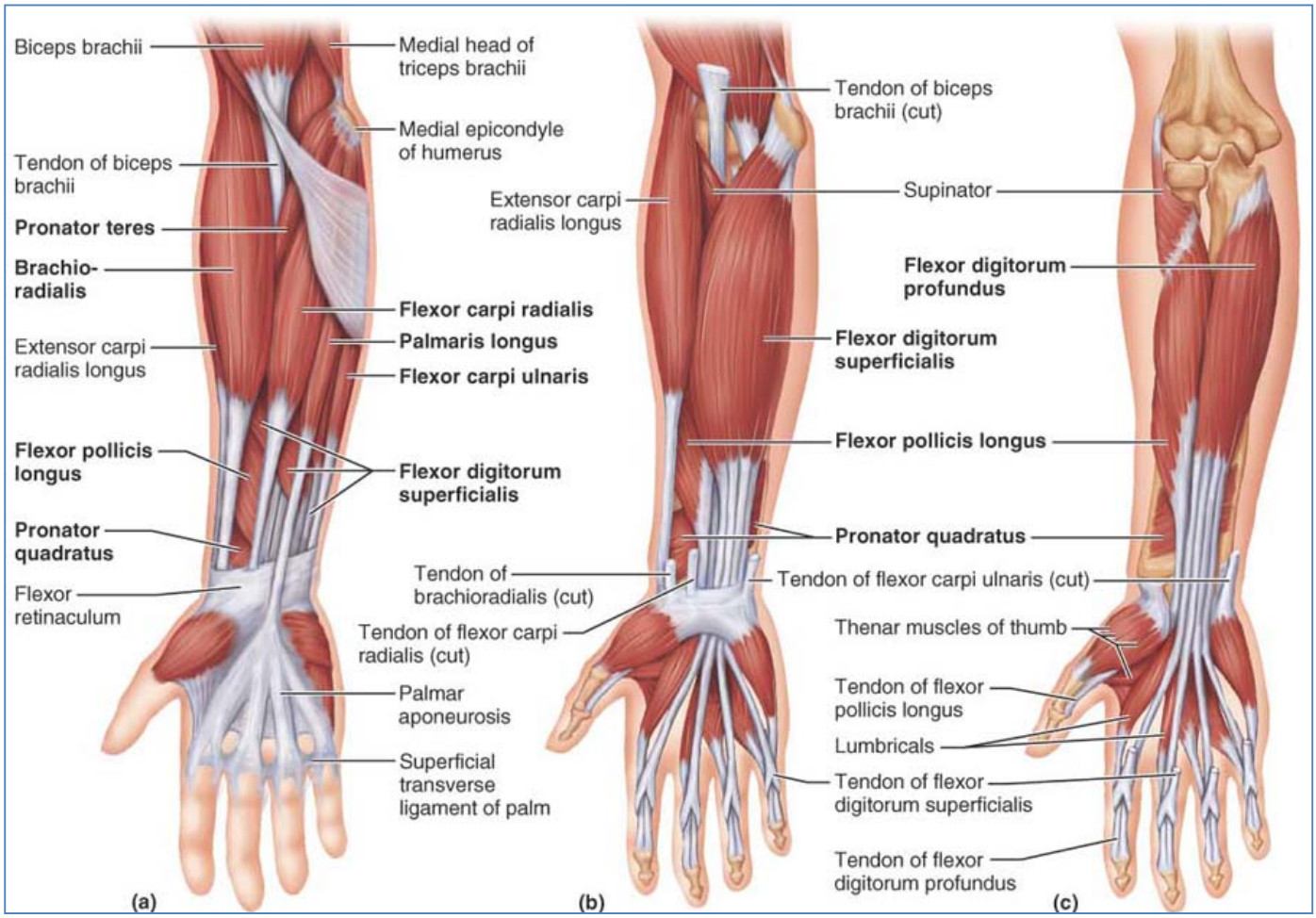


- **Muscles of the Forearm:**
  - **Anterior (FLEXORS) - Superficial:**

Muscle	Origins/Insertions	Action
Pronator Teres	O – Medial Epicondyle of Humerus & Coronoid Process of Ulna I – Lateral Midshaft of Radius.	Pronation of Forearm
Flexor Carpi Radialis	O – Medial Epicondyle of Humerus I – Base of 2nd & 3rd Metacarpals	Flexion of Wrist Abduction of Hand
Palmaris Longus	O – Medial Epicondyle of Humerus I – Palmar Aponeurosis	Tenses Skin & Fascia of Palm Flexion of Wrist
Flexor Carpi Ulnaris	O – Medial Epicondyle of Humerus, Olecranon Process of Ulna Posterior Surface of Ulna I – Pisiform & Hamate Bones + Base of 5th Metacarpal	Flexion of Wrist Adduction of Hand (in concert with Extensor Carpi Ulnaris)
Flexor Digitorum Superficialis	O – Medial Epicondyle of Humerus, Coronoid Process of Ulna, Shaft of Radius I – Middle Phalanges of Fingers 2-5.	Flexion of Wrist & Middle Phalanges of Fingers 2-5.

  - **Anterior (FLEXORS) - Deep:**

Muscle	Origins/Insertions	Action
Flexor Pollicis Longus	O – Anterior Proximal Radius I – Distal Phalanx of Thumb	Flexes Distal Phalanx of Thumb
Flexor Digitorum Profundus	O – Coronoid Process of Ulna I – Four Tendons → Distal Phalanges of Fingers 2-5.	Flexor of any/all of Fingers 2-5 - the only muscle that flexes Distal Interphalangeal Joints.
Pronator Quadratus	O – Distal Anterior Ulnar Shaft I – Distal Anterior Radial Shaft	Forearm Pronation Helps hold Ulna & Radius together

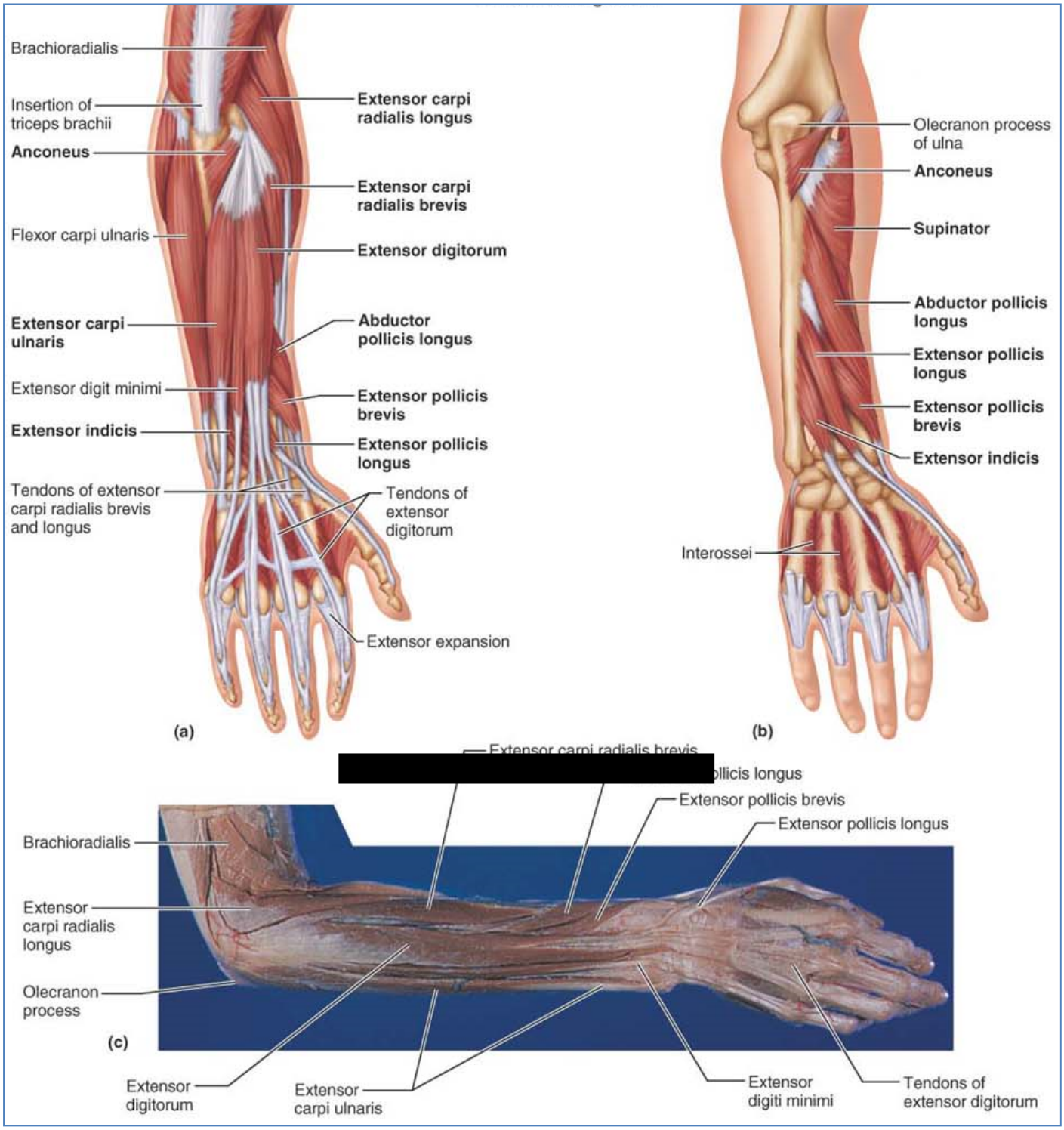


- **Posterior (EXTENSORS) - Superficial:**

Muscle	Origins/Insertions	Action
BrachioRadialis	O – Lateral SupraCondylar Ridge of Humerus I – Base of Styloid Process of Radius	Synergist in forearm flexion. Stabilises Elbow Joint during rapid flexion/extension.
Extensor Carpi Radialis Longus	O – Lateral SupraCondylar Ridge of Humerus I – Base of 2nd Metacarpal	Extension of Wrist (Along with Extensor Carpi Ulnaris) Abduction of Wrist (Along with Flexor Carpi Radialis)
Extensor Carpi Radialis Brevis	O – Lateral Epicondyle of Humerus I – Base of 3rd Metacarpal	Extension of Wrist Abduction of Wrist
Extensor Digitorum	O – Lateral Epicondyle of Humerus I – Four Tendons → Distal Phalanges of Fingers 2-5.	Extension of Fingers Extension of Wrist
Extensor Digit Minimi	O – Lateral Epicondyle of Humerus I – Distal Phalanx of 5th Finger	Extension of 'little finger' Helps in extension of wrist
Extensor Carpi Ulnaris	O – Lateral Epicondyle of Humerus I – Base of 5th Metacarpal	Extension of Wrist (Along with Extensor Carpi Radialis) Adduction of Wrist (Along with Flexor Carpi Ulnaris)

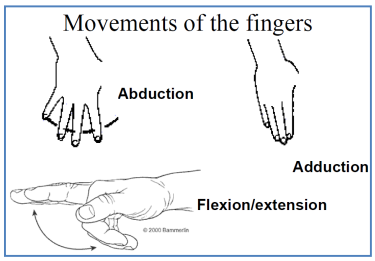
- **Posterior (EXTENSORS) – Deep**

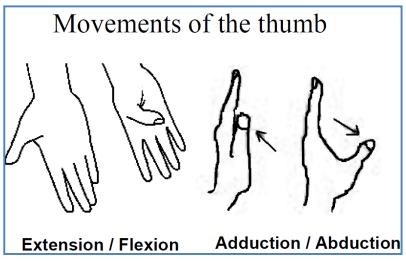
Muscle	Origins/Insertions	Action
Supinator	O – Lateral Epicondyle of Humerus & Proximal Ulna I – Proximal End of Radius	Supination of Forearm
Abductor Pollicis Longus	O – Posterior Surfaces of Ulna & Radius I – Base of 1st Metacarpal & Trapezium	Abducts & Extens Thumb Abducts Wrist
Extensor Pollicis Longus	O – Mid Shaft Surfaces of Ulna & Radius I – Base of Distal Phalanx of Thumb	Extension of Thumb
Extensor Pollicis Brevis	O – Mid Shaft Surfaces of Ulna & Radius I – Base of Proximal Phalanx of Thumb	Extension of Thumb
Extensor Indicis	O – Posterior, Distal Ulna I – Extensor Expansion of Index Finger Joins Tendon of Extensor Digitorum	Extension of Index Finger Extension of Wrist



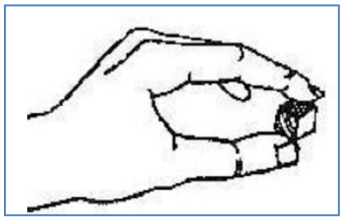
The Hand:

- **Movements:**

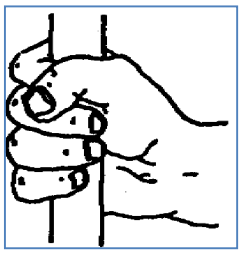


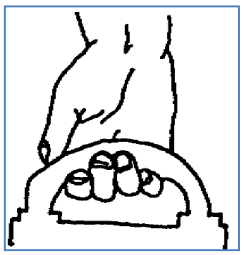


- **Grips:**
  - **Precision Grip:**
    - Flexion of digits (esp. At MCP joints)
    - Short Intrinsic Muscles
    - Opposition of thumb
    - Best when wrist is extended.

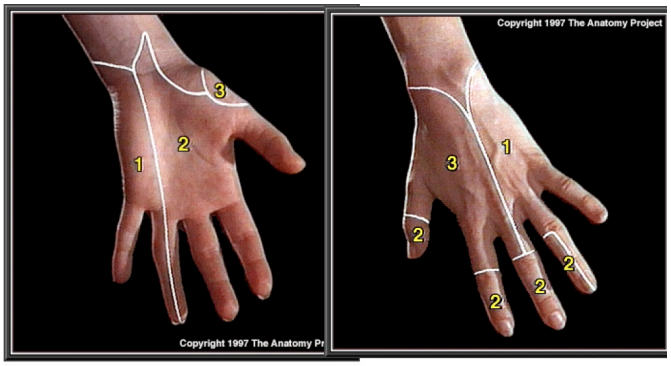


  - **Power Grip:**
    - Flexion of IP & MCP Joints
    - Powerful Extrinsic Flexor Muscles
    - Best when wrist is extended
    - Eg:
      - Palmar Grip
      - Hook Grip





  - **Dermatomes:**

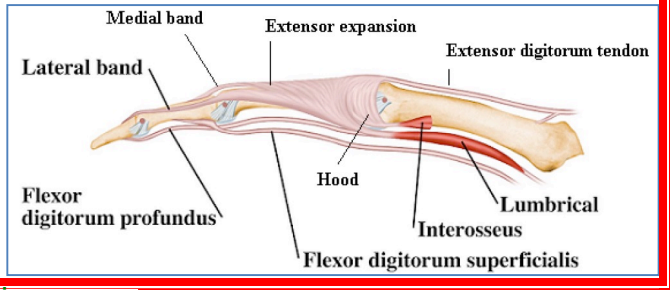


1. Ulnar; 2. Median; 3. Radial

  - **Innervation:**
    - **Motor:**
      - **Ulnar –** Hypothenar Muscles, Lumbricals 3 & 4, Interossei. (Over Carpal Tunnel)
      - **Median** – Thenar Muscles, Lumbricals 1 & 2. (Through Carpal Tunnel)

      - **NB: 'Communicating Nerve' –** Connects Median & Ulnar Nerve Networks in Palm.

  - **Extensor Expansion:**
    - Is the flattened tendons of the Long Extrinsic Extensors
    - Enables Lumbricals & Interossei to Flex the Digits @ MCP Joints, & Extend IP Joints Simultaneously.
    - **2 Bands:**
      - **Median –** to middle phalanx
      - **2x Lateral** – to distal phalanx



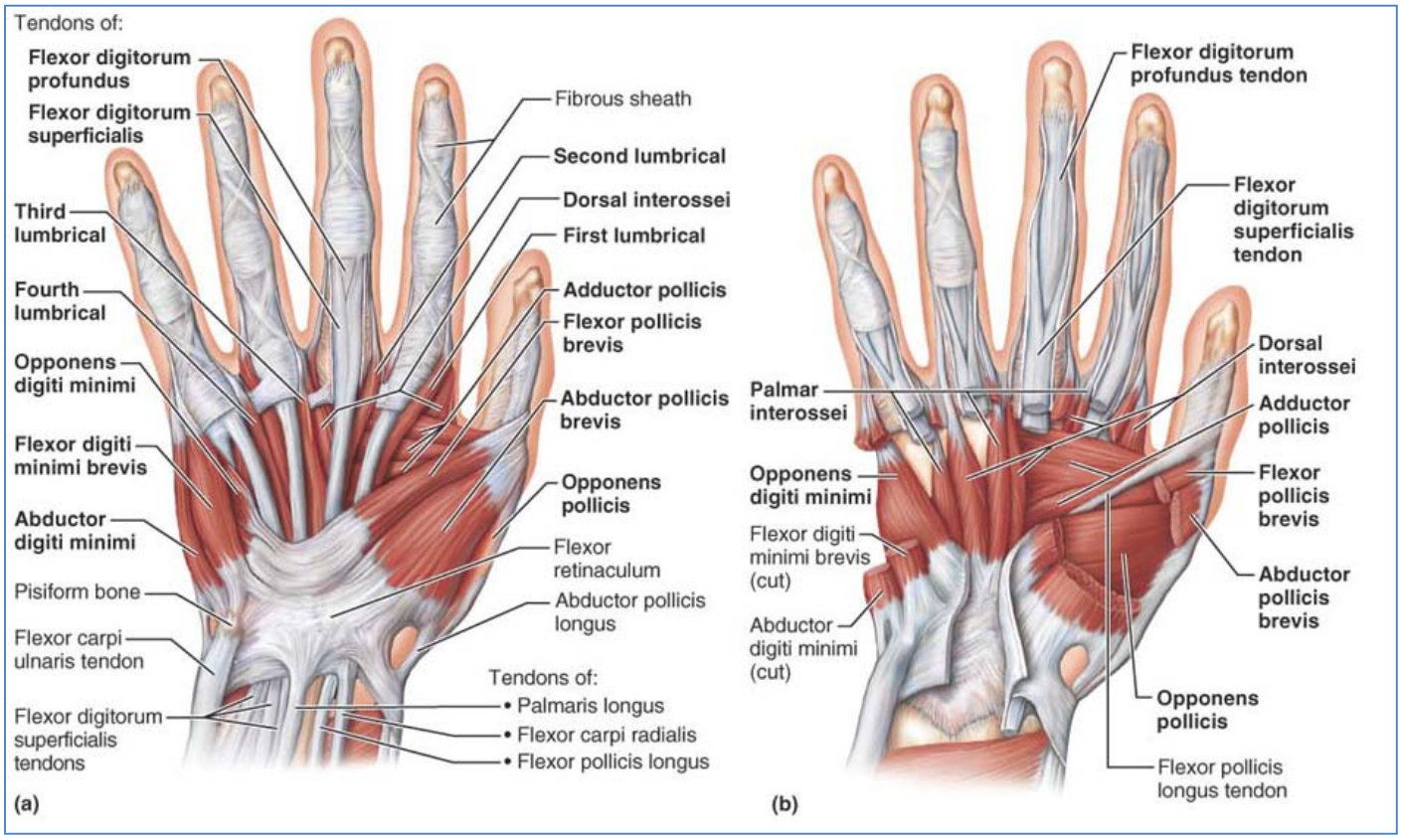
- **Intrinsic Muscles of the Hand:**
  - Precision movements
  - Short muscles & tendons
  - Small Motor Units.
  - **Thenar/Hypothenar/Midpalmar (lumbricals/Interossei)**

  - **Thenar Muscles:**
    - "Ball" of the Thumb.
    - **Median Nerve** (Except *Adductor Pollicis = Ulnar Nerve)
    - *Adductor Pollicis isn't part of the 'Thenar' group, but is included as it acts on the thumb.

Muscle	Origins/Insertions	Action
Abductor Pollicis Brevis	O – Flexor Retinaculum (& some carpals) I – Lateral base of Thumb's Proximal Phalanx	Abducts thumb (at carpometacarpal joint)
Flexor Pollicis Brevis	O – Flexor Retinaculum & Trapezium I – Lateral Base of Thumb's Proximal Phalynx	Flexes thumb (at carpometacarpal & metacarpophalangeal joints)
Opponens Pollicis	O – Flexor Retinaculum & Trapezium I – Whole anterior side of Metacarpal 1	Opposition of thumb → pinky
***Adductor Pollicis**	O – Capitate bone & bases of Metacarpals 2-4 I – Medial Base of Thumb's Proximal Phalanx	Adduction of Thumb Opposition of Thumb

  - **Hypothenar Muscles:**
    - "Ball" of the Little Finger
    - **Ulnar Nerve**

Muscle	Origins/Insertions	Action
Abductor Digiti Minimi	O – Pisiform Bone I – Medial side of Proximal Phalanx #5	Abducts the Little Finger
Flexor Digiti Minimi Brevis	O – Hamate Bone & Flexor Retinaculum I – Medial side of Proximal Phalanx #5	Extension of Little Finger
Opponens Digiti Minimi	O – Hamate Bone & Flexor Retinaculum I – Medial side of Metacarpal #5	Opposition of Little Finger



- **Lumbricals:**
  - 4 worm-shaped muscles
  - In the Palm
  - One to each finger (except thumb)
  - **Median Nerve** (Lateral 2) & **Ulnar Nerve** (Medial 2)

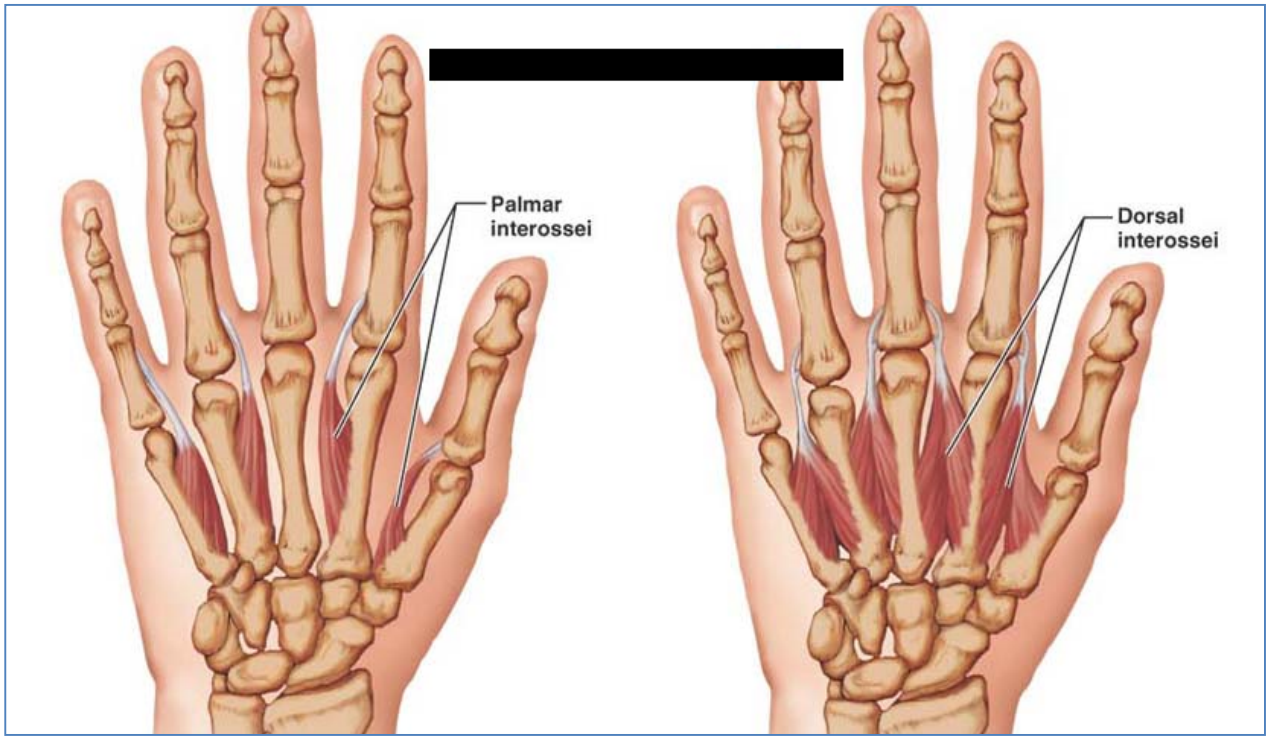
Muscle	Origins/Insertions	Action
Lumbrical 1 – Index Finger	O – Lateral side of each of the 4 Tendons of Flexor Digitorum Profundus in the palm. I – Lateral edge of extensor on 1st phalanx of fingers 2-5.	Flexion of Matacarpophalangeal Joints. Extension at Interphalangeal Joints.
Lumbrical 2 – Middle Finger		
Lumbrical 3 – Ring Finger		
Lumbrical 4 – Little Finger		

- **Interossei:**
  - **Palmar Interossei: (PAD – Palmar Adduct Fingers)**
    - 4 long, cone-shaped muscles
    - In spaces between metacarpals
    - Absent on metacarpal #3
    - **Ulnar Nerve**

Muscle	Origins/Insertions	Action
Thumb	O – The "Middle-Finger-Side" of each metacarpal (except #3) I – The "Middle-Finger-Side" of the Extensor Expansion on the 1st Phalanx of each finger (except #3)	Adductors (convergers) of Fingers Extension at Interphalangeal Joints. Flexion of Matacarpophalangeal Joints.
Index Finger		
Ring Finger		
Little Finger		

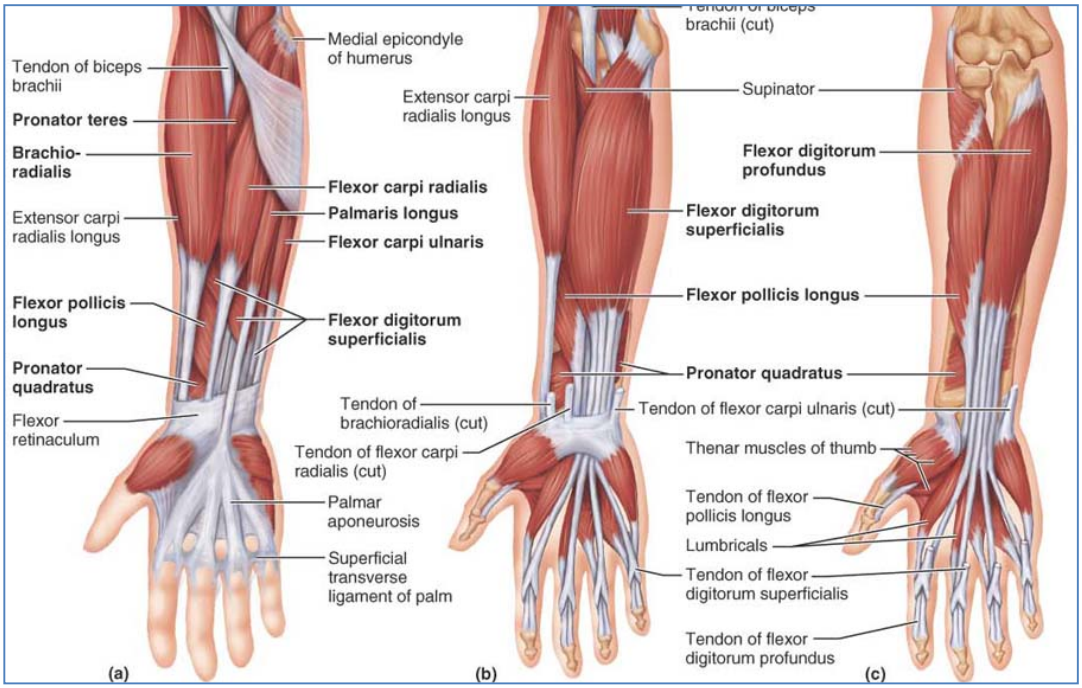
  - **Dorsal Interossei: (DAB – Dorsal Abduct Fingers)**
    - 4 Bipennate Muscles
    - Deepest Palm Muscles
    - Between the Metacarpals
    - Visible from Dorsal side of Hand.
    - **Ulnar Nerve**

Muscle	Origins/Insertions	Action
1 – Index Finger	O – Sides of Adjacent Metacarpals (2 MC's/Muscle) I – Extensor Expansion of 1st Phalanx of Fingers #2-#4. (On sides opposite to midaxis of hand) (Both sides of Finger #3 – Middle Finger)	Abducts (diverges) Fingers Extends Fingers @ Interphalangeal Joint Flexes Fingers @ MetacarpoPhalangeal Joint.
2 – Middle Finger		
3 – Middle Finger		
4 – Ring Finger		

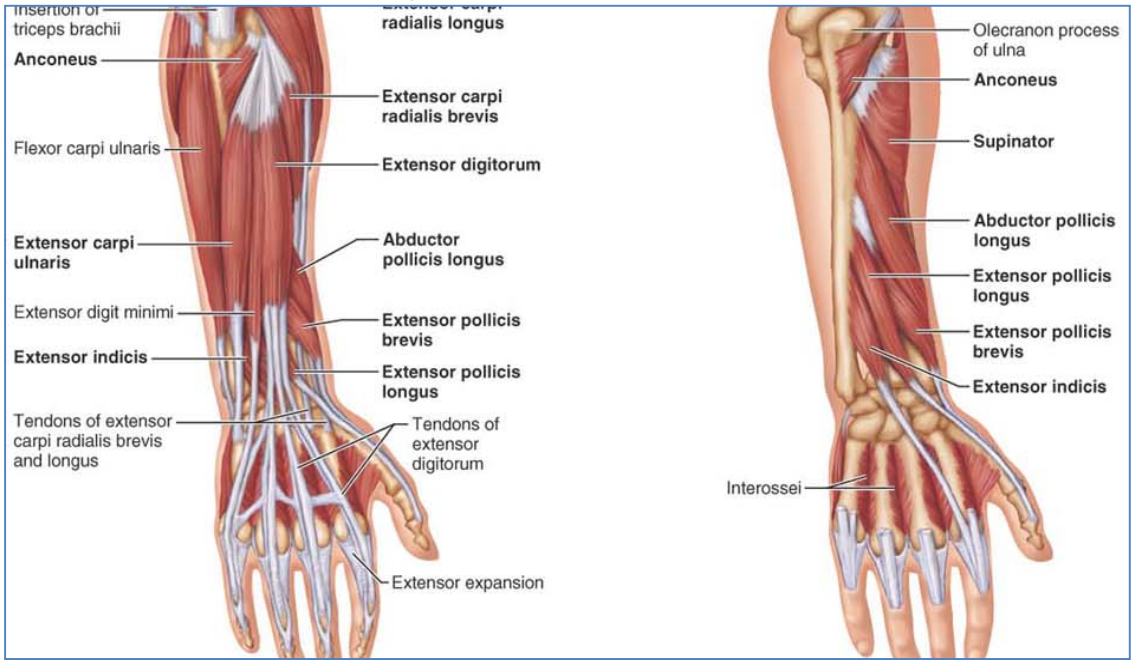


- **Extrinsic Muscles of the Hand:**
  - Power Movements
  - Insert via Long Tendons from the Forearm
    - Anterior Tendons pass through Carpal Tunnel
  - Large Motor Units
  - **Anterior Flexors/Posterior Extensors**

  - **Anterior Flexors:**
    - Flexor Digitorum Superficialis
    - Flexor Digitorum Profundus
    - Flexor Pollicis Longus



  - **Posterior Extensors:**
    - Extensor Digitorum
    - Extensor Digiti Minimi
    - Extensor Indices
    - Extensor Pollicis Longus
    - Extensor Pollicis Brevis
    - Abductor Pollicis Longus



MUSCLE GALLERY TABLE 10.12 **Summary of Actions of Muscles Acting on the Arm, Forearm, and Hand (Figure 10.17)**

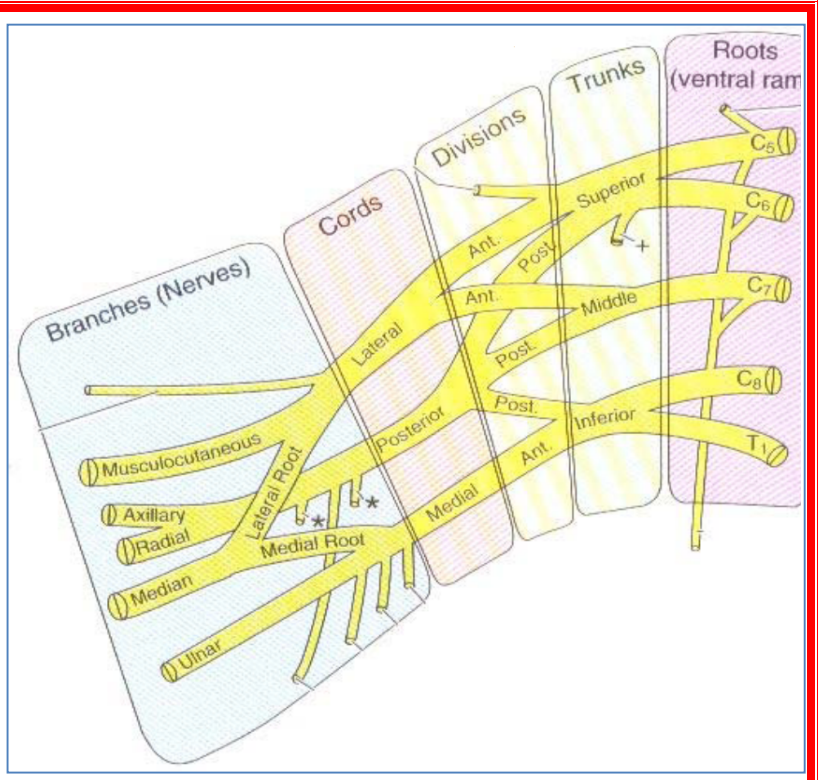
Part I: Muscles Acting on the Arm (Humerus) (PM = prime mover)	ACTIONS AT THE SHOULDER					
	Flexion	Extension	Abduction	Adduction	Medial Rotation	Lateral Rotation
Pectoralis	× (PM)			× (PM)	×	
Latissimus dorsi		× (PM)		× (PM)	×	
Deltoid	× (PM) (anterior fibers)	× (PM) (posterior fibers)	× (PM)		× (anterior fibers)	× (posterior fibers)
Subscapularis					× (PM)	
Supraspinatus			×			
Infraspinatus				×		× (PM)
Teres minor				× (weak)		× (PM)
Teres major		×		×	×	
Coracobrachialis	×			×		
Biceps brachii	×					
Triceps brachii				×		

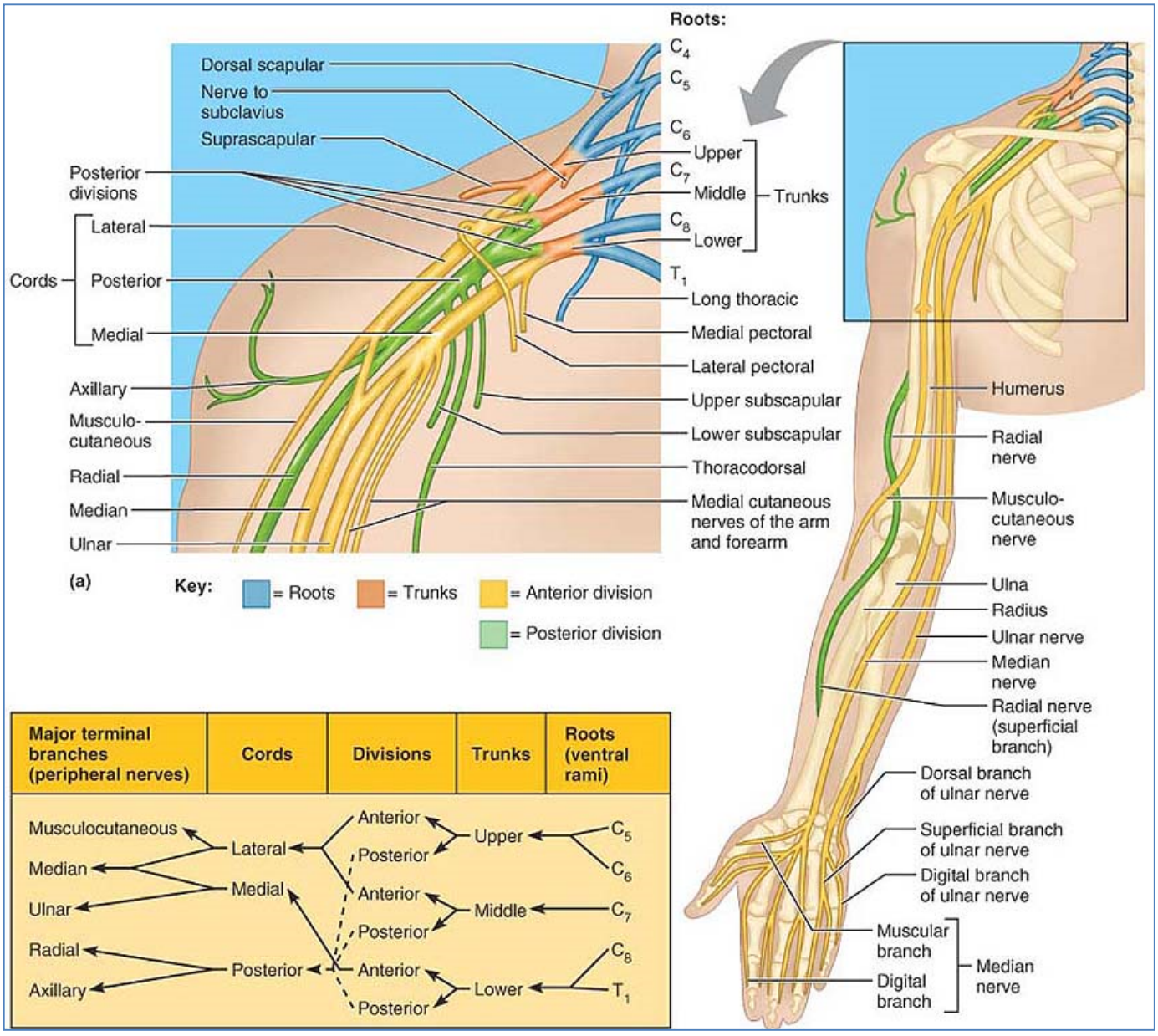
Part II: Muscles Acting on the Forearm	ACTIONS			
	Elbow Flexion	Elbow Extension	Pronation	Supination
Biceps brachii	× (PM)			×
Triceps brachii		× (PM)		
Anconeus		×		
Brachialis	× (PM)			
Brachioradialis	×			
Pronator teres	× (weak)		×	
Pronator quadratus			× (PM)	
Supinator				×

Part III: Muscles Acting on the Wrist and Fingers	ACTIONS ON THE WRIST				ACTIONS ON THE FINGERS	
	Flexion	Extension	Abduction	Adduction	Flexion	Extension
Anterior Compartment						
Flexor carpi radialis	× (PM)		×			
Palmaris longus	× (weak)					
Flexor carpi ulnaris	× (PM)			×		
Flexor digitorum superficialis	× (PM)				×	
Flexor pollicis longus					× (thumb)	
Flexor digitorum profundus	×				×	
Posterior Compartment						
Extensor carpi radialis longus and brevis		×	×			
Extensor digitorum		× (PM)				× (and abducts)
Extensor carpi ulnaris		×		×		
Abductor pollicis longus			×		(abducts thumb)	
Extensor pollicis longus and brevis						× (thumb)
Extensor indicis		×				× (index finger)

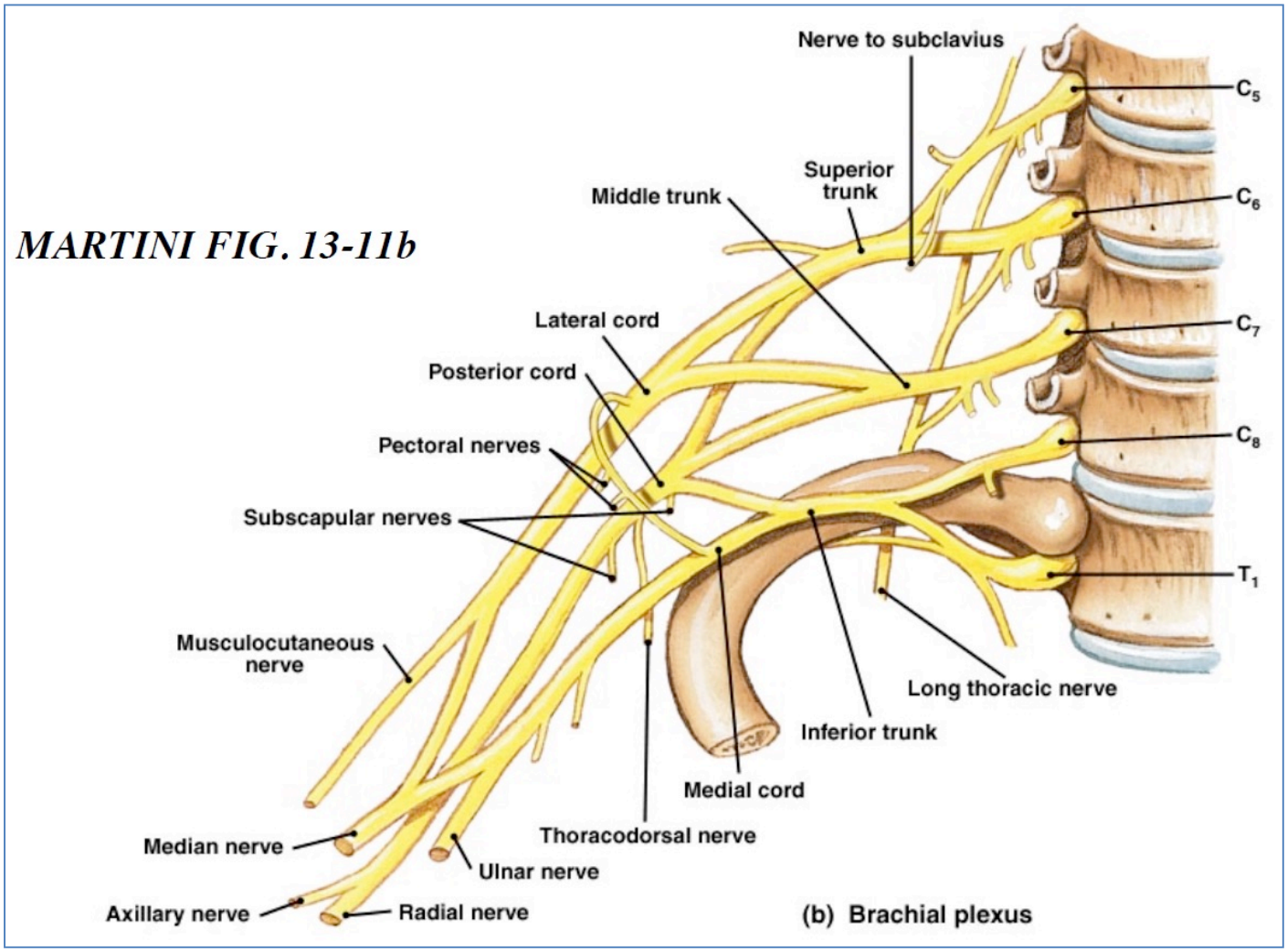
Innervation (Peripheral):

- **Axilla (Brachial Plexus)**
  - **Roots (Ventral Rami)**
    - C5, C6, C7, C8, T1
  - **Trunks**
    - Superior Trunk
    - Middle Trunk
    - Inferior Trunk
  - **Divisions**
    - Anterior
    - Posterior
  - **Cords**
    - Lateral Cord
    - Posterior Cord
    - Medial Cord
  - **Terminal Branches (Nerves)**
    - (Ant) Musculocutaneous
    - (Ant) Median
    - (Ant) Ulnar
    - (Post) Radial
    - (Post) Axillary

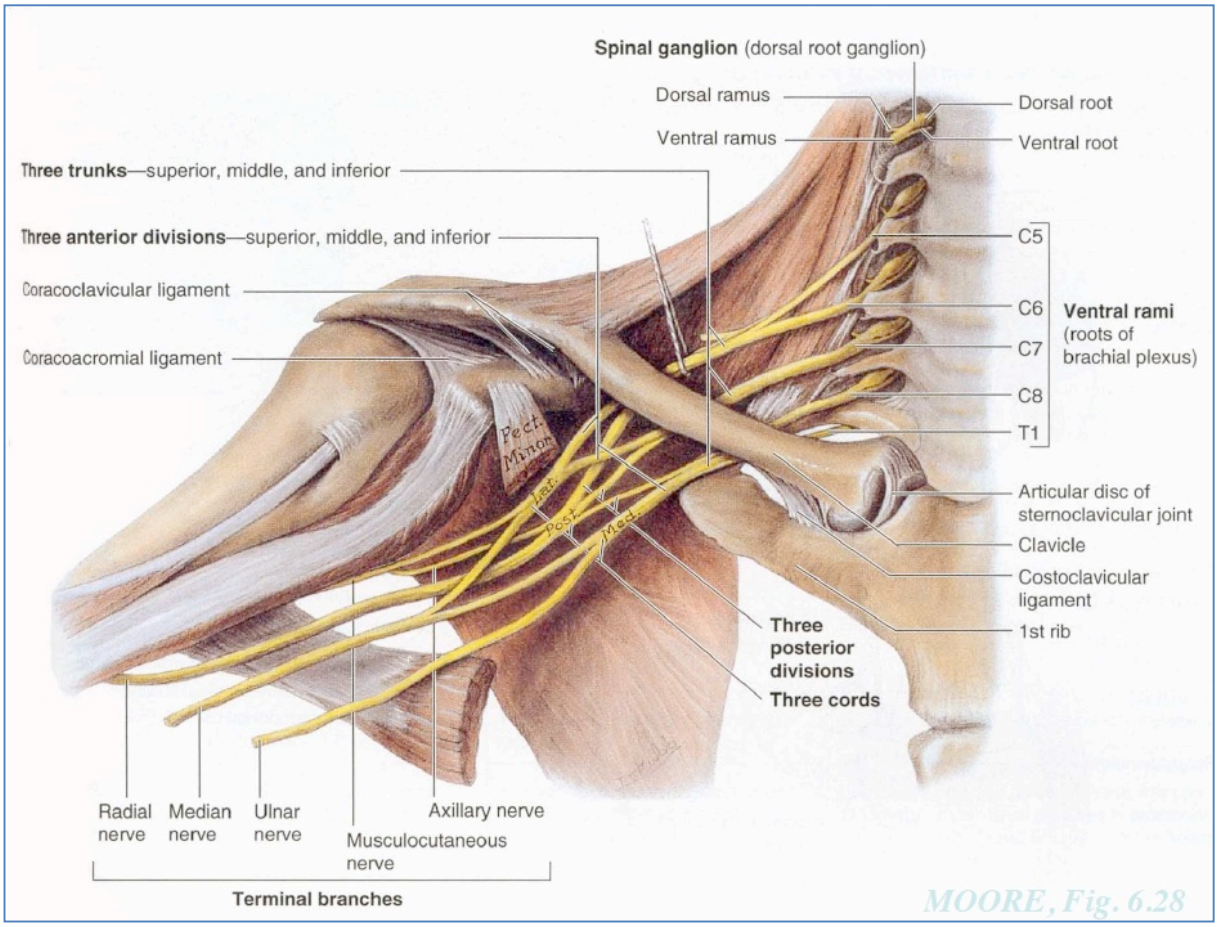




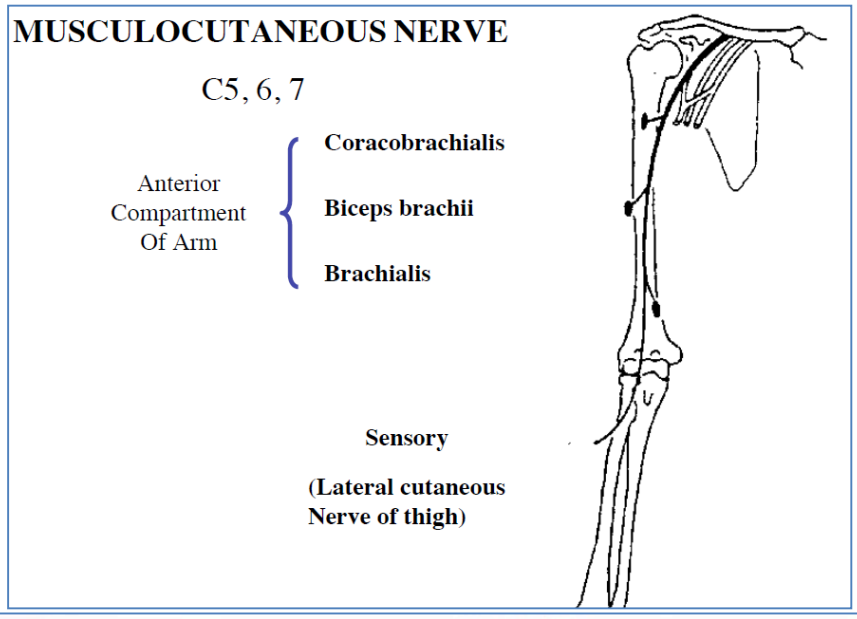
Major terminal branches (peripheral nerves)	Cords	Divisions	Trunks	Roots (ventral rami)
Musculocutaneous	Lateral	Anterior	Upper	C_5
Median	Lateral	Posterior	Upper	C_6
Ulnar	Medial	Anterior	Middle	C_7
Radial	Posterior	Posterior	Middle	C_7
Axillary	Posterior	Anterior	Lower	C_8
	Medial	Posterior	Lower	T_1

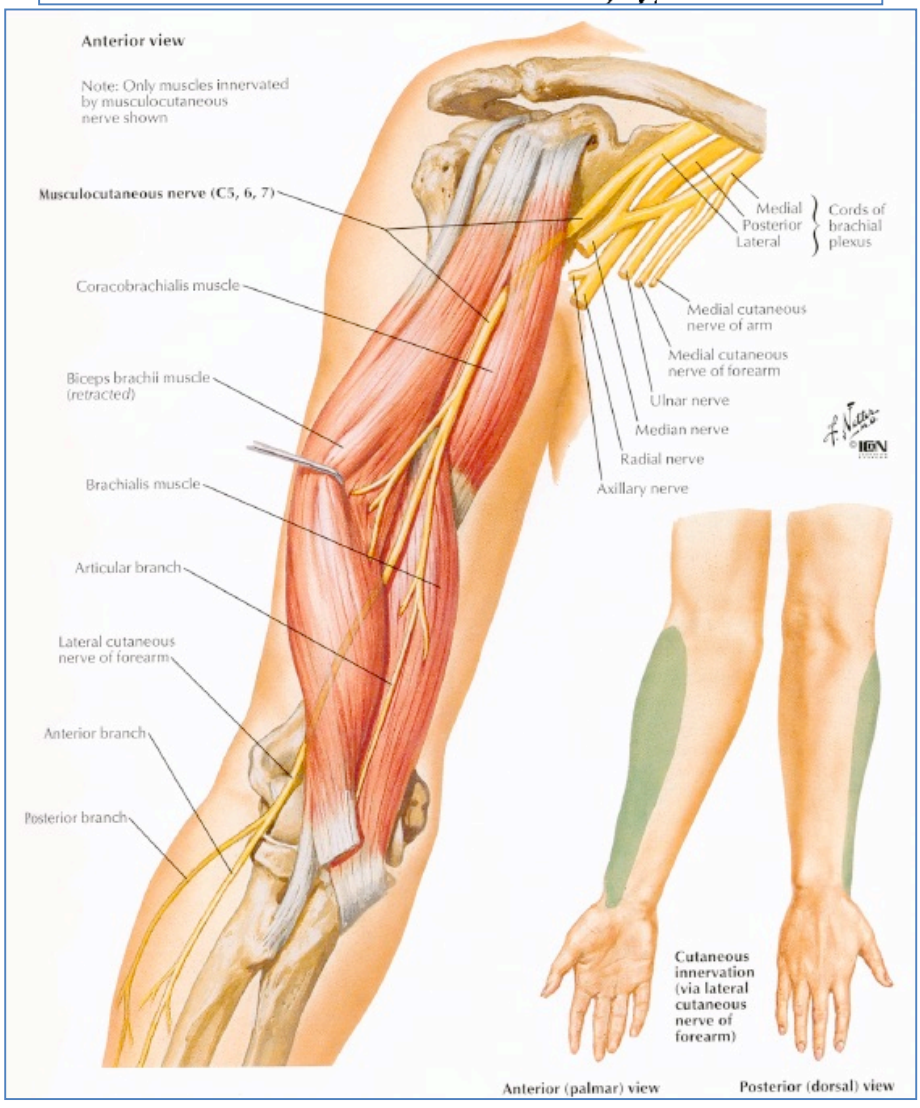


Placement In A Cadaver:

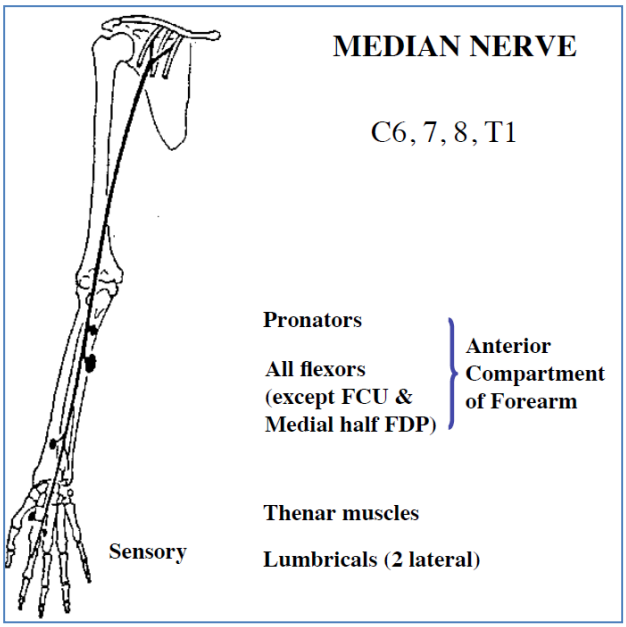


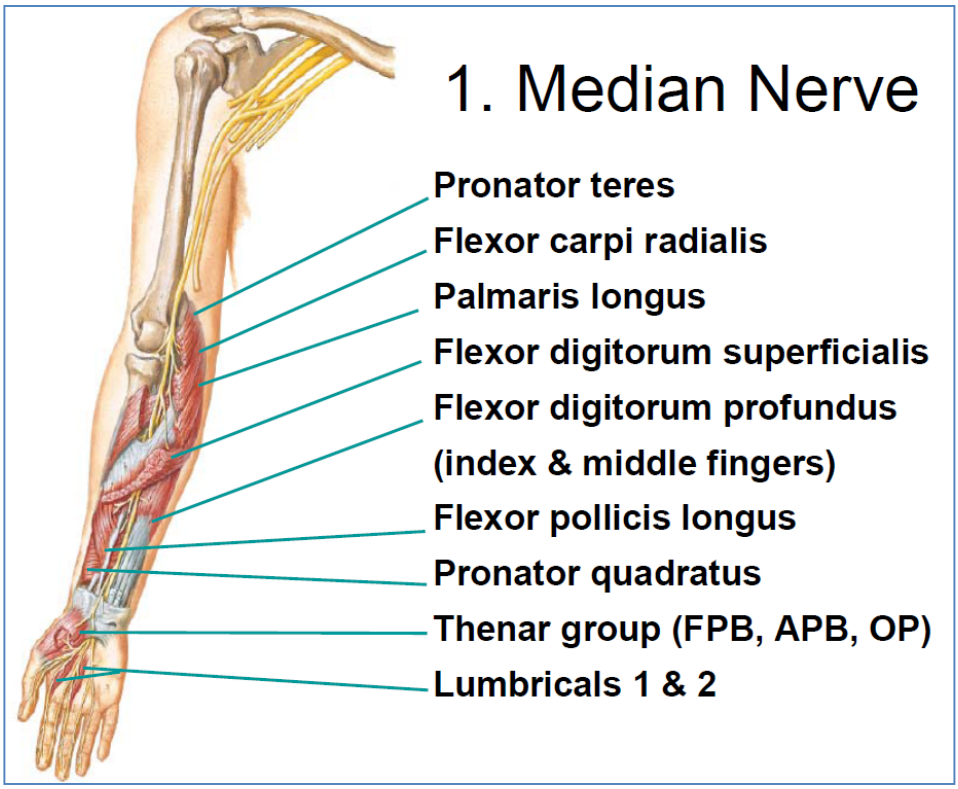
- **(Ant) Musculocutaneous**
  - Branches off Lateral Cord
  - Runs down Anterior Arm
  - Innnervates:
    - Flexors of Arm:
      - Biceps Brachii
      - Brachialis
      - Coracobrachialis
    - Skin of Anterio-Lateral Forearm



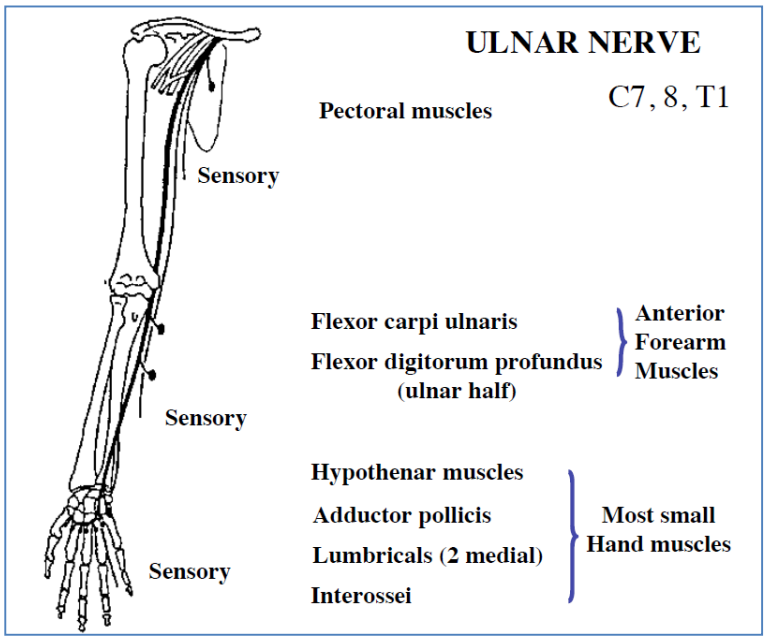


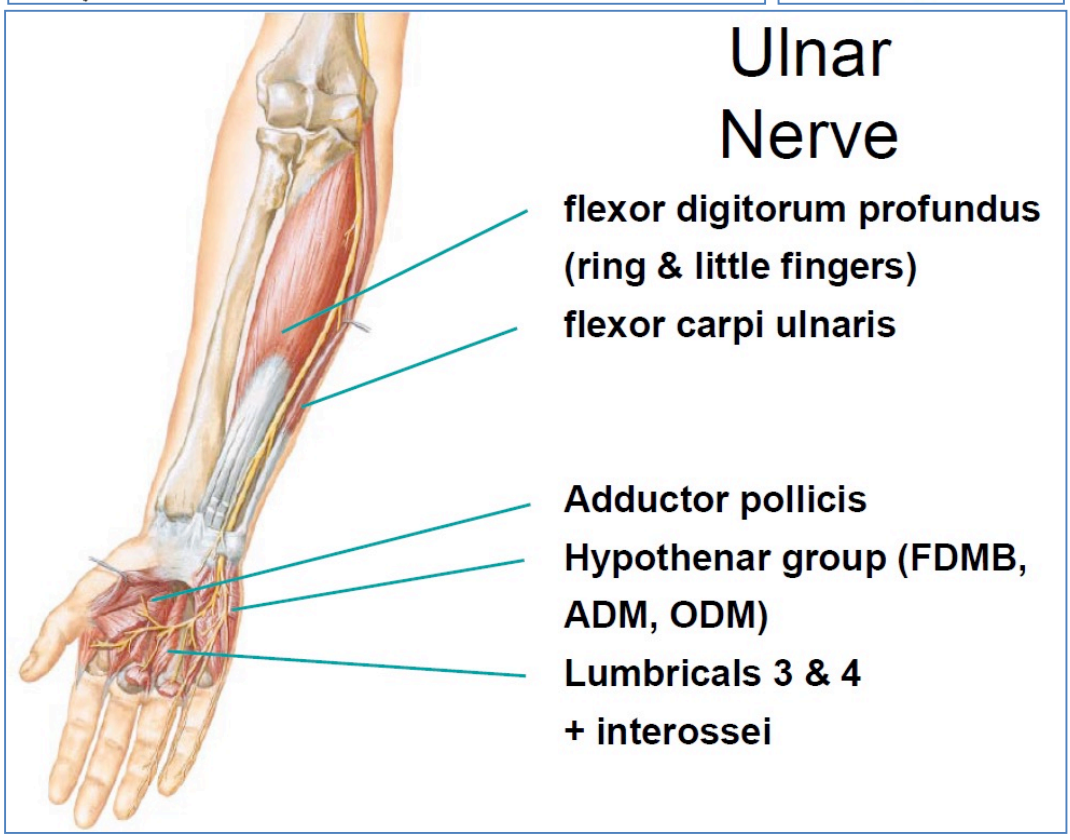
- **(Ant) Median**
  - Branches off Medial & Lateral Cords
  - Runs down Anterior Arm & Forearm
  - Innervates:
    - Flexors of Anterior Forearm:
      - Palmaris Longus
      - Flexor Carpi Radialis
      - Flexor Digitorum Superficialis
      - Lateral ½ of Flexor Digitorum Profundus
      - Flexor Pollicis Longus
      - Pronator Teres
      - Pronator Quadratus
      - Thenar Muscles (Intrinsic muscles of Lateral Palm)
      - Lumbricals #1 & #2
      - Digital Branches to Fingers
    - Skin of Lateral 2/3 of Hand, Palm Side & Dorsum of Fingers 2 & 3



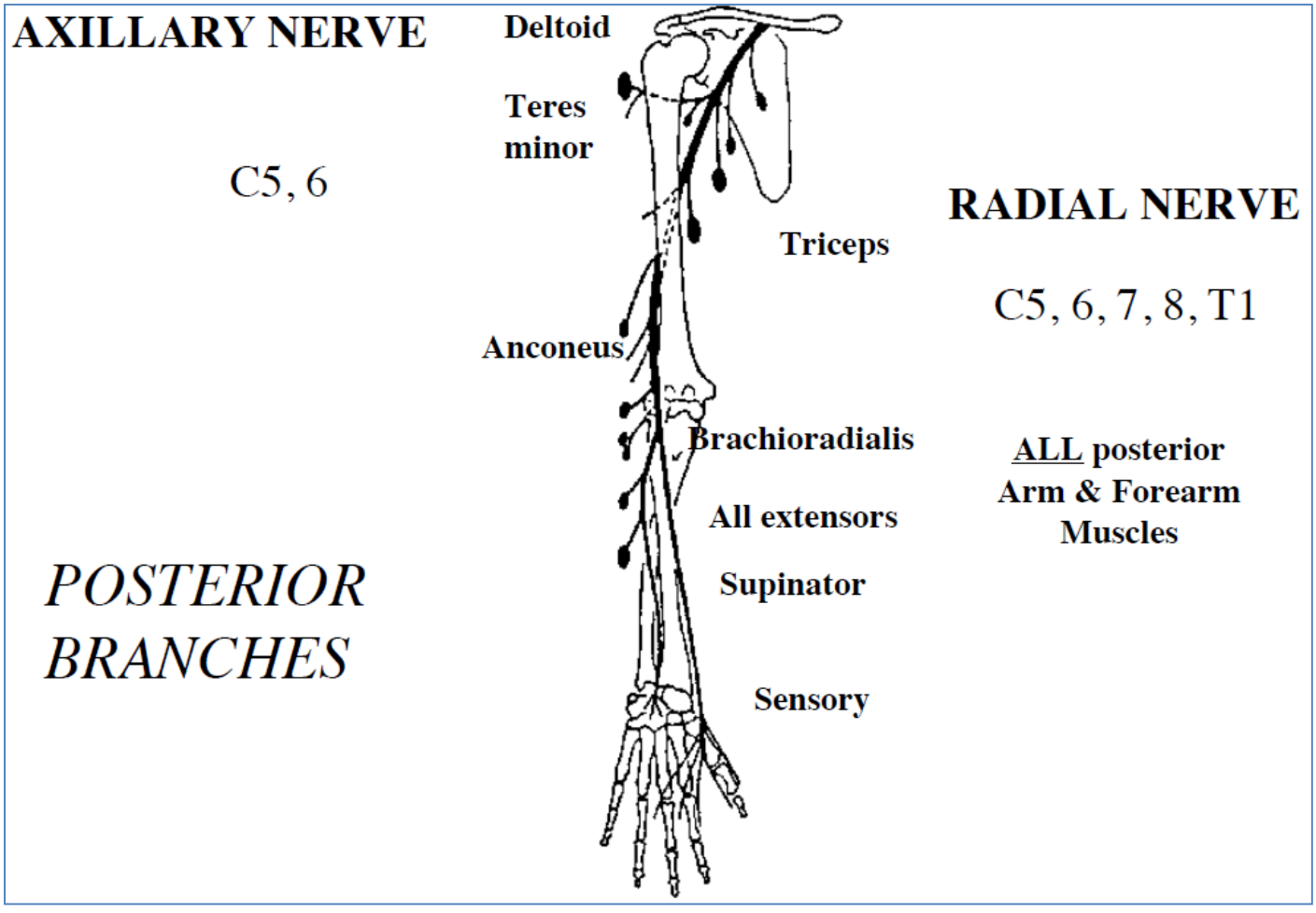


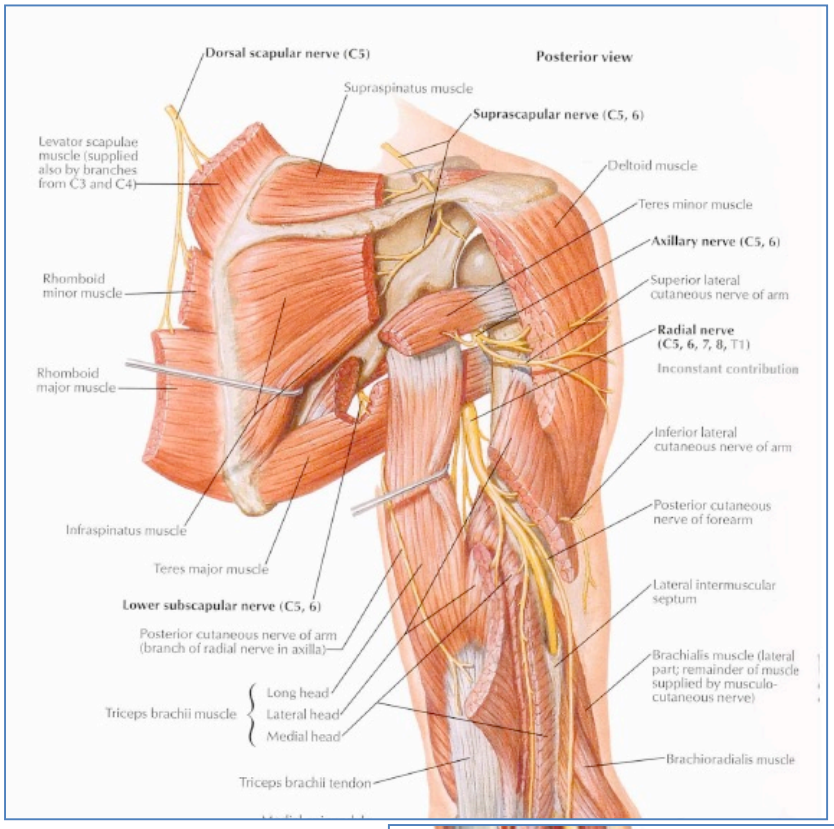
- **(Ant) Ulnar**
  - Branches off Medial Cord
  - Runs down Medial Arm→Behind Medial Epicondyle→Follows Ulna down Medial Forearm→Hand
  - Innervates:
    - Flexors of Anterior Forearm:
      - Flexor Carpi Ulnaris
      - Medial part of Flexor Digitorum Profundus
      - Majority of Intrinsic Muscles of Hand
        - Adductor Pollicis
        - Flexor Digiti Minimi Brevis
        - Abductor Digiti Minimi
        - Opponens Digiti Minimi
        - Lumricals #3 & #4
        - Interossei
    - Skin of Medial 1/3 of Hand (Ant & Post).

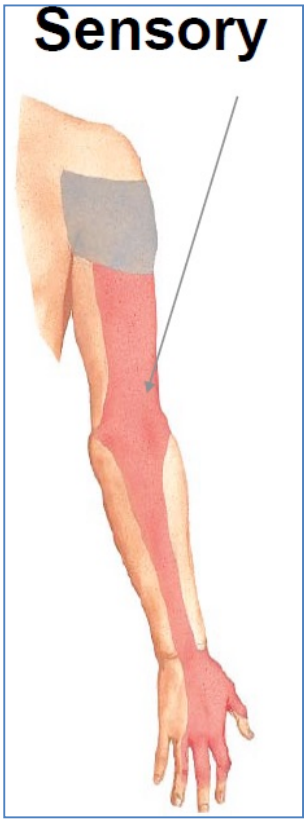


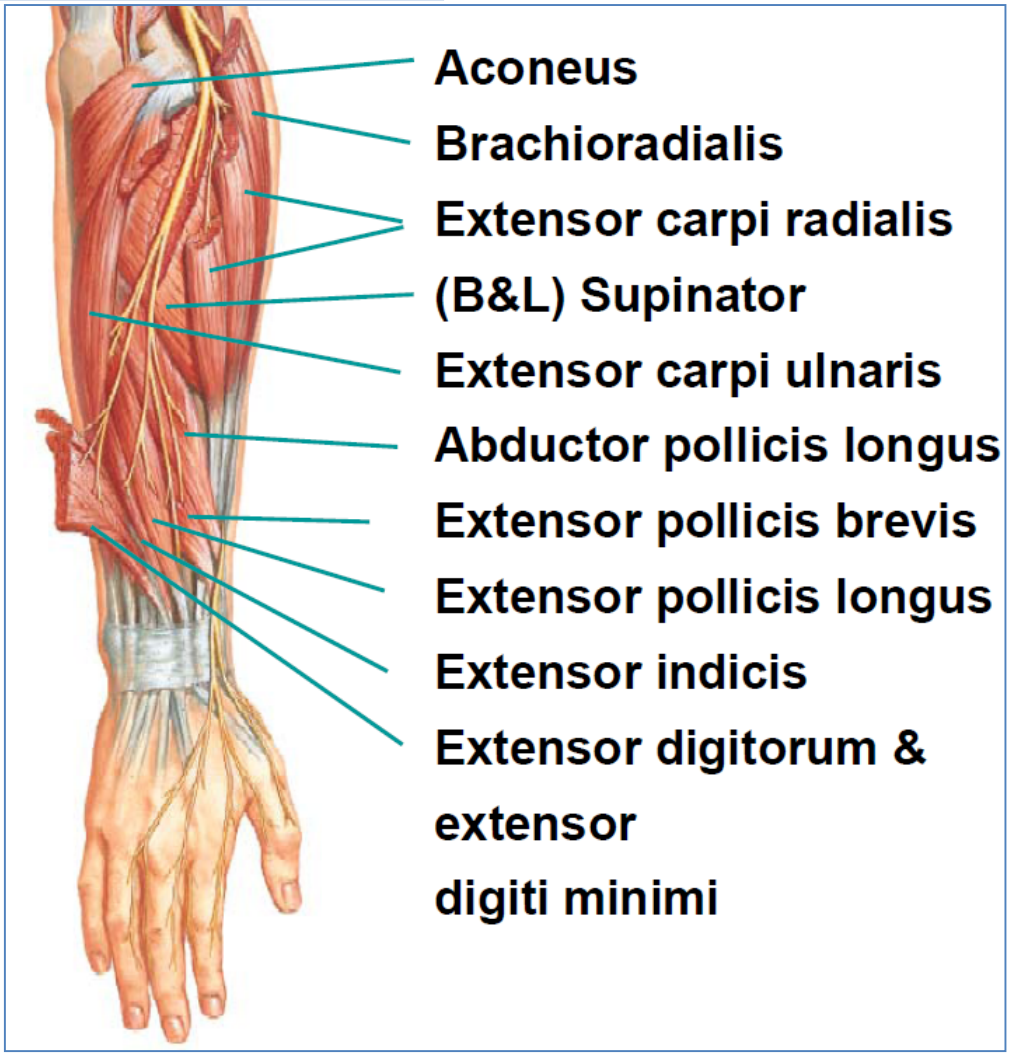


- **(Post) Axillary**
  - Branches off Posterior Cord
  - Runs Posterior to Neck of Humerus
  - Innervates:
    - Deltoid
    - Teres Minor
    - Skin & Joint Capsule of Shoulder
- **(Post) Radial**
  - Branches of Posterior Cord
  - Runs around Posterior Humerus (Radial-groove)→Anteriorly around Lateral Epicondyle→2 Branches:
    - Superficial: Follows Lateral edge of Radius → Hand
    - Deep: Runs Posteriorly to Radius
  - ALL Posterior Upper-Arm & Forearm Muscles.
    - Extensor Muscles of Arm, Forearm & Hand:
      - Triceps Brachii
      - Anconeus
      - Supinator
      - Brachioradialis
      - Extensor Carpi Radialis Brevis
      - Extensor Carpi Radialis Longus
      - Extensor Carpi Ulnaris
      - Abductor Pollicis Longus
      - Extensor Pollicis Brevis
      - Extensor Pollicis Longus
      - Extensor indicis
      - Extensor Digitorum
      - Extensor Digiti Minimi
    - Skin of Entire Latero-Posterior Arm & Forearm & Hand (except dorsum of fingers 2 & 3)



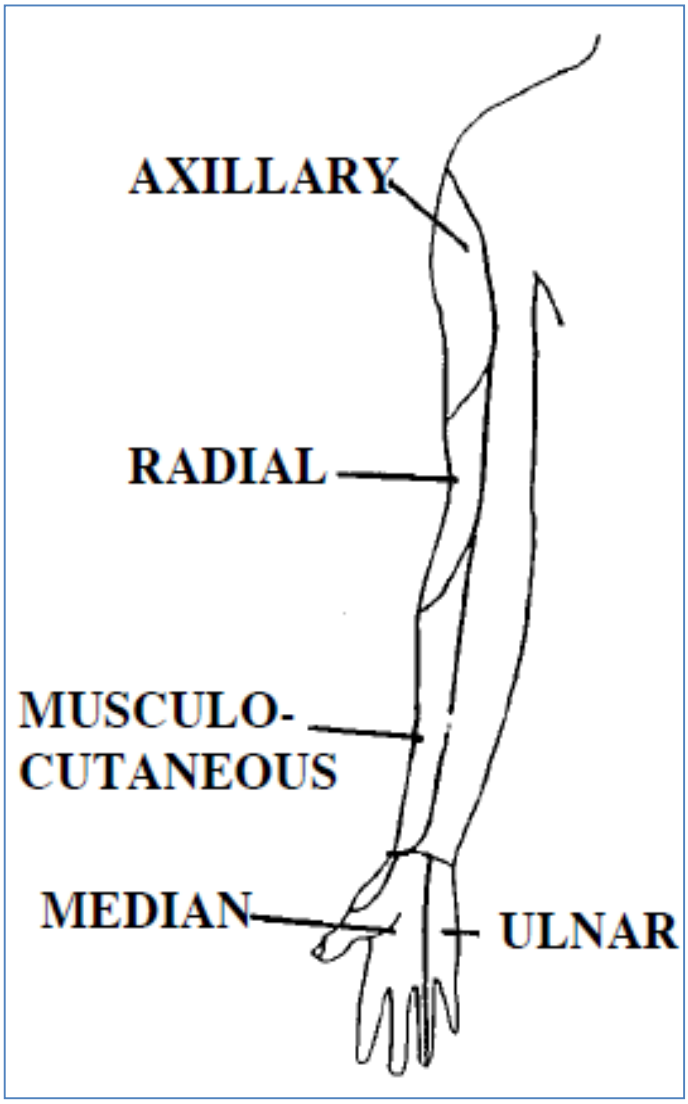

Posterior view
Dorsal scapular nerve (C5)
Supraspinatus muscle
Suprascapular nerve (C5, 6)
Levator scapulae muscle (supplied also by branches from C3 and C4)
Deltoid muscle
Teres minor muscle
Axillary nerve (C5, 6)
Rhomboid minor muscle
Superior lateral cutaneous nerve of arm
Radial nerve (C5, 6, 7, 8, T1)
Inconstant contribution
Rhomboid major muscle
Inferior lateral cutaneous nerve of arm
Posterior cutaneous nerve of forearm
Infraspinatus muscle
Teres major muscle
Lateral intermuscular septum
Lower subscapular nerve (C5, 6)
Posterior cutaneous nerve of arm (branch of radial nerve in axilla)
Brachialis muscle (lateral part; remainder of muscle supplied by musculocutaneous nerve)
Triceps brachii muscle
Long head
Lateral head
Medial head
Brachioradialis muscle
Triceps brachii tendon


Sensory

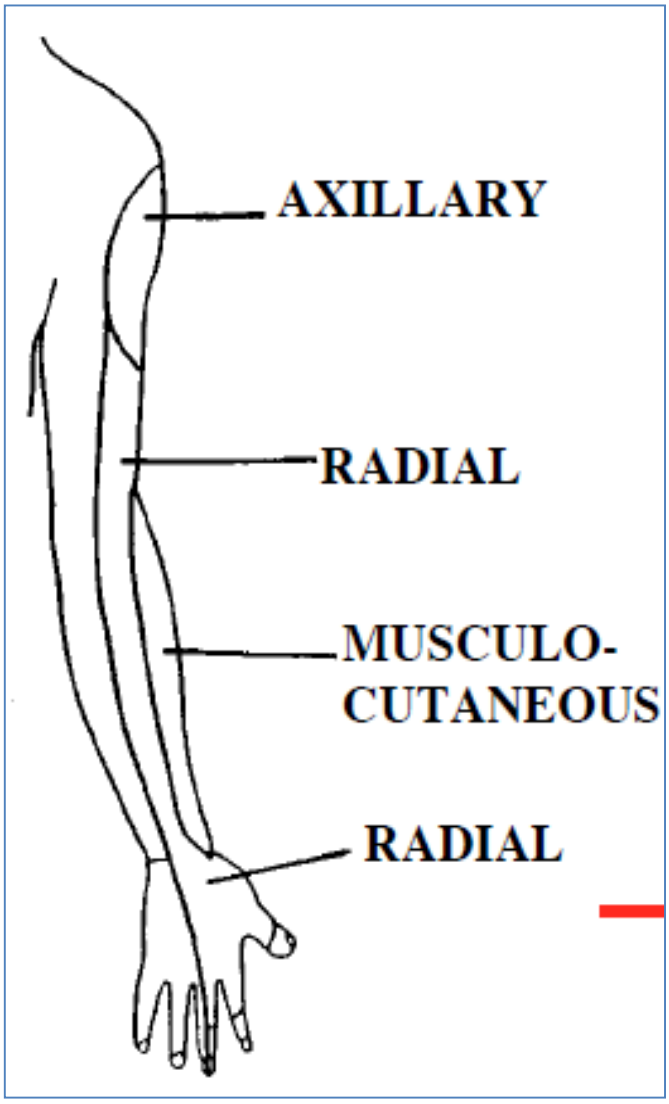

Aconeus
Brachioradialis
Extensor carpi radialis
(B&L) Supinator
Extensor carpi ulnaris
Abductor pollicis longus
Extensor pollicis brevis
Extensor pollicis longus
Extensor indicis
Extensor digitorum &
extensor
digiti minimi

Dermatomes of Upper Limb: (CUTANEOUS INNERVATION – NOT MYOTOMES!!)

Anterior



Posterior



Nerve Lesions:

- **Afferent: Sensory Loss**
  - Sensory impulses don't reach spinal cord
  - Loss of cutaneous sensation
  - Loss of spinal reflexes
  - Weird sensations – tingling, itching, pain, etc.
- **Efferent: Paralysis**
  - If impulse can't reach muscle.
  - Muscle becomes flaccid – no tone.
  - Complete/Incomplete
  - Loss of spinal reflexes

NERVE	SITE OF INJURY	PARALYSIS	MOTOR LOSS	SENSORY LOSS
Axillary	axilla	deltoid	humeral abduction	over lower deltoid
Musculocutaneous	axilla	arm flexors	weak forearm flex. & supination	lateral forearm
Radial	axilla	supinator & extensors	weak supination, loss of extension	lat. dorsum of hand
	cubital fossa	all except triceps	as above except triceps	
Median	elbow	pronators, flexors exc. FCU/med. FDP, thenar, lat 2 lumbricals	loss/impaired flexion of wrist & digits loss of opposition & precision grip	lat. 3 1/2 digits
	wrist	thenar mm. & lat 2 lumbricals	loss opposition & precision grip	Lat. 3 1/2 digits
Ulnar	above elbow	FCU, med. FDP, hypothenar, add. poll., med. 2 lumbricals, interossei	impaired hand function; "claw hand" - loss of power grip	palm & dorsal 1 1/2 digits
	at wrist	as above, except FDP	unimpaired flexion of digits 4, 5 at IP joints	

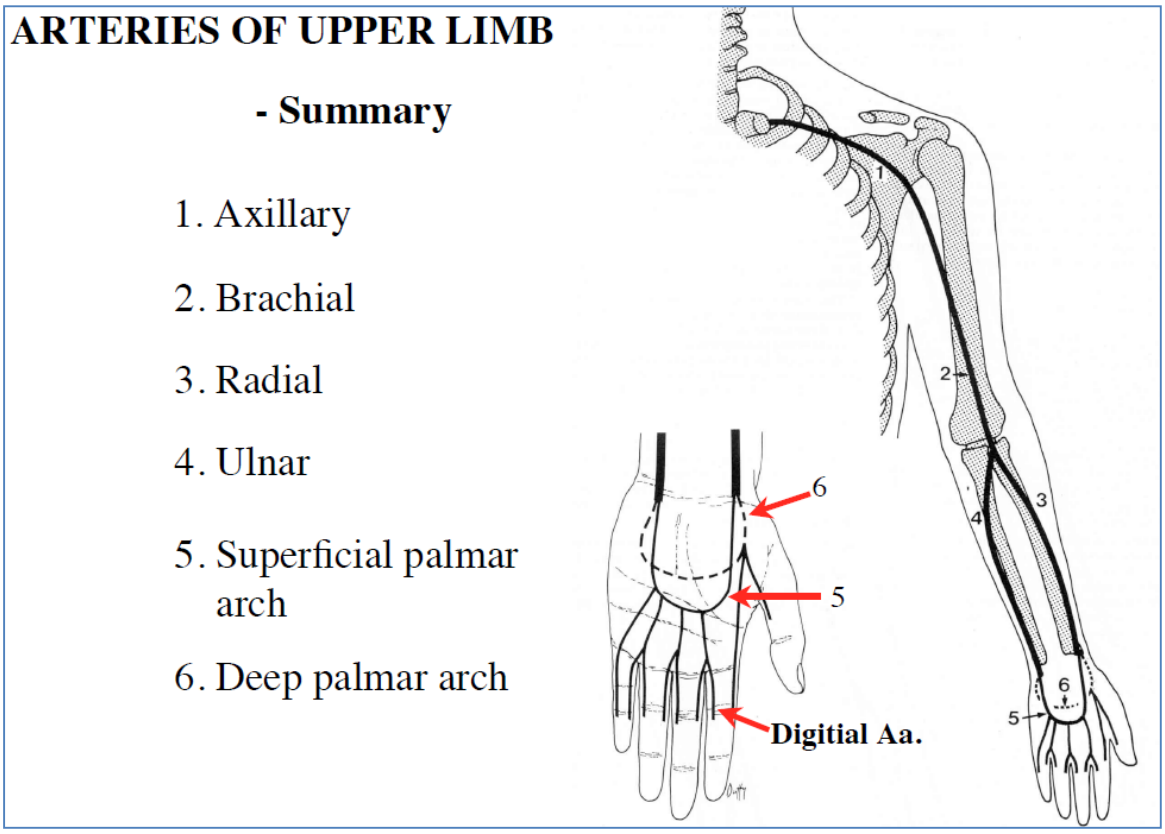
Arterial Blood Supply:

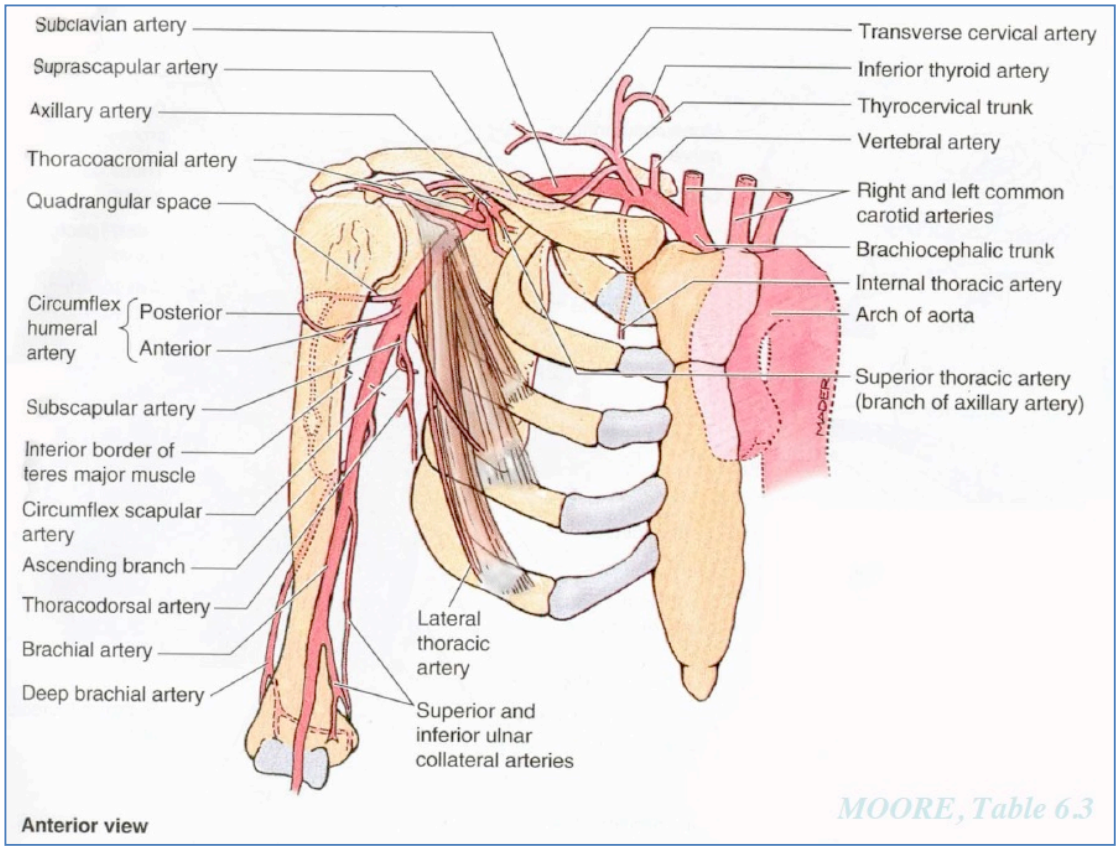
- **NB: Arterial Anastomoses:**
  - Collateral Circulation
  - Back streets (alternate pathways) in case the main artery is blocked
  - In areas subject to compression
  - Around joints

- **Thoracic Origins**
  - BrachioCephalic Trunk →
  - Right / Left SubClavian Arteries →
  - Axillary Artery
- **Axilla**
  - Axillary Artery →
  - Brachial Artery
- **Upper Arm**
  - Brachial Artery →
  - Radial & Ulnar Artery (at cubital fossa)
- **Forearm**
  - Radial Artery & Ulnar Artery →
  - Superficial & Deep Palmar Arches
- **Hand**
  - Superficial Palmar Arch →
  - Digital Arteries

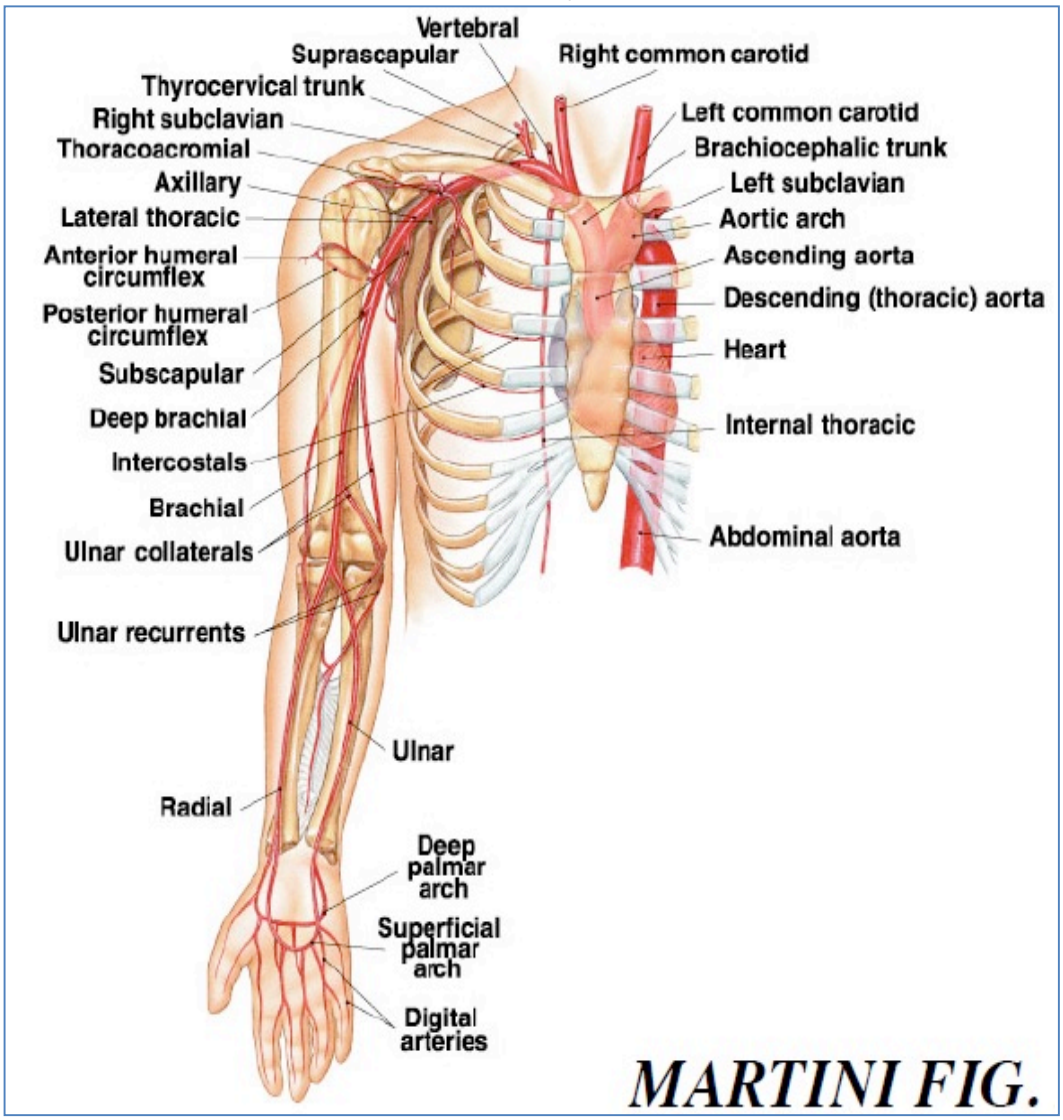
  - Deep Palmar Arches →
  - Metacarpal Arteries

  - **NB:** Digital & Metacarpal Arteries **Anastomose** with each other





NB: Just know major arteries.

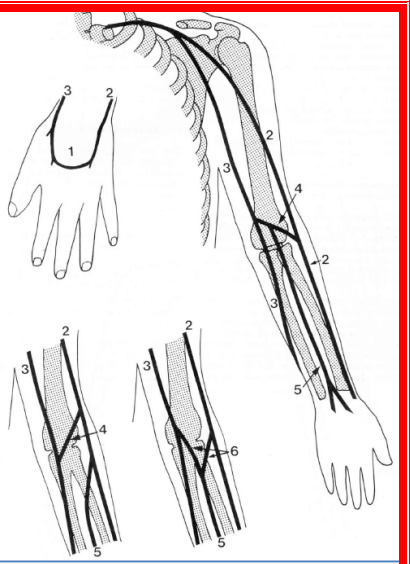


Venous Blood Drainage:

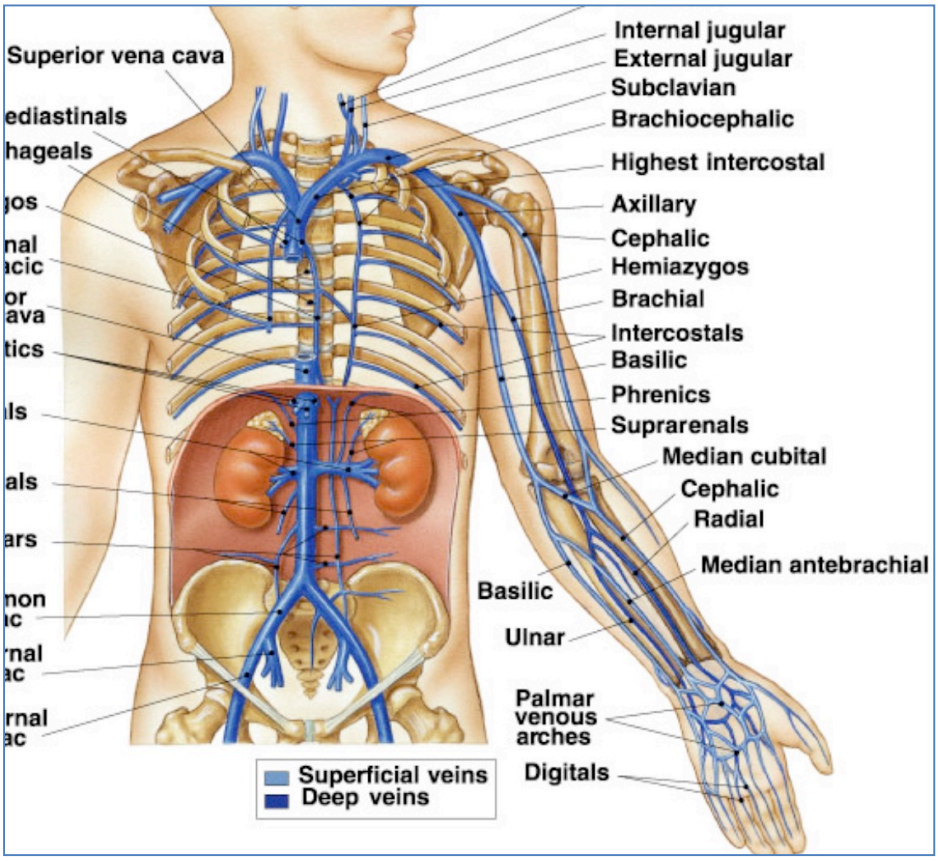
- Deep & Superficial
- Flow: Superficial→Deep→Heart
- Valves – one way flow
- Varies from person-person
- Deep Veins run in pairs clinging to Arteries.

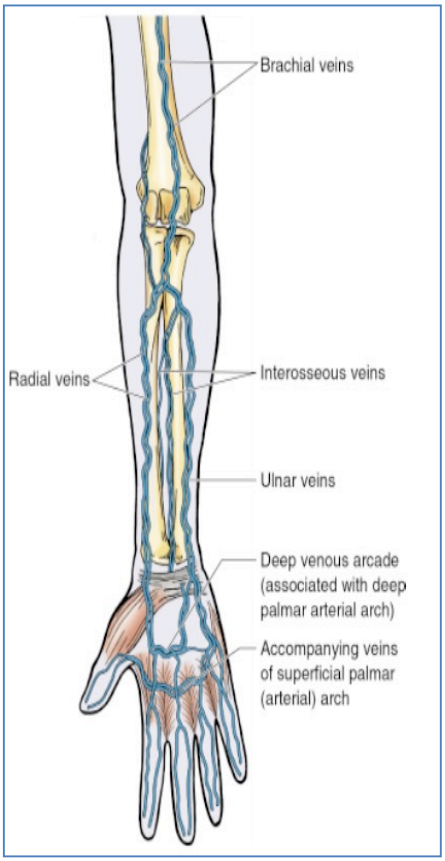
- Summary

1. Dorsal venous arch
2. Cephalic vein
3. Basilic vein
4. Median cubital
5. Median antebrachial
6. Median cephalic & median basilic



- **Hand, Forearm & Upper Arm**
  - **Superficial:**
    - Superficial Dorsal & Palmar Venous Arches →
      - Cephalic Vein → Median Cubital→ Cephalic & Basilic Veins →Axillary Vein
      - Basilic Vein → Median Cubital→ Cephalic & Basilic Veins →Axillary Vein
      - Median AnteBrachial → Median Cubital →Cephalic & Basilic Veins →Axillary Vein
  - **Deep:**
    - Deep Palmar Arches →
      - Radial Veins →Brachial Veins→Axillary Vein
      - Ulnar Veins →Brachial Veins→Axillary Vein
      - Interosseous Veins →Brachial Veins→Axillary Vein
- **Axilla:**
  - Axillary Vein →
  - Subclavian Vein
- **Thoracic:**
  - Subclavian Vein→
  - BrachioCephalic →
  - Superior Vena Cava →
  - Heart

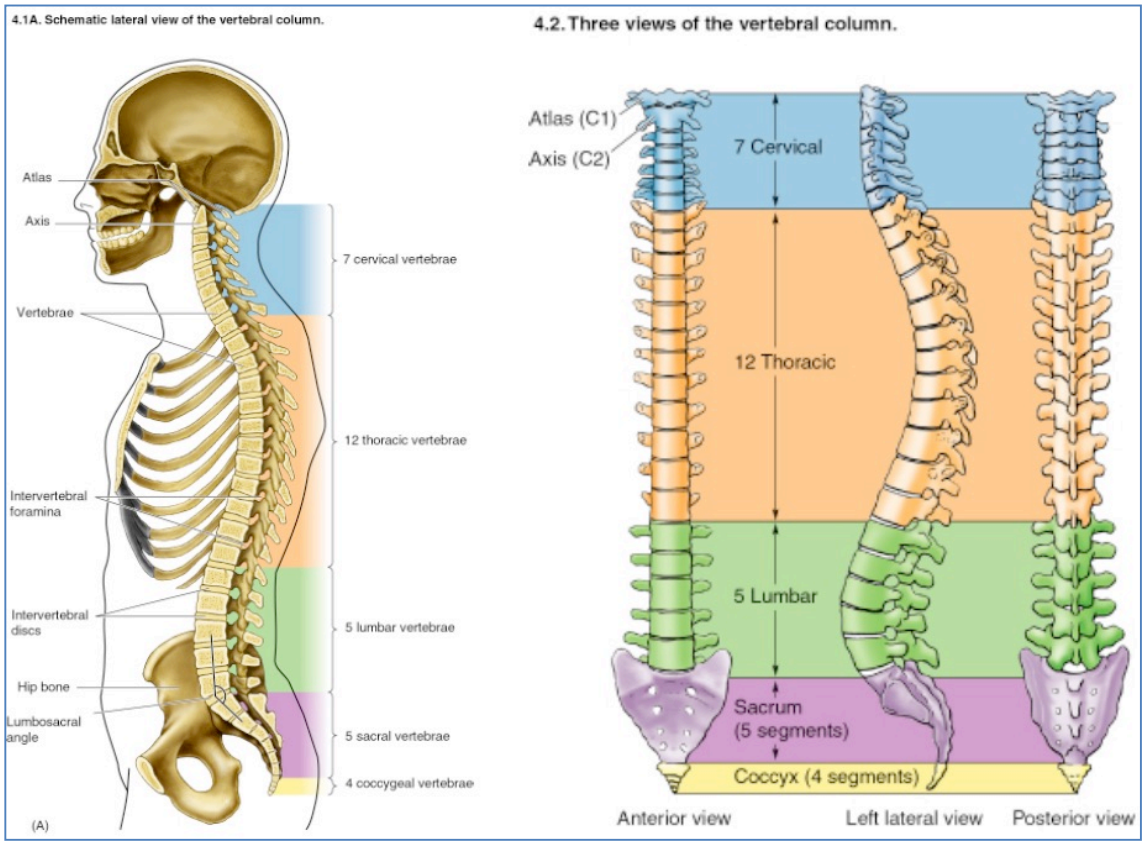




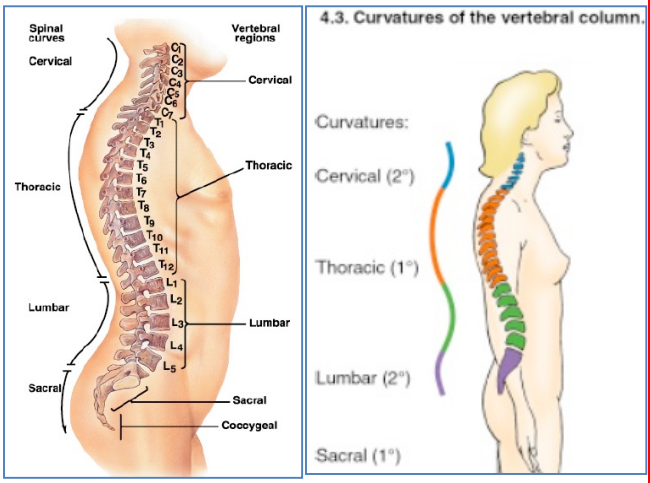
The Back: Bones & Muscles

Bones:

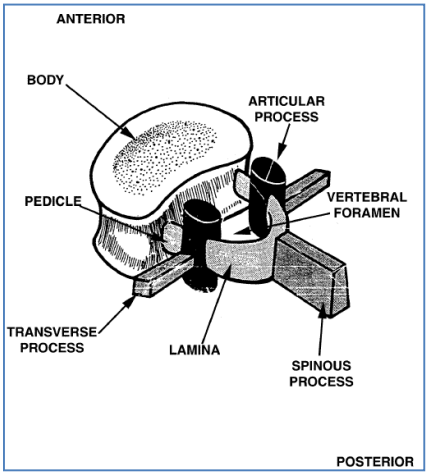
- **Vertebral Column:**
  - **General Info:**
    - 33 Vertebrae
    - 5 Regions:
      - 7x Cervical
      - 12x Thoracic
      - 5x Lumbar
      - 5x Sacral (fused by adulthood)
      - 4x Coccygeal
    - Bones increase in size towards the bottom. (due to increased load/weight)
    - Supports Skull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

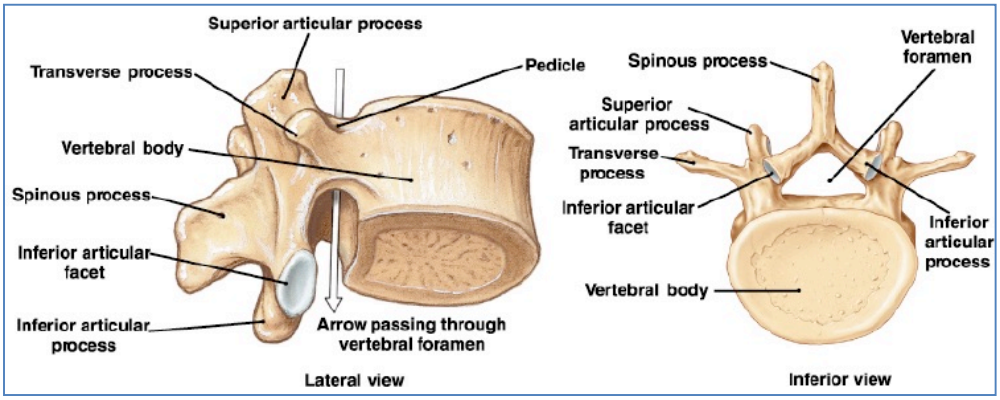


- **Curvatures:**
  - **2x Primary:** (Concave Anteriorly)
    - Ie. Thoracic
    - & Sacral
  - **2x Secondary** (Concave Posteriorly)
    - Ie. Cervical
    - & Lumbar
  - **Abnormalities:**
    - **Kyphosis:** Excess 1^0 curvature
    - **Lordosis:** Excess 2^0 curvature
    - **Scoliosis:** Lateral Deviation

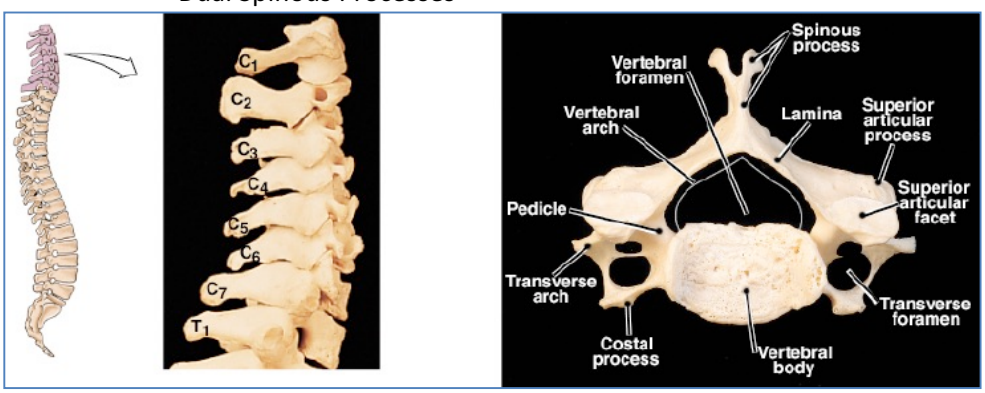


- **Typical Vertebrae:**
  - Body
  - Vertebral Arch
    - Lamina
    - Pedicle
  - Vertebral Foramen (canal)
  - Transverse Processes
  - Spinous Processes
  - Articular Processes
    - Superior
    - Inferior
  - Vertebral Notches
  - Intervertebral Foramen (passage of the spinal nerve root between vertebrae)

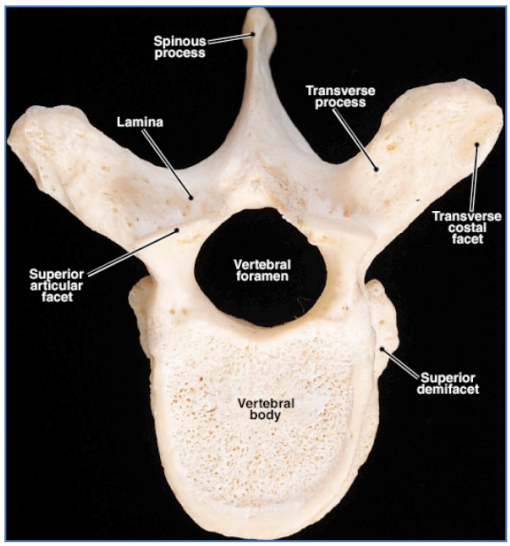


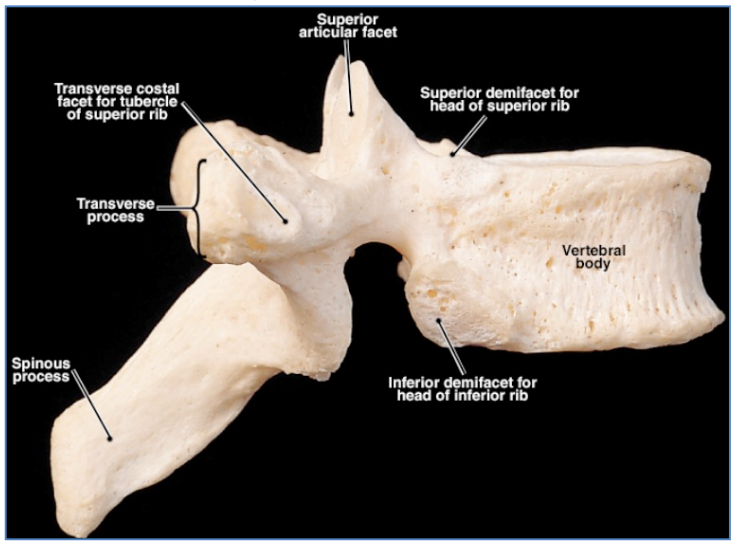


  - **7x Cervical:** Distinguishing Features:
    - Small Body
    - Very Large Vertebral Foramen
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries
    - Dual Spinous Processes

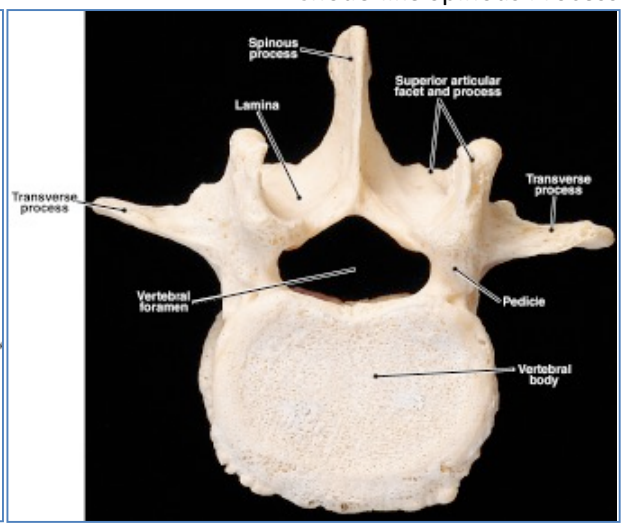


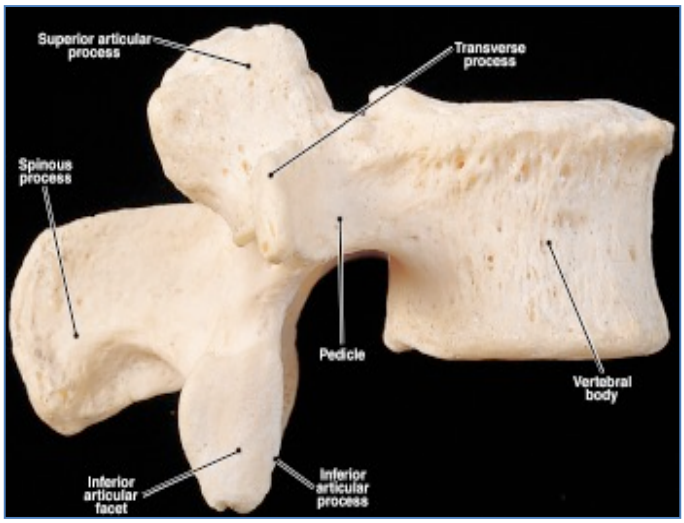
- **12x Thoracic:** Distinguishing Features:
  - Medium Sized Body
  - Thick Lamina
  - Single Spinous Process
  - Costal Facet on Transverse Processes & Body – for Ribs



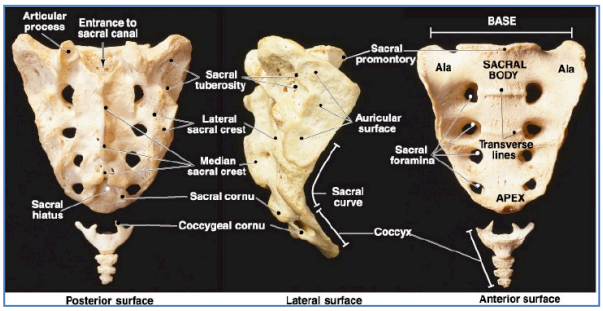


- **5x Lumbar:** Distinguishing Features:
  - Very Large Body
  - Smaller Vertebral Foramen
  - No Costal Facets
  - Chode-like Spinous Processes

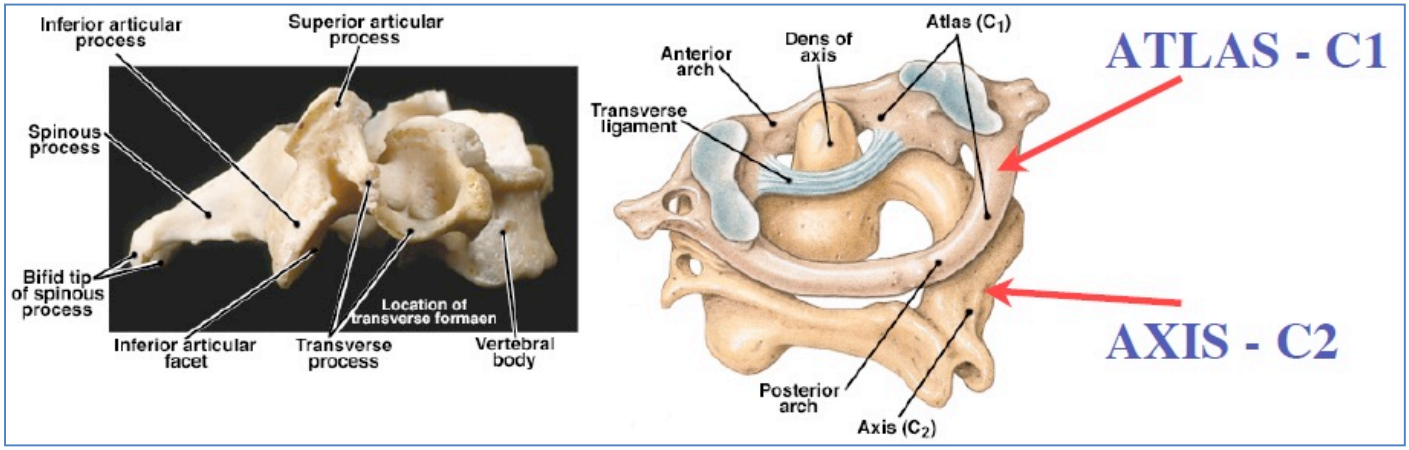


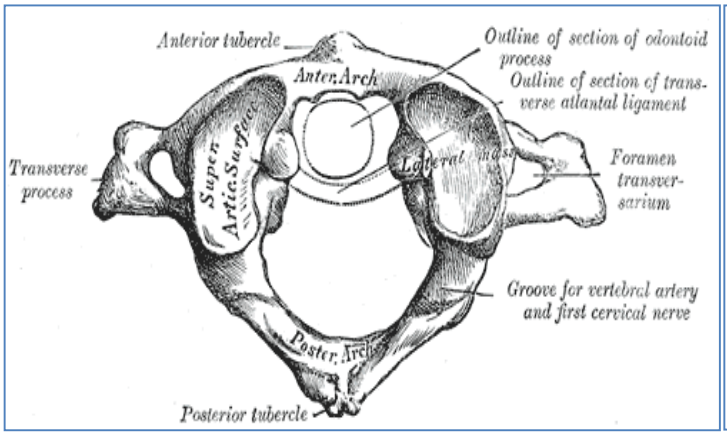


- **5x Sacrum:** Distinguishing Features:
  - Obvious
  - Don't bother with landmarks of this
- **4x Coccyx:** Distinguishing Features:
  - Obvious
  - Don't bother with landmarks of this

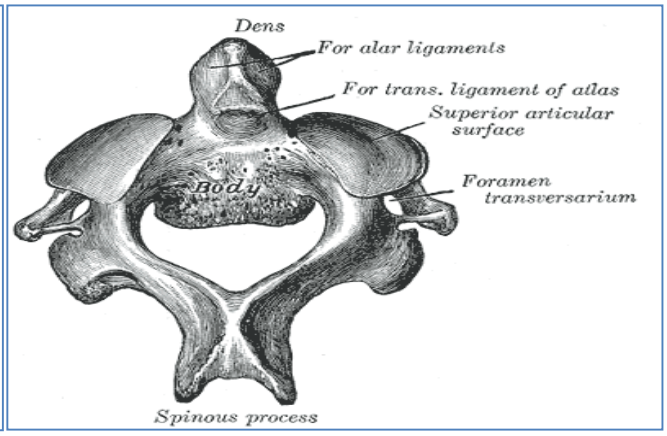


- **Special "Atypical" Vertebrae:**
  - **C1 - Atlas:**
    - No Body
    - Just a ring of bone
      - Anterior Arch
      - Posterior Arch
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries
    - Transverse Ligament – for Dons of Axis
    - Skull Sits on top of this bone
  - **C2 - Axis:**
    - Small body with a protuberance: The "Dens of Axis"
    - Wide Lamina & Vertebral Foramen
    - Transverse Foramena: Holes in Transverse Processes → passage of vertebral arteries





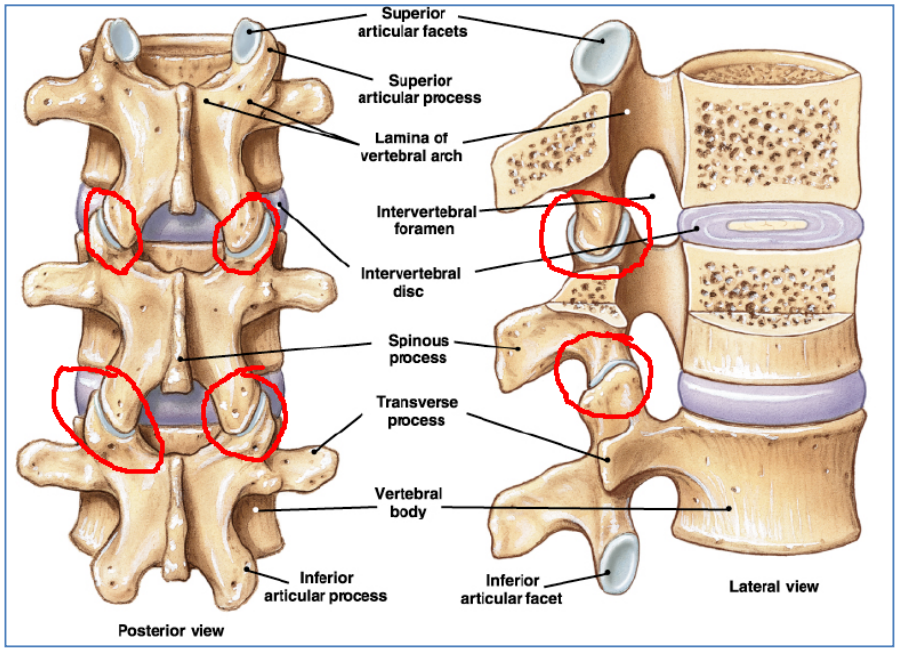
Atlas



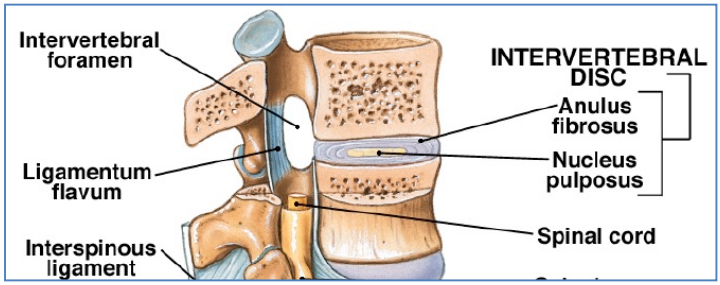
Axis

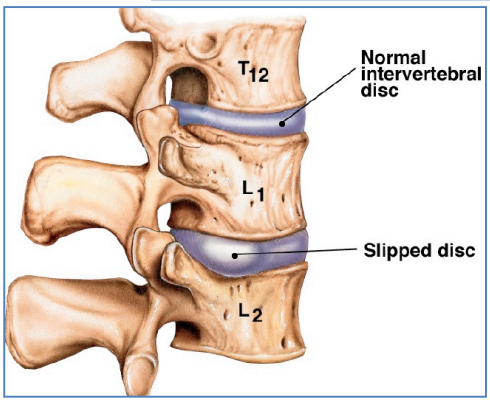
- **Joints:**
  - **Atlanto-Occipital Joint:**
    - Synovial Egg & Spoon Joint
    - Between the Skull & The Atlas
    - Allows you to nod (the 'yes' joint)
  - **Atlanto-Axial Joint:**
    - 2 Parts:
      - Synovial Pivot –
        - Dens of Axis & Transverse Ligament of Atlas
      - Synovial Planar –
        - Superior Articular Surface of Axis & Inferior Articular Surface of Atlas.
    - Allows the head to turn (the 'no' joint)

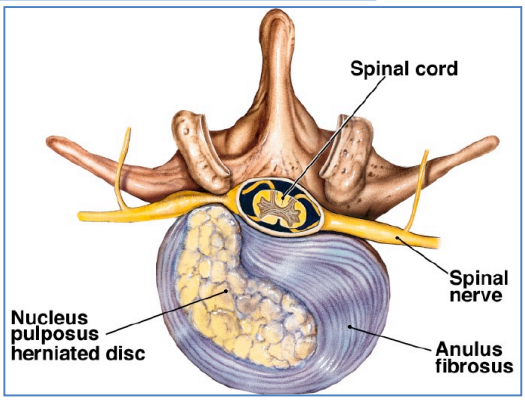
- **Zygopophyseal (Facet) Joints:**
  - Synovial Planar Joints
  - Between the Superior & Inferior Articular Processes of 2 Vertebrae



- **Intervertebral Discs:**
  - Cartilaginous Joints (Symphyses)
  - Allows slight movement between vertebrae
  - 2 Parts – Similar to a Jam Doughnut:
    - **Anulus Fibrosis**
      - Concentrc rings of collagenous Fibrocartilage
      - Distributes pressure evenly across the disc
    - **Nucleus Pulposus**
      - Loose fibers suspended in a Mucoprotein Jelly.
      - Acts as a shock absorber
      - Keeps the two vertebrae separated.
  - Nucleus can herniate out → 'Slipped Disc'
    - If the herniation puts pressure on a spinal nerve → pain.

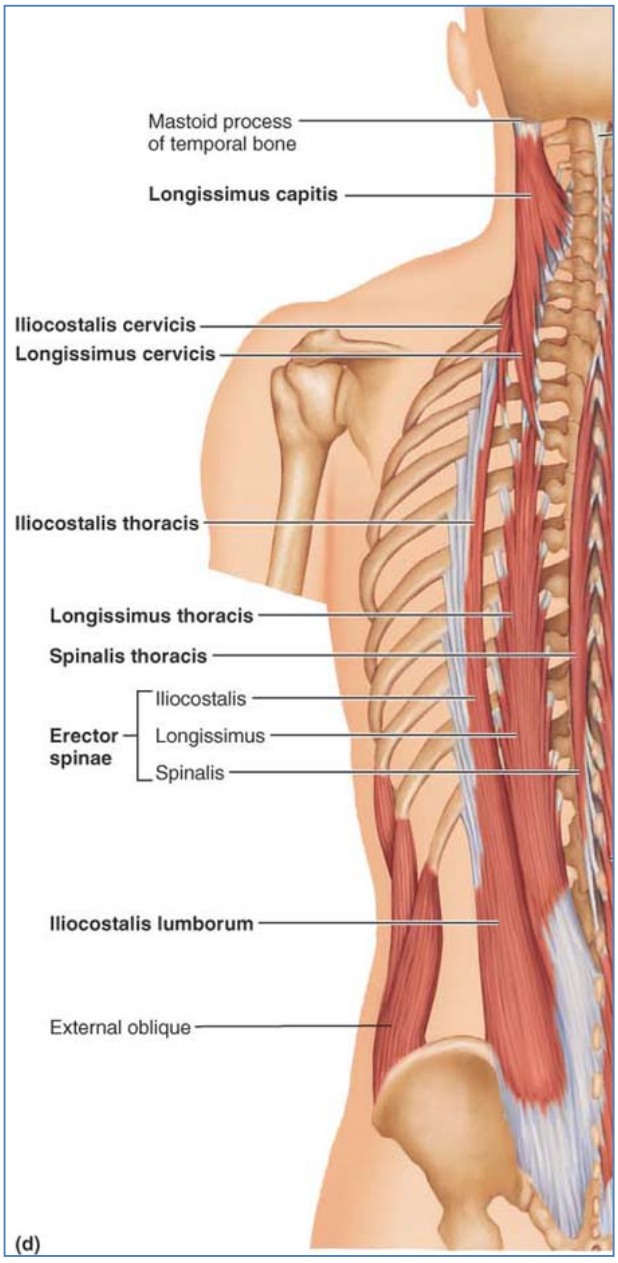




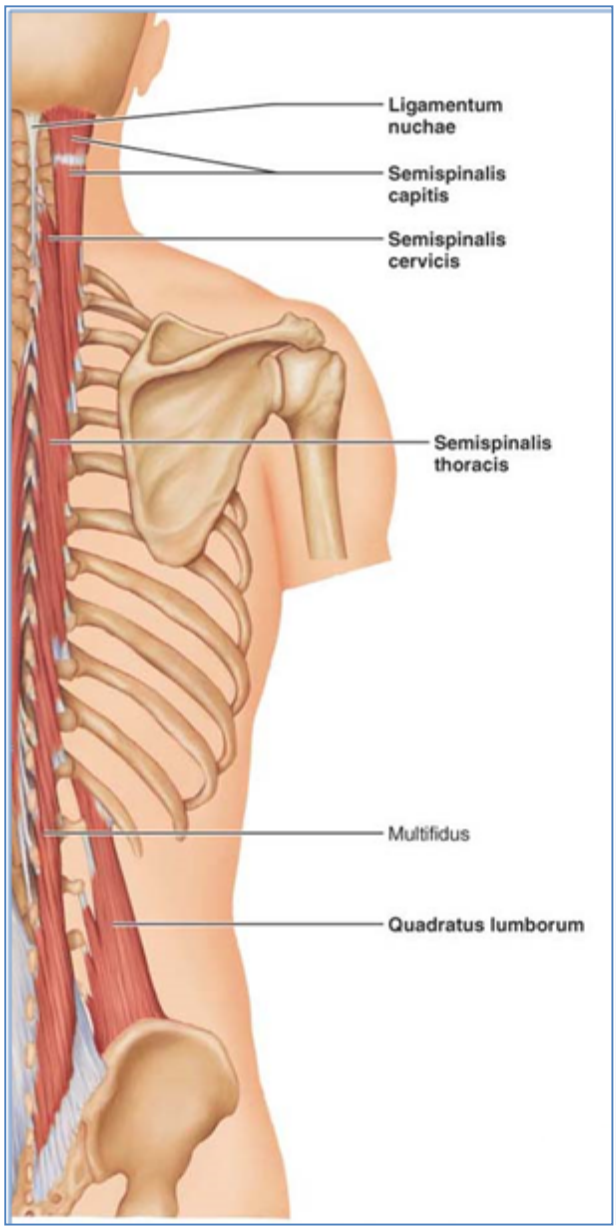


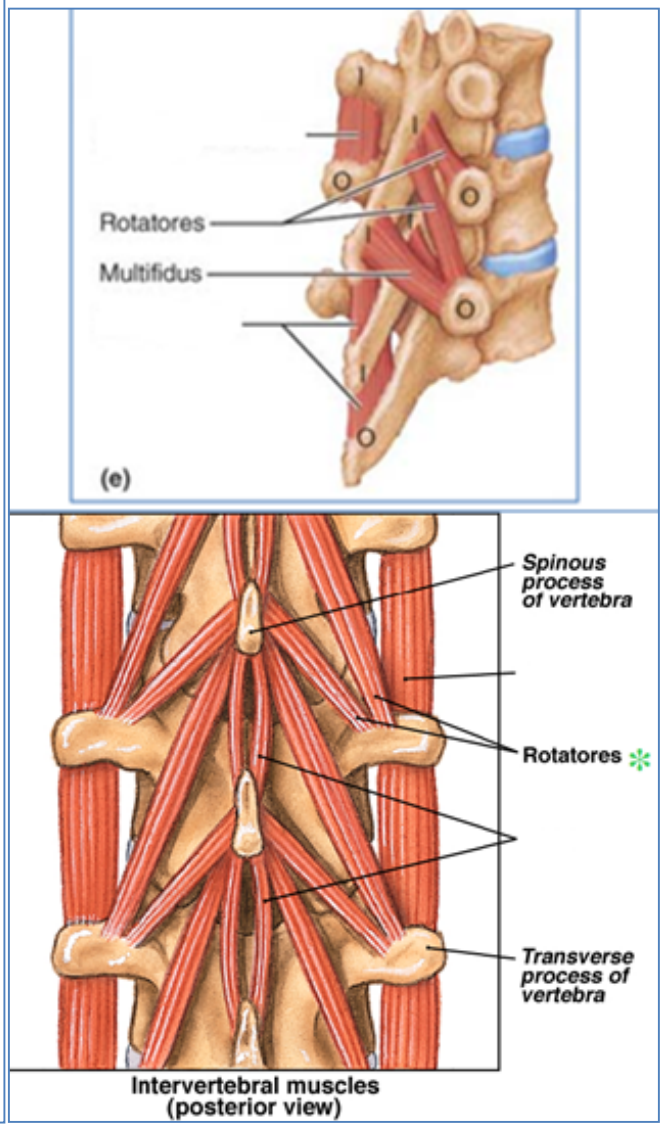
Back Muscles:

- **Superficial:**
  - Muscles of the shoulder girdle
- **Intermediate:**
  - Respiratory Muscles
- ***Deep:** (All innervated by Posterior Spinal Nerves)
  - **Erector Spinae:** Most Superficial Group
    (**I** Love **S**ex)
    - **Iliocostalis:** (Lumborum/Thoracis/Cervicis)
      - Lateral-most
      - O – Iliac Crest
      - I – Lumbar & Thoracic Ribs + Transverse Processes of Cervical Vertebrae
    - **Longissimus:** (Thoracis/Cervicis/Capitus)
      - Between Iliocostalis & Spinalis
      - O – Transverse Processes of Lumbar, Thoracic & Cervical Vertebrae
      - I – Ribs Superior to Origin, Or, Transverse Processes of Thoracic or Cervical Vertebrae
    - **Spinalis:** (Thoracis/Cervicis/Capius)
      - Medial-most
      - O – Spines of Upper-Lumbar & Lower-Lumbar Vertebrae
      - I – Spinous Processes of Upper Thoracic & Cervical Vertebrae

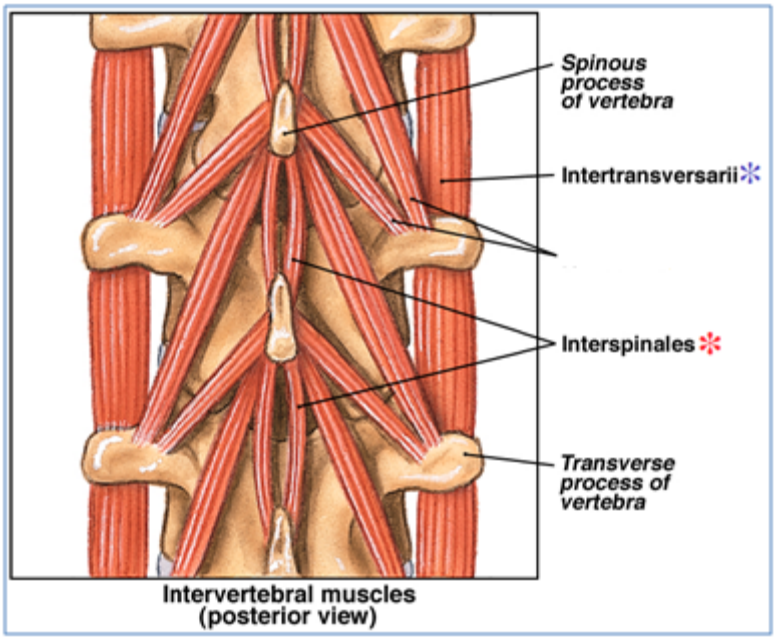


- **TransversoSpinalis:** Intermediate Group
  (**S**ex **M**e **R**ight)
  - **Semispinalis**
    - O – Transverse Processes of Thoracic Vertebrae
    - I – Occipital bone & Spinous Processes of Thoracic & Cervical Vertebrae.
  - **Multifidus**
    - A series of pairs of small muscles extending the full length of the spine
    - Just Superficial to Rotatores
    - Each spans 2 or 3 intervertebral spaces before inserting
    - O – Posterior Sacrum/Iliac Crest/Transverse Processes of Lumbar or Thoracic Vert. /Articular Processes of Cervical Vertebrae.
    - I – Spinous Processes of All Vertebrae (except Atlas)
  - **Rotatores**
    - Beneath Multifidus
    - In Thoracic Region Only
    - O – Transverse Processes of Thoracic Vertebrae
    - I – Spinous Processes of The 2 Above Vertebrae.





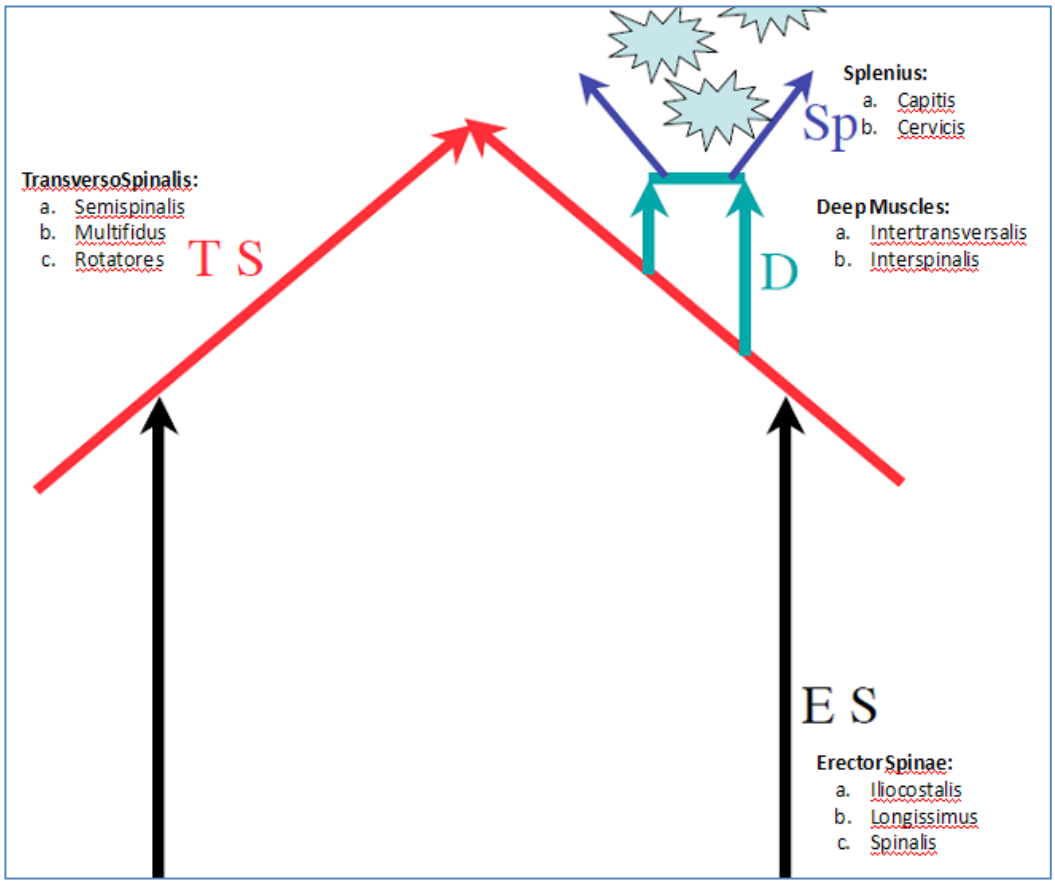
- **Deep Group:** Deepest Group
  (**I Tr**ied **In**door **S**ex)
  - **InterTransversalis**
  - **InterSpinales**



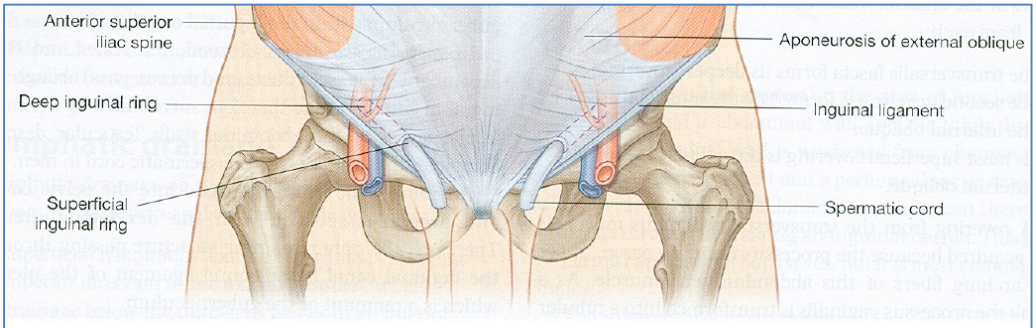
Intervertebral muscles (posterior view)

Splenius:

- **Splenius Capitis:**
  - O – Spinous Processes of Upper 4 Thoracic Vertebrae & 7th Cervical Vertebra
  - I – Mastoid Process & Occipital Bone
- **Splenius Cervicis:**
  - O – Spinous Processes of 3rd – 6th Thoracic Vertebrae
  - I – Transverse Processes of Upper 3 Cervical Vertebrae



Inguinal Canal:

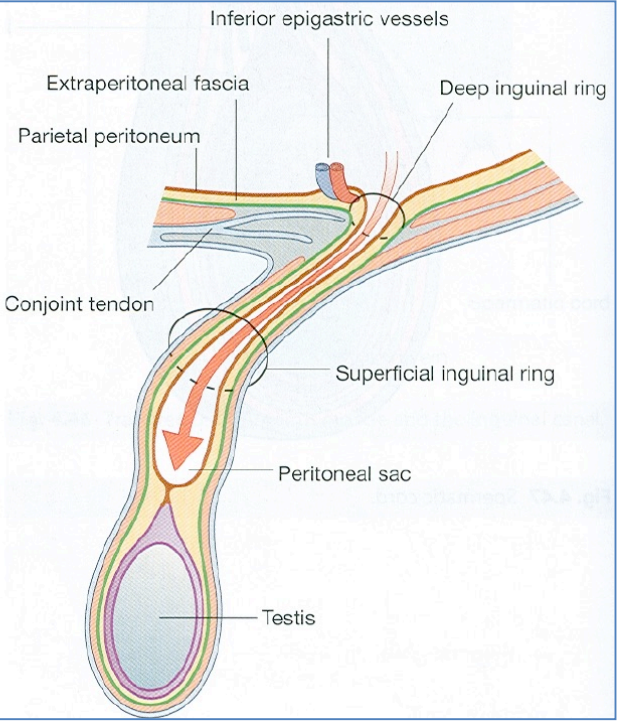


superficial inguinal ring in external oblique aponeurosis.
deep inguinal ring in transversalis fascia to the

Indirect inguinal hernia

Enters deep inguinal ring to pass out of the abdomen within spermatic cord

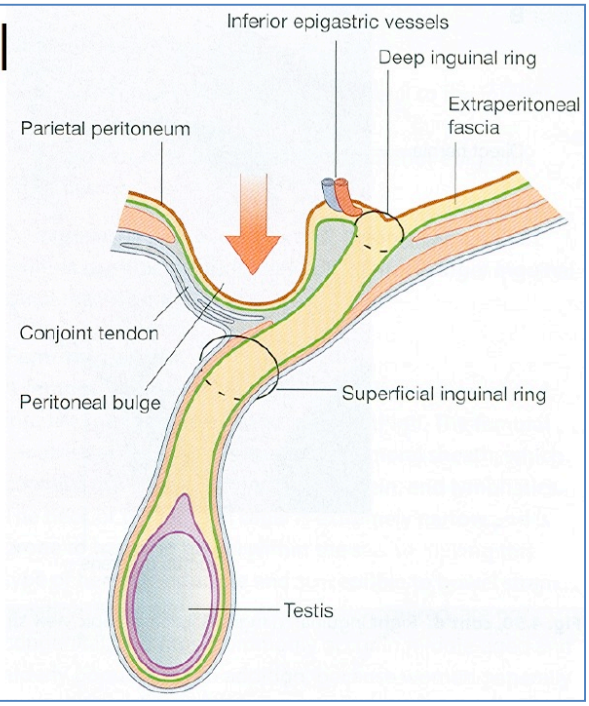
Presents as a swelling in the scrotum



Direct inguinal hernia

Passes through a weakness in the anterior abdominal wall lateral to the inferior epigastric vessels

Presents as a swelling in the groin



MUSCULOSKELETAL Pathology:
BONY INJURIES

Key words + Definitions:

- **Fracture:** A Break in a Bone
- **Compound fracture:** An *Open* Fracture where there is broken skin.
- **Dislocation (or "*Luxation*"):** The Displacement of Joint Surfaces with Abnormal Articulation.
- **Reduction:** Restoration of a fracture or dislocation to the correct alignment.
- **Splint:** Medical device for immobilizing limbs/spine to prevent further injury
- **Neurovascular compromise:** Vessels /Nerves Damage due to injury → functional impairments.
- **Compartment syndrome:** Bleeding/Swelling into a muscle compartment→ Compress vessels/nerves.

What is a Musculoskeletal Emergency and why?

- **Fractures:**
  - Breaks in Bone.
  - **Emergency Because:**
    - If it's an '*Open Fracture*' – Risk of Infection
    - Some fractures won't heal without treatment
    - Neurovascular compromise – can pull/tear/compress/rupture surrounding nerves/vessels.
- **Dislocations:**
  - The Displacement of Joint Surfaces such that Normal Articulation no longer occurs.
  - When forces on joint are greater than stabilizing forces of Bone, Ligament & Muscle.
  - **Emergency Because:**
    - The longer the delay before reduction, the more difficult it becomes, as the muscles around the joint contract.
    - Delay can also result in significant joint & ligament damage → Impairment of function.
    - Neurovascular compromise – can pull/tear/compress/rupture surrounding nerves/vessels.
- **Dismemberment:**
  - Loss of limb or Extreme Tissue-loss resulting in permanent functional impairment of that limb.

Factors Affecting the Degree of Urgency:

- Abnormal ABC
- Bleeding
- Major Vascular Compromise
- Open Vs. Closed Injury
- Neurological Compromise
- Pain
- Potential Loss of Function if Injury is Untreated.

The Basic Priorities of MSK Care:

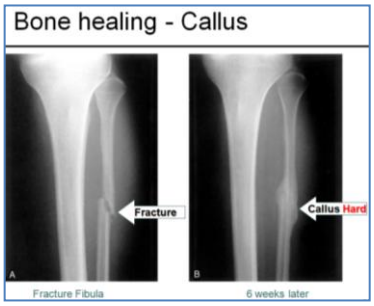
- Primary Survey – "ABC" (Life before limb)
- Identify Injury
- Analgesia
- Splint
- Prevent Infection
- Reduction (Restoring Alignment)

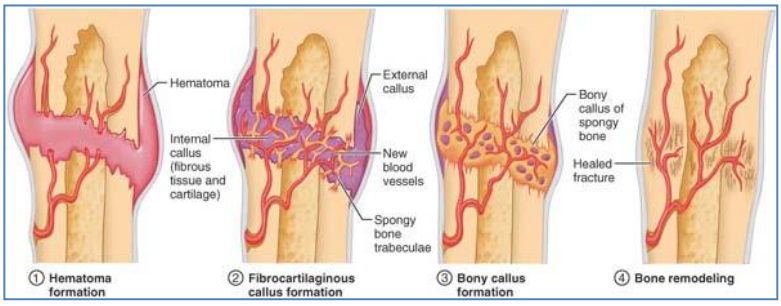
Benefits of Reduction & Splinting:

- **Splinting:**
  - Reduces Pain
  - Reduce Bleeding
  - Promote Healing
  - Reduce risk of Further Compromise (Bone/Neuro/Vascular/Functional)
- **Reduction:**
  - Reduce Pain
  - Restore Function
  - Reduce risk of Further Compromise (Neuro/Vascular/Functional)

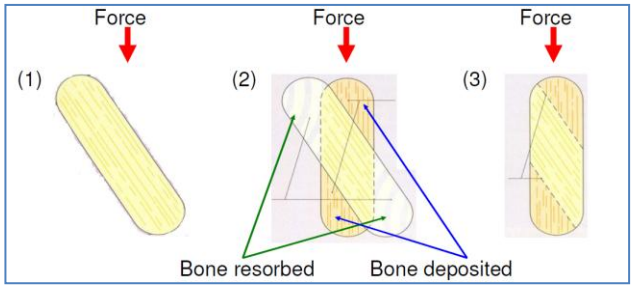
FRACTURES & FRACTURE HEALING:

- **Aetiology:**
  - *Traumatic Injury
  - Pathological Fracture – (Osteolytic Bone Metastasis, or Osteoporosis)
- **Mechanisms of Fracture Healing:**
  - Fracture
  - **1.** (1-3days) - Haematoma & Inflammation (Blood Clot + Fibrin Mesh)
  - **2.** (1-3weeks) - Soft Callus (Deposition of Osteoid + Granulation Tissue + Fibroblasts)
  - **3.** (1-2mths) - Hard Callus (Mineralisation of Osteoid)– NB: VISIBLE ON XRAY
  - **4.** (>2mths) - Remodelling of Woven Bone with Lamellar Bone



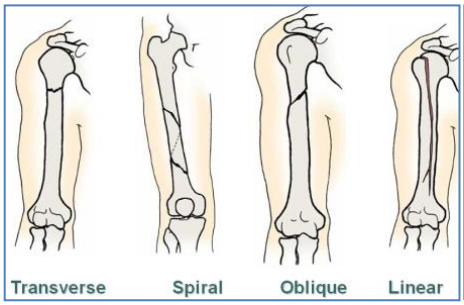


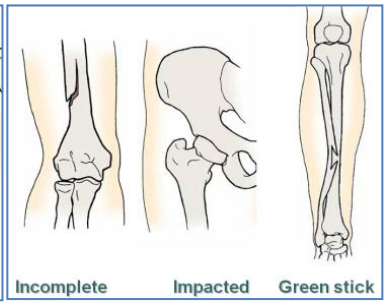
- **Bone Remodelling:**
  - **Bone remodels in response to:**
    - Calcium requirements in body...and
    - Mechanical Stress
    - Physical Activity (Stress)
    - Nutrition
    - Vitamin D
    - Age
    - Hormones (Eg. PTH, PHRP)
  - **Resorption** – destruction of old bone matter by **Osteoclasts**
  - **Apposition** – deposition of new bone matter by **Osteoblasts**

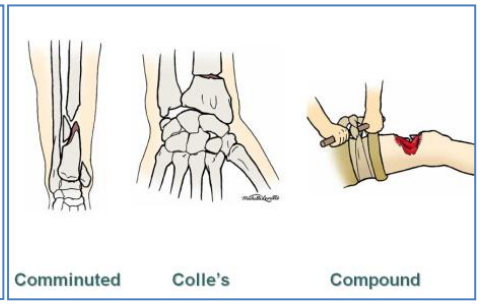


- **Clinical Features:**
  - **Emergency Because:**
    - **Risk of Infection** - If an '*Compound/Open Fracture*'.
    - Some *require* treatment to heal.
    - **Risk of NV-Compromise** – can pull/tear/compress/rupture surrounding nerves/vessels.
    - **Risk of Compartment Syndrome** - Bleeding into muscle compartments → Compresses blood vessels and nerves → (May lead to "Crush Syndrome")
    - **NB: Crush Syndrome:** Muscle Ischaemia/Necrosis due to Compartment Syndrome → Pain, Swelling, Inflammation, DIC, Rhabdomyolysis → Limb Amputation.
- **Treatment:**
  - ***Reduction*** (Either Open or Closed Reduction)
  - ***Immobilisation*** (Splint/Cast/Rod/Pins/Brace/etc)
  - ***Analgesia***
  - ***Rest → Physio***

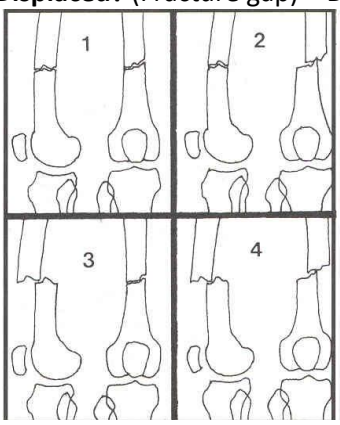
- **Morphology of Fractures:**

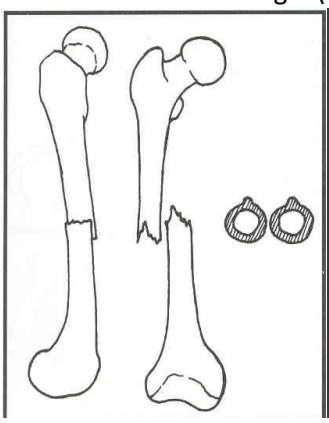




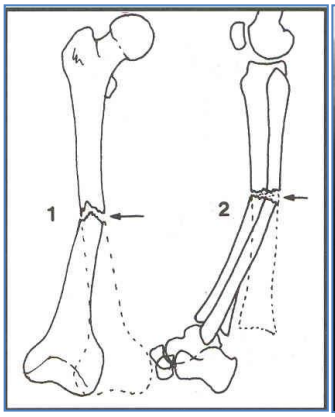


  - **Displaced?** (Fracture gap) – Described as a Percentage. (Eg. 50% Displaced)

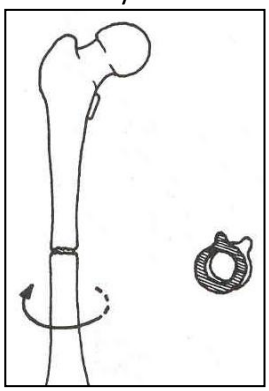




  - **Angulation** – Expressed in *Degrees* relative to Each Other. (Eg. A 30^{o} Angulation)



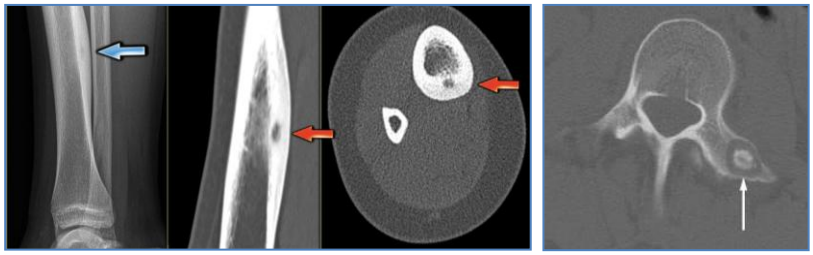
  - **Rotated** – Can be hard to see on an X-Ray.



MUSCULOSKELETAL Pathology:
BONY TUMOURS

Benign Tumours:

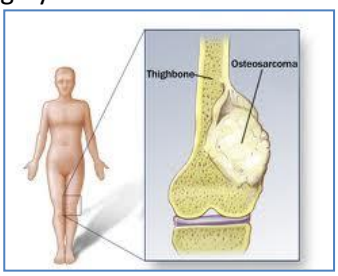
- **OSTEOID OSTEOMA:**
  - **Aetiology:**
    - Benign Tumour of the Osteoblasts
  - **Pathogenesis:**
    - Mild Dysplasia of Osteoblasts
  - **Clinical Features:**
    - **Young Adults**
    - **Symptoms:**
      - *Severe, Intermittent Pain @ Night.
      - *Dull, Persistent Pain during the Day
      - Limping & Muscle Atrophy
      - Location – Typically Diaphysis of Tibia or Femur.
  - **Diagnosis:**
    - **XR & CT -** Small (<1.5cm), Round Radiolucent nodule Surrounded by Dense Bone.
  - **Treatment:**
    - **Pain Characteristically Relieved by Aspirin.**
    - May be surgically removed, or left to resolve.
  - **Prognosis:**
    - **Benign -** Will Resolve Spontaneously in ~3yrs if untreated.



- **SIMPLE BONE CYSTS:**
  - **Aetiology:**
    - Unknown (Can occur in ↑PTH → ↑Osteoclastic → Cyst Formation)
  - **Pathogenesis:**
    - Benign Cyst Formation within a bone filled with Straw-Coloured Fluid.
  - **Clinical Features:**
    - Benign
    - Asymptomatic
    - May → Pain, Swelling
    - May → Path Fracture through the Cyst.
  - **Diagnosis:**
    - Xray (Hollow cavity in Metaphysis)
  - **Treatment:**
    - Curettage +/- Bone Graft if in a Structurally-Compromising Location.
  - **Prognosis:**
    - Benign

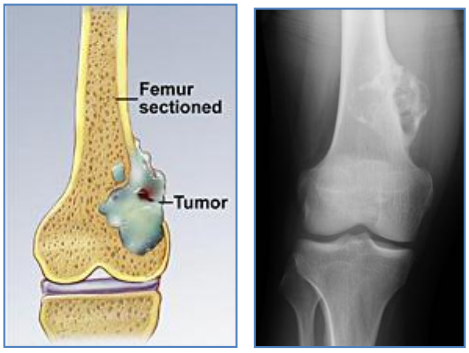
Malignant Tumours:

- **OSTEOSARCOMA:**
  - **Aetiology:**
    - Malignant Tumour of the Osteoblasts
  - **Pathogenesis:**
    - **Malignant Dysplasia of Osteoblasts → Bone Forming**
  - **Morphology:**
    - **Metaphysial – *"Chicken-Drumstick Appearance"***
    - Raised/lifting Periosteum → "Codman's Triangle" → Triangular reactive bone formation
    - Infiltration into the marrow
  - **Clinical Features:**
    - **Epi:** **YOUNG (Children** & Adolescents)
    - **Location:** Typcially **Knee** & **Shoulder** (Metaphysis of Long Bones)
    - **Symptoms:**
      - *Fever!*
      - *Weight Loss*
      - Chronic Localised **Bone Pain** & **Tenderness**
        - NB: Does NOT involve Joints
      - **Inflammation, Redness**
  - **Complications:**
    - Pathological Bone Fracture (Mild/No Trauma)
    - Non-Healing Fractures
  - **Diagnosis:**
    - DON'T Biopsy
    - **X-Ray, & Bone-Scan**
  - **Treatment:**
    - ***Surgery* + *Chemotherapy***
  - **Prognosis:**
    - **Reasonable Prognosis** - Highly Chemosensitive = <50% Curable

- **EWING'S SARCOMA:**
  - **Aetiology:**
    - Genetic
  - **Pathogenesis:**
    - Malignant Round-Cell Tumour
  - **Clinical Features:**
    - **Teenagers**
    - **Long Bones** (Arms & Legs)
    - **Symptoms:**
      - Localised Pain & Swelling
      - Pathological Fracture
  - **Diagnosis:**
    - Fever, Anaemia, Leukocytosis & ESR
    - **XRay – (**Moth-Eaten Appearance with Periosteal "Onion-Skinning").
  - **Treatment:**
    - ***Surgery*** **+** ***Chemotherapy*** **+** ***Radiotherapy***
  - **Prognosis:**
    - Metastases Frequent
    - Poor Prognosis (80% Local; 25% Metastatic)

- **CHONDROSARCOMA:**
  - **Aetiology:**
    - Primary = Unknown
    - Secondary = to Osteochondroma
  - **Pathogenesis:**
    - Malignant Tumour of Cartilage
  - **Clinical Features**
    - **Adults** (>40)
    - **Symptoms:**
      - Asymptomatic
      - Pathological Fracture
  - **Diagnosis:**
    - **X-Ray:** Large Exostosis + Calcification in the Cap
  - **Treatment:**
    - **Aggressive Surgical Resection (NOT Responsive to Chemotherapy)**
  - **Prognosis:**
    - **25-90% 5yr Survival Depending on Grade.**



- **GIANT CELL TUMOUR OF THE BONE:**
  - **Aetiology:**
    - Unknown
  - **Pathogenesis:**
    - Osteoclast-Monocyte Tumours
  - **Clinical Features:**
    - Local Pain & Swelling
    - Limited ROM if Joint Involvement
    - Pathological Fractures
  - **Treatment:**
    - ***Surgery*** +/- ***Radiotherapy***
    - ***Bisphosphonates*** may help.
  - **Prognosis:**
    - 66% Malignant

MUSCULOSKELETAL Pathology:
CRYSTAL ARTHROPATHIES

GOUT (GOUTY ARTHRITIS):

- **Aetiology:**
  - Anything that causes ↑Urea Production or ↓Urea Excretion
    - Eg. High Protein/Alcohol Diet
  - (NB: Also Secondary Causes – Eg. Renal Failure, Thiazides, Hypothyroidism, Haemolysis, Obesity)
- **Pathogenesis:**
  - Derangement in Purine Metabolism → Hyperuricaemia → ***Monosodium Urate*** Crystal Deposition in Joint tissue → Forms "*Tophi*" → Chronic Inflammation → Destruction of the tissue
- **Morphology:**
  - **Macro:** Red, Hot, Swollen Joints (Typically 1st MTP Joint & Hands) + Gouty Tophi
- **Clinical Features:**
  - Typically Males >45yrs
  - **Recurrent Severely Painful Episodes of Acute Arthritis:**
    - – Typically Lower Extremities First (1st MTP Joint)
    - - Can also affect Hands
    - - May mimic Cellulitis (But will have ↓ROM, Cf. Cellulitis has normal ROM)
    - - Attacks last 1wk.
  - **Gouty "*Tophi*" (Urate deposits in Joints, Cartilage, Tendons, Bursae & Soft Tissues)**
    - Common Sites: 1st MTP joint, Tendon Insertions, Pressure Points
    - Painless, but ↓ROM
  - **Effects on Kidney:**
    - Uric Acid Stones
    - Urate Nephropathy
- **Diagnosis:**
  - **Clinical Diagnosis**
  - **Joint Aspirate & Microscopy** – (*Needle-Shaped* Monosodium-Urate Crystals)
- **Treatment:**
  - ***Colchicine*** (For Acute Relief)
  - ***Allopurinol*** (Preventative Only; Can *Worsen* an Acute Attack)
  - ***NSAIDs***
  - ***Corticosteroids***
  - ***Lifestyle Change*** **–** (Avoid *High-Purine* Foods (Meats, Fish, Beans, Peas, Beer))

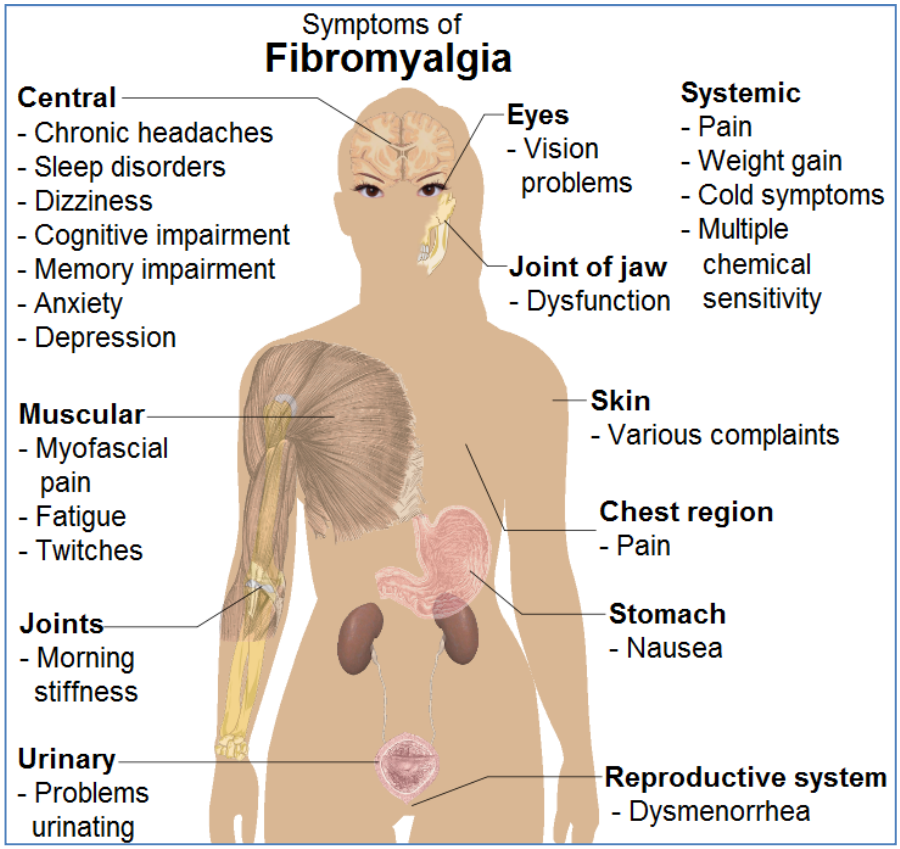
PSEUDOGOUT ("*Chondrocalcinosis*"):

- Actually more common than "True" Gout
- **Aetiology:**
  - ↑Calcium [Eg. Hyperparathyroidism, Hypomagnesemia], Diabetes, Haemochromatosis, Elderly.
  - NB: Recurrence may be Triggered by Dehydration, Acute Illness, Surgery or Trauma.
- **Pathogenesis:**
  - ***Calcium Pyrophosphate*** deposition in Joints → Calcification & Inflammation → Pain = Arthritis.
- **Morphology:**
  - Red, Tender, Swollen Joints which may mimic Gouty Arthritis.
- **Clinical Features:**
  - Polyarticular Arthritis (Severely Painful)
  - Knees, Wrists, Hips & Feet are Most Common
  - Duration – Self-Limiting Up to 3 Wks
- **Diagnosis:**
  - **XRay – (***"Chondrocalcinosis"* – Radiographic Calcification in Cartilage)
  - ****Joint Aspirate** – (*Calcium Crystals in Joints*; + RULE OUT Septic Arthritis & True Gout).
- **Treatment:**
  - ***Joint Aspiration*** **&** ***Rest***
  - **NSAIDS**
  - ***Intra-Articular Steroids*** ***to ↓Inflammation.***
- **Prognosis:**
  - 50% of Pseudogout → Degenerative Joint Changes (Osteoarthritis)

MUSCULOSKELETAL Pathology:
FIBROMYALGIA

FIBROMYALGIA:

- **Aetiology:**
  - **Psychosomatic**
  - Associated with **Chronic Fatigue Syndrome** & **Psychiatric Illness (**Depression & Anxiety**)**
  - Associated with **IBS**, **Migranes**, **Obesity**,.
- **Pathogenesis:**
  - None
- **Morphology:**
  - Joint Examination is Normal
  - No Pathology
- **Clinical Features:**
  - Middle Aged Women – (3F:1M, 25-45)
  - **Widespread Aching, Stiffness & Reproducible Tender Points.**
  - **Chronic Fatigue**
  - Symptoms Aggravated by Physical Activity, Poor Sleep & Stress.
  - **Neurology – Hyperalgesia & Paraesthesias.**
- **Diagnosis:**
  - >3mth History of Widespread Pain
  - Diagnosis of Exclusion – (Lab Ix Normal)
- **Treatment:**
  - ***Stress Reduction***
  - ***Tricyclic Antidepressants***



MUSCULOSKELETAL Pathology:
GAIT & GAIT DISTURBANCES

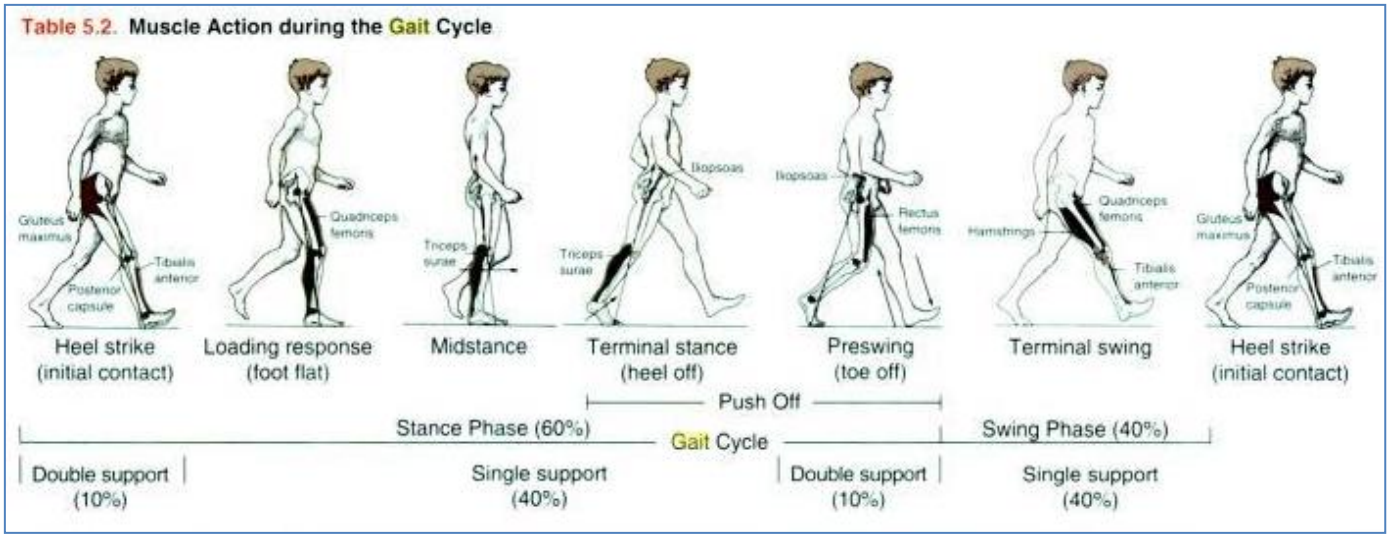
Gait – The Process of Walking:

- **Tasks of Gait:**
  - Weight Acceptance
  - Single Limb Support
  - Advancement of Limb
- **Phases of Walking:**
  - **Stance:** (Foot is on the ground)

		Hip	Knee	Ankle
Heel Strike	**Position:**	Flexed	Mildly Flexed	Dorsiflexed
	Prime Mover/s:	Psoas Muscle	Gravity	Tibialis Anterior
	Stabiliser/s:	Gluteus Maximus	Iliotibial Tract Quadriceps	Inverters/Everters
Midstance	**Position:**	Flexed →Neutral	Extended	Neutral/Dorsiflexed
	Prime Mover/s:	Gluteus Maximus Hamstrings	-	-
	Stabiliser/s:	Gluteus Medius Gluteus Minimus Tensor Fascia Lata	Quadriceps Femoris Medial Muscles	Intrinsic Foot Muscles
Toe-Off	**Position:**	Neutral → Flexed	Beginning to Flex	Plantar Flexion
	Prime Mover/s:	Gluteus Maximus	-	Triceps Surae
	Stabiliser/s:	-	Quadriceps Femoris	Toe Flexors

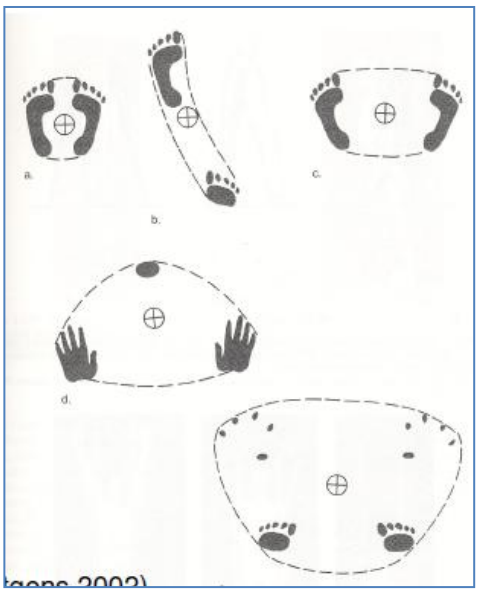
  - **Swing:** (Foot is off the ground)
    - **Swing:**

		Hip	Knee	Ankle
Swing	**Position:**	Extended→Flexion	Flexed→Extension	Dorsiflexion
	Prime Mover/s:	Iliopsoas Lateral Rotators	Gravity	Tibialis Anterior
	Stabiliser/s:	Antag: Gluteus Maximus	Quadriceps Femoris Antag: Hamstrings	-



  - **Features of Gait:**
    - Centre of Gravity — Lower = More Stable
    - Base of Support — Larger = More Stable (eg. Zimmer frames/walking sticks)
    - Step Length

- Velocity
- Cadence (steps/minute)

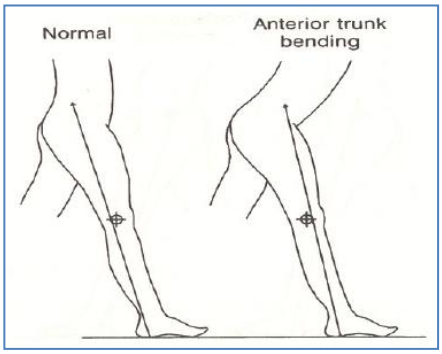


Base of Support

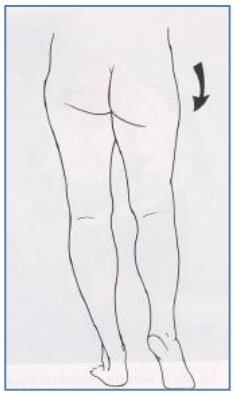
- **Factors Influencing Gait:**
  - Age/Maturation – adult gait patter occurs at ≈10yrs
  - Old age
  - Gender
  - **Pain**
  - **CNS Disorders –** Stroke/MS/Parkinsons/Kennedy's Disease/etc
  - **MSS Impairments –** Injury/Fused Joint/Tendonitis/Arthritis/etc
  - Assistive devices
  - Braces/Orthotics/Taping
  - Habit
  - Terrain
  - Velocity
  - Emotion
  - Height
  - Weight

- **Methods of Gait Analysis:**
  - Visual Method (eg. In the doctor's office)
  - Video Method (eg. Slo-mo camera)
  - Gait Timing (Foot Switches/Sensored Catwalks)

- **Examples of Gait Abnormalities:**
  - **Anterior Trunk Bending:**
    - Weak knee extensors – need to 'lock' their knee to walk/
    - Fused knee/
    - Tight hip flexors/

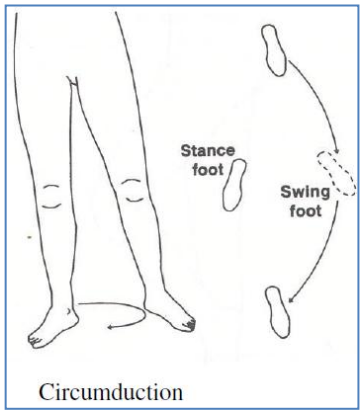


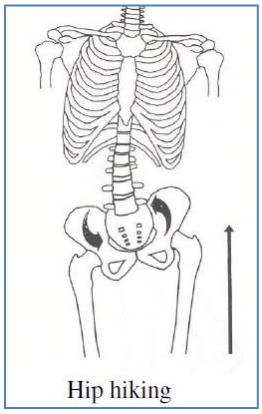
  - **Trendelenburg (ie. 'Hip Drop'):**
    - Hip-abductor weakness/



- **Leg Length Discrepancy:**
  - Anatomical:
    - Actual difference in leg length
  - Functional:
    - Eg. Neurological Muscle imbalance – ie. Stroke/foot-drop/etc.
    - Eg. Musculoskeletal Problems

  - Patients may try to overcome this by:
    - Circumducting the hip
    - Hip Hiking
    - Steppage
    - Vaulting





- **Excessive Knee Extension:**
  - Ie. Snapping the knee into its 'locked' position midway through stance phase.
  - Due to Weak Knee Flexors.

- **'Foot Slap':**
  - Ie. Lack of eccentric control of Dorsiflexion → following 'heel strike', the foot slaps the ground.

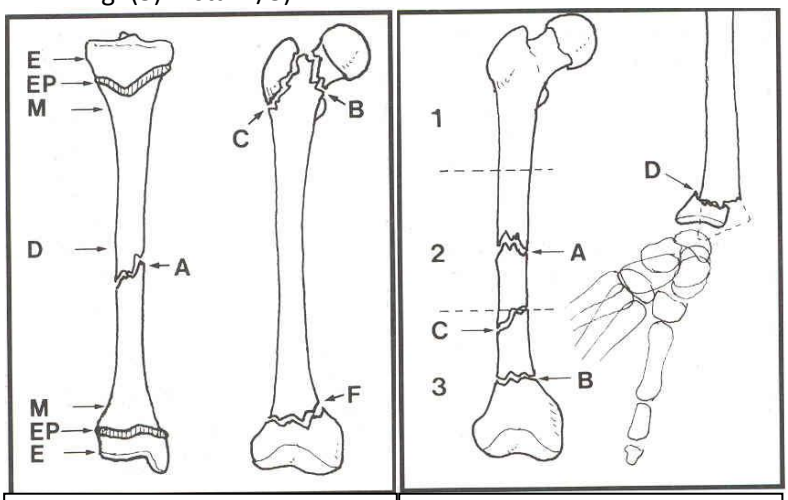
- **'Toe Drag':**
  - Ie. Inadequate Dorsiflexion →during Swing Phase, the ankle hangs down in the plantarflexed position → drags along the ground.

- **Insufficient 'Toe-Off':**
  - Where the whole foot is lifted off the ground at once (as opposed to pushing off from the toes)
  - Due to:
    - Nerve lesions/
    - Fusion of the ankle/
    - Archilles Tendon Problem (torn/inflamed/etc)
    - Pain in front (ball) of foot

MUSCULOSKELETAL Pathology:
MSK INJURY RADIOLOGY

***XRays* - Differentiate Normal from Abnormal and Describe an X-Ray:**

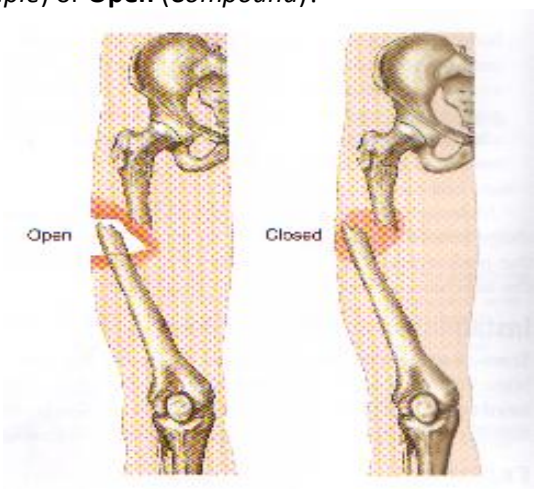
- **Describing an X-Ray:**
  - **Fracture (#) or Dislocation?**
  - **Which Bone?**
  - **Location? (Which part of the Bone?):**
    - (E) Epiphysis
    - (EP) Epiphyseal Plate
    - (M) Metaphysis
    - (D) Diaphysis (Shaft) [In 'Thirds']
      - Eg. (1) Proximal 1/3
      - Eg. (2) Diaphyseal (mid) 1/3
      - Eg. (3) Distal 1/3)



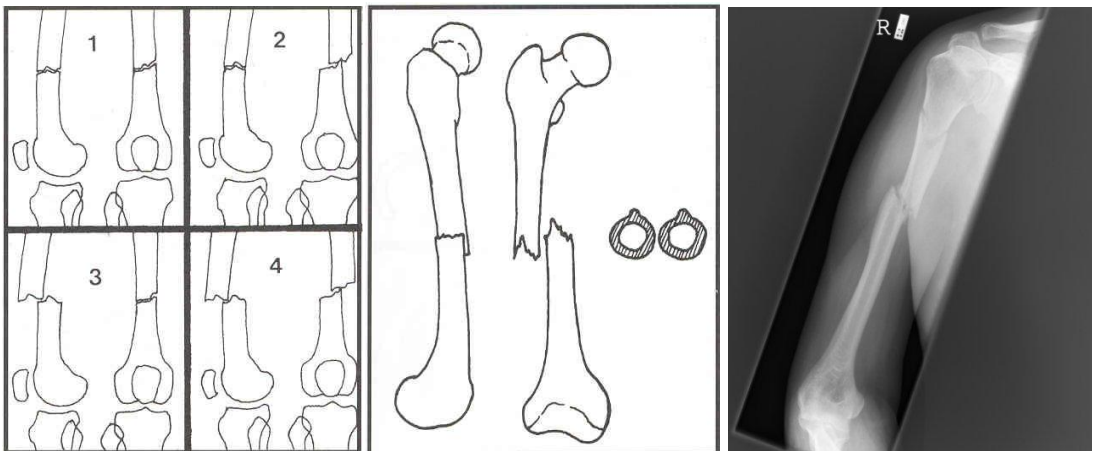
(A) = Tibial Diaphysis (B) = Femoral Neck (C) = Greater Trochanter (F) = Supracondylar #	(A) Diaphyseal Femur # (B) Distal Femur # (C) Mid-Distal Femur # (D) Radial 'Colles' #

    - Epicondyle
    - Malleolus
    - Etc.

- **If It's a Fracture (#):**
  - **Properties of Fractures:**
    - **Closed** (*Simple*) or **Open** (*Compound*)?



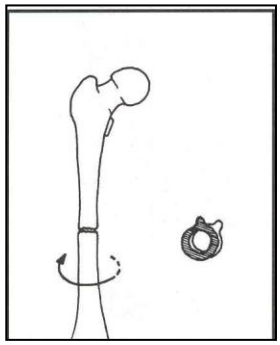
- **Displaced?** (Fracture gap) – Described as a Percentage. (Eg. 50% Displaced)



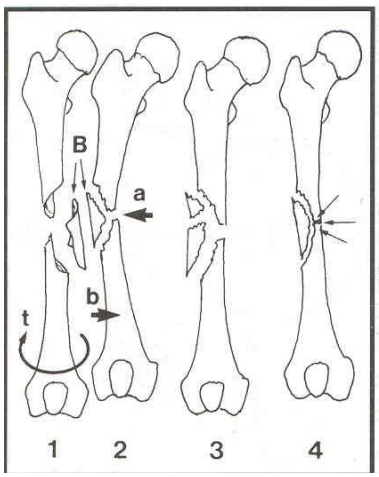
1) Aligned; 2) 50% Displaced; 3) 80% Displaced;
4) 90% Displaced; Right) 100% Displaced

- **Angulation** – Expressed in *Degrees* relative to Each Other. (Eg. A 30^{o} Angulation)
  - 1) Fracture of the Mid 1/3 of Femur with distal fragment tilted laterally.
  - 2) Midshsaft fracture of the Tibia & Fibula with Distal Fragment tilted Anteriorly.

- **Rotated** – Can be hard to see on an X-Ray.

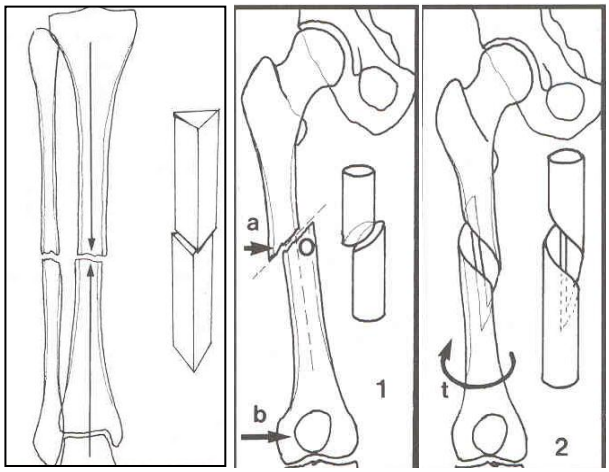


- **Types of Fractures:**
  - **Complete**: A fracture in which bone fragments separate completely.
  - **Incomplete**: A fracture in which the bone fragments are still partially joined.
  - **Greenstick**: Occurs mostly in children with non-brittle bones. (An Incomplete #)
  - **Comminuted**: 3 or More Pieces



  - **Compacted**: A fracture caused when bone fragments are driven into each other.

- **What shape is the #?**
  - **Linear**: A fracture that is parallel to the bone's long axis.
  - **Transverse**: A fracture that is at a right angle to the bone's long axis.
  - **Oblique**: A fracture that is diagonal to a bone's long axis.
  - **Spiral**: A fracture where at least one part of the bone has been twisted.



Transverse **Oblique** **Spiral**

- **If Dislocation (AKA: *"Luxation"*):**
  - **1. Which Joint?**
    - Shoulder (Gleno-humoral)
    - Fingers (Inter-Phalangeal)
    - Wrist - Usually accompanied by a fracture
    - Elbow - Usually accompanied by a fracture
    - Knees
    - Ankle - Usually accompanied by a fracture
  - **2. What Direction?:**
    - Superior/Inferior
    - Anterior/Posterior
  - **3. Is there an Associated Fracture?**
  - **4. Any possible Neurovascular Compromises?**

MUSCULOSKELETAL Pathology:
MYOSITIS

INFECTIONS OF MUSCLE:

- ~~Myalgia~~ = muscle ache/stiffness
- **Myositis** = infection of the muscle (skeletal)
  - single or multiple muscle groups
- **Spread via:**
  - Soft tissue infection
    - - gas gangrene (*C. perfringens*)
    - - abscesses (*S. aureus*, GAS)
  - Haematogenous (Ie. Bacteraemia)

- **Muscle Abscesses:**
  - **Presentation:**
    - Muscle & Joint Pain for a few days
    - Swelling Develops
  - **Pathogenesis:**
    - Infection spreads along plane of muscle
    - Necrotic Muscles don't Regenerate → Local Wasting & Deformity
  - **Diagnosis:**
    - Ultrasound – Look for discrete fluid collections → Aspirate for diagnosis or drained therapeutically

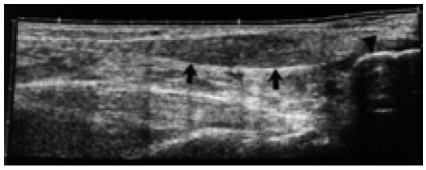


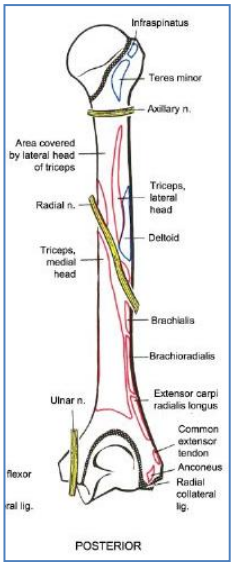
Image showing abscess (arrowheads) anterior to the sternum (curved arrows) and extending to the right of the midline.

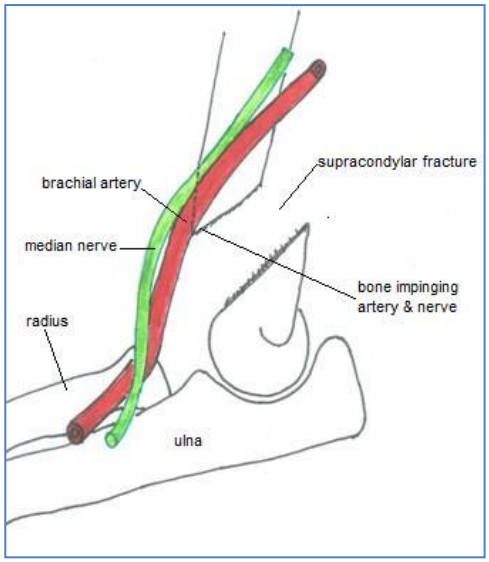
Percutaneous aspiration yielded pus that grew *Staphylococcus aureus*

MUSCULOSKELETAL Pathology:
NEUROVASCULAR COMPROMISES

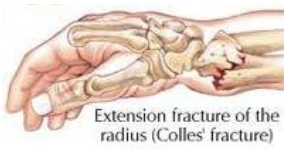
Possible Neurovascular Compromises From...:

- **Common Fractures:**
  - **Humeral #:**
    - **Neck:**
      - Axillary Nerve Damage
    - **Mid-Shaft:**
      - Radial Nerve Damage (As it closely traverses the lateral aspect of the humerus)
    - **Supracondylar:**
      - Median Nerve Damage
      - Brachial Artery.



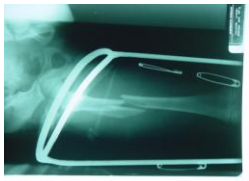


  - **Radial (Colles?) #:**
    - Median Nerve (Compression)
    - Ulnar Nerve (Compression)
    - Radial Artery



  - **Wrist (Both Radius & Ulnar) #:**
    - Median Nerve Damage
    - Ulnar Nerve Damage
    - Radial Artery Laceration
    - Ulnar Artery Laceration

  - **Femoral Shaft #:**
    - Femoral Nerve
    - Sciatic Nerve
    - Femoral Artery



- **Neck of Femur #:**
  - Sciatic Nerve
  - Femoray Nerve
  - Femoral Artery

- **Ankle #:**
  - Post. Tibial Artery
  - Tibial Nerve

- **Common Dislocations:**
  - **Shoulder (Gleno-humoral):**
    - Axillary Nerve Damage
    - Musculocutaneous Nerve Damage
    - Radial Nerve Damage

  - **Hip:**
    - Sciatic Nerve Damage

  - **Knee - Usually accompanied by Severe Ligament Damage:**
    - Tibial Nerve
    - Common Fibular Nerve
    - Popliteal Artery
    - Popliteal Vein

  - **Ankle - Usually accompanied by a Fracture:**
    - Post. Tibial Artery
    - Tibial Nerve

- **Laceration:**
    - **Volar (Palmar) Aspect of Wrist – (Eg. In Attempted Suicide):**
        - Median Nerve
        - Ulnar Nerve
        - Radial Artery
        - Ulnar Artery
        - Basilic Vein
        - Cephalic Vein
        - (+ Wrist Flexor Tendons)

What Functional Impairments Suggest Damage to These Nerves?:

- **Upper Limb:**

Nerve	Site of Injury	Paralysis	Motor Loss	Sensory Loss
Axillary Nerve	Axilla	Deltoid	Shoulder Abduction	Deltoid Region
Musculocutaneous Nerve	Axilla	Arm Flexors	Forearm Flexion	Lateral Forearm 
Radial Nerve	Axilla	Arm Extensors + Supinator	Elbow Extension, Supination, Wrist Extension	Lateral Dorsum of Hand, & Posterior Arm. 
	Cubital Fossa	Arm Extensors, *Except* Triceps	Supination, Wrist Extension	
Median Nerve	Elbow	Wrist Flexors, Thenar Muscles, Lateral 2x Lumbricals	Weak Wrist Flexion, Thumb Opposition, Lateral 2x Finger-Flexion	Lateral 3.5 Fingers 
	Wrist	Thenar Muscles, Lateral 2x Lumbricals	Thumb Opposition, Lateral 2x Finger-Flexion	
Ulnar Nerve	Above Elbow	Wrist Flexors, Hypothenar Muscles, Medial 2x Lumbricals	Weak Wrist Flexion, Medial 2x Finter-Flexion	Palm, Medial 1.5 Fingers 
	At Wrist	Hypothenar Muscles, Medial 2x Lumbricals	Medial 2x Finter-Flexion	

- **Lower Limb:**

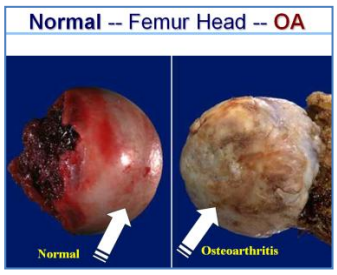
Nerve	Site of Injury	Paralysis	Motor Loss	Sensory Loss
Femoral Nerve	Femoral Neck, Shaft #	Quadriceps Femori	Knee Extension, Hip Flexion	Antero-Medial Leg 
Obturator Nerve	Hip	Hip Adductors	Hip Adduction	Medial Thigh 
Sciatic Nerve	Hip, Femur #	Hamstring Function, Plantar-Flexors, Dorsi-Flexors, Intrinsic Foot Muscles.	Knee Flexion, Plantar-Flexion, Dorsi-Flexion, Ankle Eversion, Toe Movement	Most of Post.Thigh, Leg & Foot
Tibial Nerve	Knee, Tibial #, Laceration	Plantar-Flexors, Intrinsic Foot Muscles	Plantar-Flexion, Toe Movement	Posterior Leg
Fibular Nerve	Knee, Fibular # Laceration, Compression	Dorsi-Flexors, Intrinsic Foot Muscles	Dorsi-Flexion, Toe Movement, Ankle Eversion,	Anterio-Lateral Leg

- **Testing for Neurovascular Compromise:**
  - Presence of Vascular Compromise?
    - Bleeding/Haematoma → Probably
    - No Distal Pulses → Probably
    - Distal Pulses Present→ Probably Not
  - Presence of Neurological Compromise?
    - Sensory Alterations/ Loss → Probably
    - Impaired Motor Function → Probably
    - Neither of the above → Probably Not

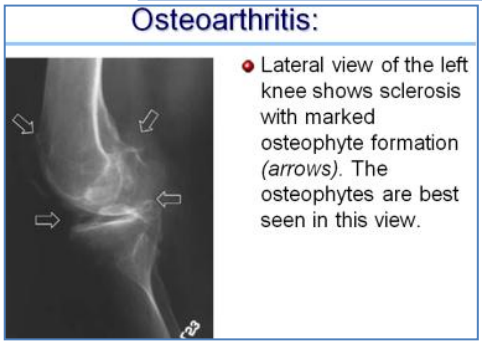
MUSCULOSKELETAL Pathology:
OSTEOARTHRITIS

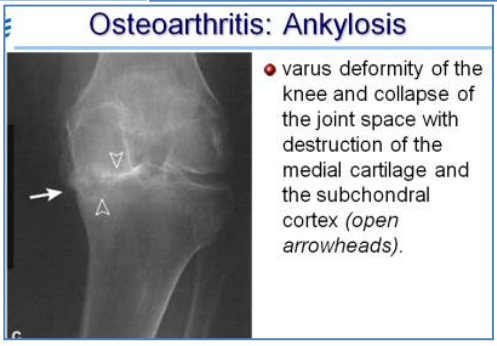
OSTEOARTHRITIS (Degenerative):

- **Aetiology:**
  - Degenerative Wear & Tear
- **Pathogenesis – (Mechanical, then Inflammatory):**
  - **Cartilage Hydration Decreases with Age → Less Resistant to Friction → Cartilage Erosion**
    - **→ Exposure of Bone → Grinding → Mechanical Damage & Inflammation**
- **Morphology:**
  - 1. Eburnation of Bone (Shiny, thickened, hardened bone)
  - 2. Cartilage Degeneration
  - 3. Peripheral Osteophytes → "Joint Lipping" (New bone formation around the joint edges)



- **Clinical Features:**
  - Typically in >40yrs
  - **Symptoms:**
    - **Large, Weight-Bearing Joints (Knees, Spine)**
    - **Nodular/Bulky, Painful Joints + Joint-Line Tenderness**
    - **Pain Worse with Activity & Cold Weather**
    - **Pain Better with Rest.**
    - **Joint Instability & Crepitus** (due to irregular joint surface)
    - **↓ROM & Muscle Wasting**
    - **Bony Overgrowths (Osteophytes) → Nodules** – ("*Bouchard's Nodes*" in PIP Joints & "*Heberton Nodes*" in DIP joints, or "*Bunions*" in the Toes).
- **Diagnosis:**
  - Normal Bloods
  - **Imaging –** (Narrowing Joint Space, "Joint Lipping", Ankylosis & **Varus Deformity**)
- **Treatment:**
  - **SIMPLE Analgesia (*Panadol Osteo*)**
  - **Surgery** – (***Joint Replacement*** / ***Spinal Fusion***)
  - ***Maintain Physical Activity***

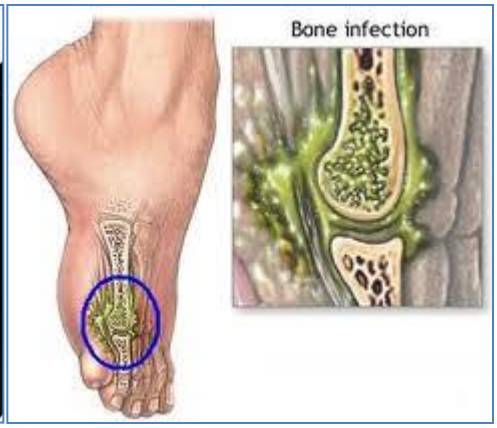


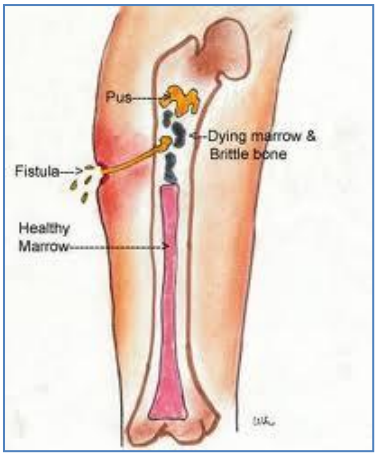


MUSCULOSKELETAL Pathology:
OSTEOMYELITIS

OSTEOMYELITIS:

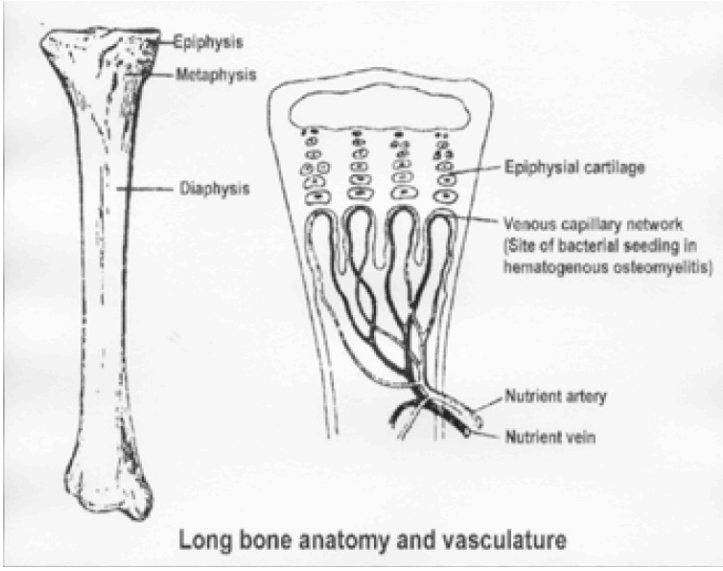
- **Aetiology:**
  - Bone Infection – Bacterial, Viral or Fungal.
- **Pathogenesis:**
  - **Bacterial –** S.aureus (Commonest), Pseudomonas (Iatrogenic), H.influenzae (Children)
- **Morphology:**
  - **Macro:**
    - Local Swelling & Redness
  - **Micro:**
    - Medullary Inflammation & Oedema
- **Clinical Features:**
  - History of Infection @ Another Site + Direct Trauma to the Area
  - Local Tenderness, Swelling, Heat at Metaphysis & ↓ROM.
  - **(+ Signs of Acute Sepsis – Fever, Chills, Dehydration, Lethargy)**
- **Diagnosis:**
  - **Blood -** ↑ESR, ↑WBC, ↑CRP, Positive Cultures
  - **X-Ray –** Normal if Acute; Lucencies after 2-4wks; "Onion-Skin" Appearance if Chronic
  - **CT/MRI –** Medullary Oedema, Cortical Destruction & Articular Damage.
- **Treatment:**
  - **Long Course IV Antibiotics** (4-6wks) – ***Rifampicin*** / ***Erythromycin*** / ***Tetracycline*** / ***Vancomycin***
  - ***Irrigation***/***Debridement***/***Amputation***
  - ***Replacement of Affected Prostheses***



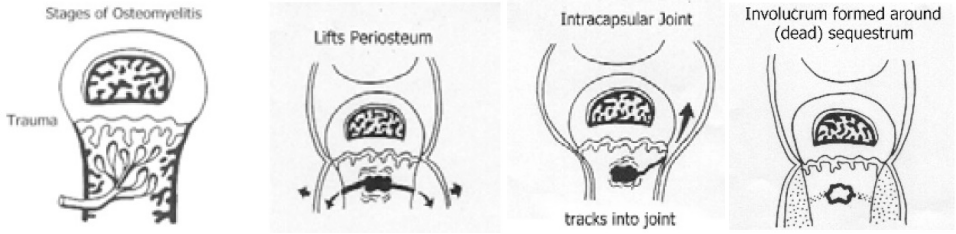


BONE INFECTIONS (Osteomyelitis):

- **Anatomy & Vascular Supply of a Long Bone:**
  - **Epiphysis**
    - Epiphysial Cartilage
  - **Metaphysis**
  - **Diaphysis**

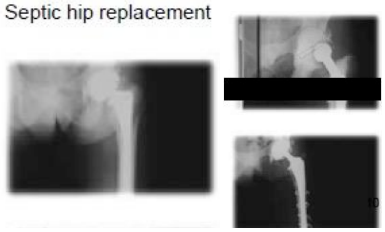


- **Osteomyelitis:**
  - **Typical Causative Organisms:**
    - *S. aureus*
    - *Group B streptococci*
    - *E. coli*
  - **Stages of Osteomyelitis:**

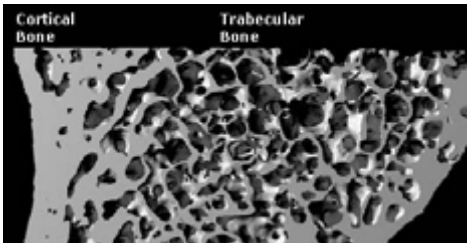


  - **Acute Vs Chronic:**
    - **ACUTE:**
      - Represents the clinical picture of infection in its early stage and usually includes systemic effects
    - **CHRONIC (If Untreated):**
      - An infection that is well established in bone (weeks – years)
      - Results when bone tissue dies as a result of the lost blood Supply

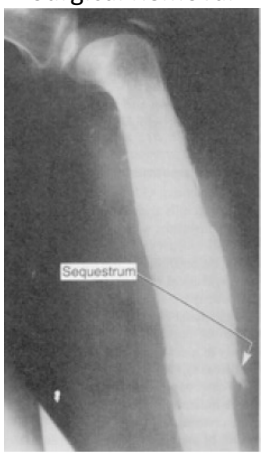
- **Source of Infection:**
  - **(1) External Sources** – Ie. Direct introduction from environment (trauma, iatrogenic)
    - **Penetrating Wound**
      - Foreign Object – Nail/Bullet/Thorn etc.
    - **Postoperative**
      - - fracture, prosthesis



- **(2) Haematogenous (Internal) Sources** – (Eg. Infected soft tissues/Bacteraemia):
  - **Mechanism of Haematogenous Infection:**
    - Infection tends to occur @ the Epiphysis where there is Rich Blood Supply.
    - **"Sludging" =**
      - Slowing of capillary blood-flow @ the distal Metaphysis
      - → Predisposes vessels to thrombosis
      - → Localized Bone Necrosis & Bacterial Seeding.
  - **Age & Anatomy Affects Location & Mechanism of Infection:**
    - **In Infants:**
      - Soft, Spongy Bone
      - Have a Loose Connection between the Periosteum & Cortex
        - →Means that infections can spread to Sub-Periosteal Space
        - →Results in abscesses in the Sub-Periosteal Space
          - →Inappropriate bone formation occurs
          - →Results in Involucrum



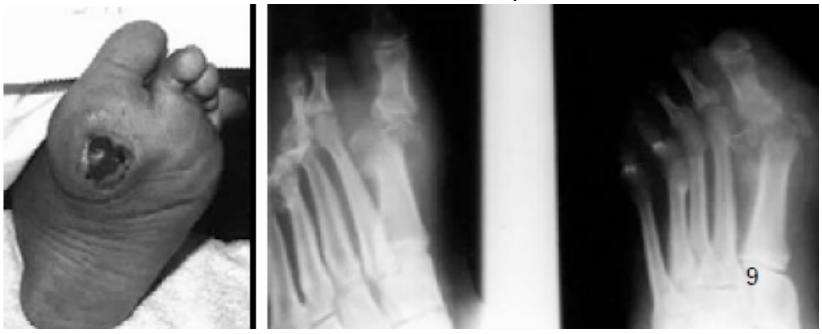
    - **In Children:**
      - Structure:
        - Bone is more calcified
        - Periosteum adhered to cortex
        - No Blood Vessels connecting metaphysis & epiphysis
      - Infection→Infection contained in metaphysis
        - → Leads to increased pressure & vascular occlusion
          - →Results in bone necrosis (sequestrum)
      - Treatment:
        - Surgical Removal



- **In Adults:**
  - Different Presentation:
    - Rarely involve long bones (Cf Infants & Children)
    - Instead, typically involve vertebrae → Can cause Vertebral Fusion
  - Begins in disc space & spreads to vertebrae above & below

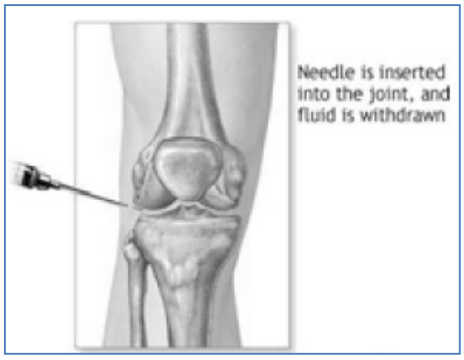
(fusion of the C 6/7 disc space - caused by a previous pyogenic infection which had resolved)

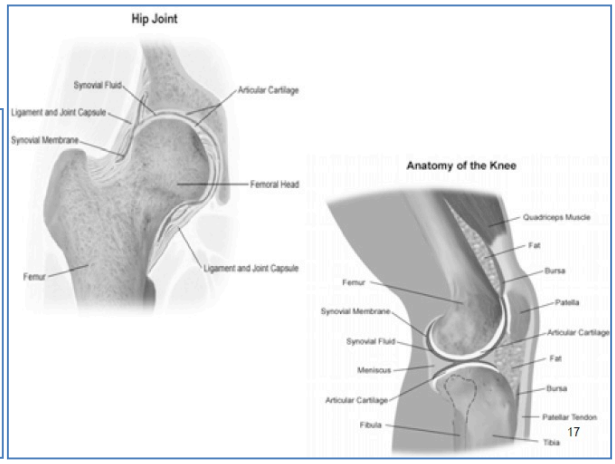
- **In Diabetics:**
  - Diabetes →
    - vascular insufficiency
    - nerve damage
  - Pathogenesis:
    - usually begin as soft tissue infections on the feet
    - penetrate into bone
    - Poor Blood Supply → ↓Immune Barriers
  - Treatment: Difficult – necrotic bone with poor blood supply
    - phagocytes & antibiotics can't get to Site.
    - debridement/amputation



INFECTION OF JOINTS:

- **Things to Find Out:**
  - **Is it infectious?**
  - **How did it get that way?**
  - **What is the infecting organism?**
- **Answered by:**
  - Patient history
  - Physical examination
  - Analysis of joint aspirate





- **Eg. Septic Arthritis:**
  - **Pathophysiology:**
    - Purulent invasion of a joint by an infectious agent → joint Inflammation (Arthritis)
  - **Causative Organisms**:
    - Commonly Gram Positive Aerobes (80%)
      - *Staphylococcus aureus* (60%)
      - *Streptococcus pneumoniae*

- **(NB: "*Reactive Arthritis*"):**
  - Reactive Arthritis = Arthritis caused by an immune consequence of an infection, but not directly attributable to the infection itself.

Infections of Muscle:

- ~~Myalgia~~ = muscle ache/stiffness
- **Myositis** = infection of the muscle (skeletal)
  - single or multiple muscle groups
- **Spread via:**
  - Soft tissue infection
    - - gas gangrene (*C. perfringens*)
    - - abscesses (*S. aureus*, GAS)
  - Haematogenous (Ie. Bacteraemia)

- **Muscle Abscesses:**
  - **Presentation:**
    - Muscle & Joint Pain for a few days
    - Swelling Develops
  - **Pathogenesis:**
    - Infection spreads along plane of muscle
    - Necrotic Muscles don't Regenerate → Local Wasting & Deformity
  - **Diagnosis:**
    - Ultrasound – Look for discrete fluid collections → Aspirate for diagnosis or drained therapeutically

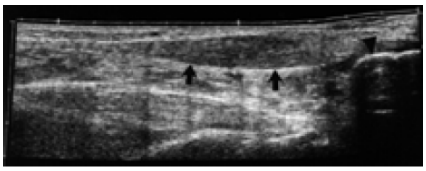


Image showing abscess (arrowheads) anterior to the sternum (curved arrows) and extending to the right of the midline.

Percutaneous aspiration yielded pus that grew *Staphylococcus aureus*

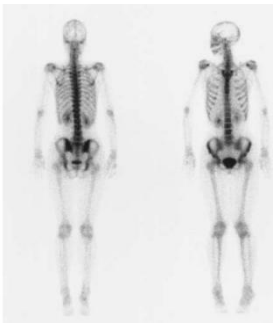
MUSCULOSKELETAL Pathology:
OSTEOPOROSIS & PAGETS DISEASE

OSTEOPOROSIS ("Porous Bones"):

- **WHO: "Osteoporosis" = "A Bone Mineral Density of >-2.5 StDs below the mean BMD"**
  - **NB: "Osteopenia" =** "A BMD of *between* -1.0 & -2.5 StDs below the mean BMD"
- **Aetiology:**
  - **Primary:**
    - **Type 1: Postmenopausal Osteoporosis** (Typically Vertebrae & NOF; females only)
      - ↓Oestrogen → ↑Osteoclast Activity
    - **Type 2: Or Senile Osteoporosis** (Affects all bones, males & females)
      - ↓Synthetic/Replicative Ability of Osteoblasts → ↓Osteoblast Activity
  - **Secondary:**
    - Endocrine (Cushings, ↑PTH, Hyper & Hypo thyroid, DM, Acromegaly, Addisons)
    - Pregnancy & Lactation
    - Myeloma
    - Malnutrition/Malabsorption
    - Drugs (Corticosteroids, Chemo, etc)
    - Alcohol
    - Immobility
- **Pathogenesis:**
  - **↑Osteoclast/↓Osteoblast Function Imbalance → ↑Bone Resorbtion →**
    - →Porous Bones
    - →↓Bone Mass (Bone Mineral Density)
- **Morphology:**
  - Trabeculae are Thinner & Fewer than Normal
- **Clinical Features:**
  - **Symptoms:**
    - Often Asymptomatic until Fracture.
  - **Complications:**
    - **"Fragility Fractures" – (= Fractures from minimal trauma – Eg. From standing height)**
      - **NB: Rel-Risk DOUBLES with every 1.0 StDeviation Below the Mean!!**
      - (<30% Mortality in Elderly; 40% Morbidity)
    - **Vertebral Compression Fracture can →** *Spinal Cord Compression, Cauda Equina Syndrome*
- **Investigations:**
  - **(Plain XRay)**
  - ****DXA (*Dual-energy X-ray Absorptiometry*) Bone-Mineral-Density Scan:**
    - ****ESSENTIAL: Lumbar Spine + Hip**
    - ***OPTIONAL: Forearm**
    - **Interpretation of T-Scores & Z-Scores:**
      - **T-Score = Pt's BMD Vs. *Young-Normal* BMD**
        - Used only for Post-Menopausal Women
      - **Z-Score = Pt's BMD Vs. *Age-Matched Mean* BMD**
        - Used only for people <50yrs (Pre-menopausal Women, Men, & Children)
  - **+ Ix for underlying cause:**
    - ESR (Exclude Myeloma)
    - Vit.D Level (Exclude 2^{o} Osteoporosis)
    - PTH Level (Exclude Hyperparathyroidism)
    - TSH Level (Exclude Hyperthyroidism)
- **Treatment & Prevention:**
  - **Pharmacological:**
    - ****Bisphosphonates** (Eg. *Alendronate [Fosamax], Risedronate)* – (Monthly Dose)
    - **Or *Stronium* →** (Stimulates Ca-Deposition & Inhibits Bone Resorption)
    - **+/- Hormonal – (*SERMS* (Eg. *Raloxifene*) or HRT (If Perimenopausal/Post-Menopausal))**
  - **OTC Supplements – (Calcium & Vit D)**
  - **Occupational – (*Reduce Falls Risk*, *↑Weight-Bearing Exercise*)**

PAGET'S DISEASE OF THE BONE:

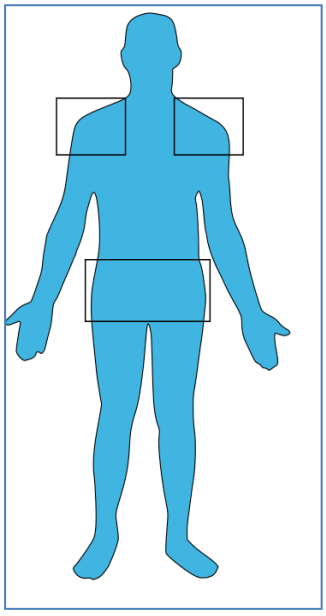
- **Aetiology:**
  - Genetic
- **Pathogenesis:**
  - **Continuous Remodelling of Bone** (Excess Turnover) → Weak, Deformed Bones & Arthritis.
- **Morphology:**
  - Markedly Thick, Deformed bones
- **Clinical Features:**
  - **May affect One or All bones**
  - **Young-middle age**
  - **Symptoms:**
    - Bone Pain, Arthritis
    - Pathological Fractures (Thick Bones, but Fragile)
    - Sclerosis, Deformity
    - Nerve Compression, Deafness
- **Diagnosis:**
  - XRay:
    - - Advancing Osteolytic Areas in Long Bones or Skull
    - – Compensatory Osteoblastic activity → Bone Thickening
  - ↑Alkaline Phosphatase Level (with normal Ca & PO4)
- **Complications:**
  - ***Osteosarcoma***
- **Treatment:**
  - ***Bisphosphonates*** (Kills Osteoclasts)
  - ***Calcitonin*** (Inhibits Osteoclast Activity)
- **Prognosis:**
  - No Cure
  - Good Prognosis if treated before major bone changes have occurred.

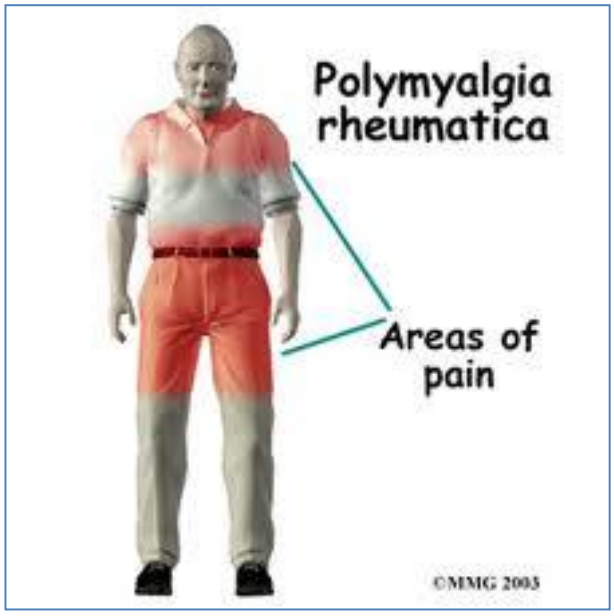



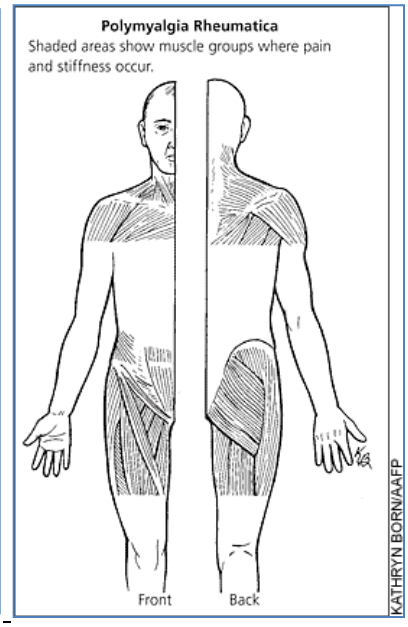
MUSCULOSKELETAL Pathology:
POLYMYALGIA RHEUMATICA

POLYMYALGIA RHEUMATICA (PMR):

- **Aetiology:**
  - **Unknown**
  - Association with Giant-Cell Arteritis (Temporal Arteritis – [A Vasculitis])
  - + Genetic (HLA-DR4) Susceptibility
  - + Possible Viral Trigger (Parvovirus, Parainfluenza Virus, Adenovirus)
- **Pathogenesis:**
  - Autoimmune Attack on the Joints & Muscles
- **Clinical Features:**
  - Older Females – (2F:1M, >50yrs)
  - **Severe Symmetrical *Myalgia*** (Not Arthralgia) of Proximal Extremities (Shoulder/Pelvic Girdle)
    - + Muscle Tenderness, BUT NO Weakness or Atrophy.
    - Myalgia Worst in Mornings
  - **+ Constitutional Symptoms** – (Fever, Weight Loss, Fatigue, Anorexia, Anaemia, Malaise)
- **Diagnosis:**
  - >50yrs
  - >2 Muscle Groups Affected
  - Elevated ESR & CRP
  - Responsive to Corticosteroids
  - NB: *NORMAL Creatinine Kinase*
- **Treatment:**
  - ***Corticosteroids***







MUSCULOSKELETAL Pathology:
RHEUMATOID ARTHRITIS

RHEUMATOID (AKA: "*Seropositive*") ARTHRITIS (Commonest):

- **Aetiology:**
  - **Genetic Autoimmune**
- **Pathogenesis:**
  - **Genetic (HLA-DR4 & -DR1 Genes) → Rheumatoid Factor Production (Anti-IgG Ab) → Autoimmune**
  - → Macrophage-Mediated Local Joint Inflammation & Destruction
- **Morphology:**
  - **Erosion** of the Articular Cartilage down to the bone.
  - **Pannus** – Inflamed thickened hyperplastic synovium with *papillary projections*
    - (NB: Normal synovium is very thin and smooth and shiny)
  - **Fibrous Ankylosis** (Bone Fusion)

- **Clinical Features:**
  - Chronic, Multisystem Condition
  - **Onset Age:** 20-40yrs
  - ***Symmetrical, POLY-arthritis, with Morning Stiffness.***
    - Particularly MCP & PIP Joints of the Hand
    - "Morning Stiffness" – (As with all Inflammatory Arthroses)
    - Joint Crepitus
  - **Signs:**
    - **"Swan-Neck Deformity"** – (Ulnar Deviation & Subluxation of the MCP Joints)
    - **Ankylosis** - (Fusion) & Restriction of movement → Muscle Wasting
    - **Dermatologic** - Rheumatoid Nodules (eg. Elbows)
    - **Vasculitis** - Digital Infarcts (can cause gangrene)
    - **Ophthalmologic** - Dry eyes, Scleritits
    - **Pulmonary** - Fibrosis, lung nodules, pleuritis, effusion
    - **Cardiac** - pericarditis, pericardial effusion, valvular defects, conduction defects
    - **GI** - PUD (from NSAIDS), dry mouth
    - **Renal** - Amyloidosis --> Proteinuria
    - **Hepatic** - Nodules (Nodular regenerative hyperplasia), portal fibrosis
    - **Neurologic** - Cervical spine instability, peripheral nerve entrapment
    - **Haematologic** - Lymphadenopathy, splenomegaly and leukopenia, amyloidosis, anaemia.
- **Diagnosis:**
  - **Diagnostic Criteria:**

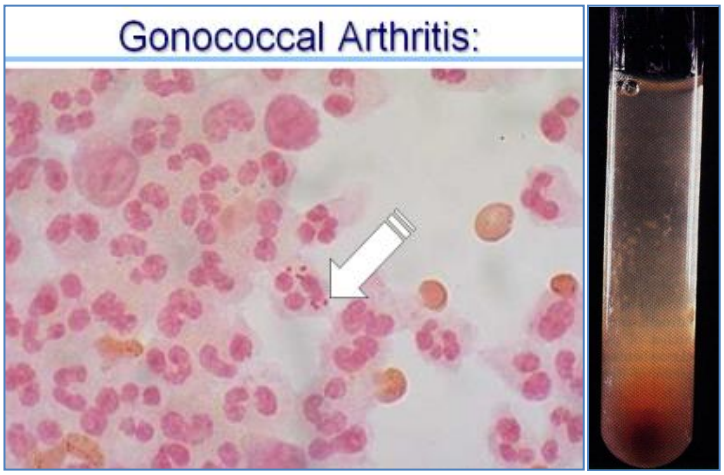
Requires 4^{+} of the Following Features for Diagnosis:
▪ Morning Stiffness
▪ >3 Joints
▪ MCP/PIP/Wrist Joints.
▪ Symmetrical Arthritis
▪ Rheumatoid Nodules in Skin
▪ RA Seropositivity (Rheumatoid Factor in Serum)
▪ X-Ray Changes: Erosions

  - **Lab:**
    - **Old - Serum Rheumatoid Factor Positive** (Anti-IgG IgM Antibodies) –Hence "Seropositive"
    - **New – ACCP** – ("Anti-Cyclic Citrullinated Peptide Antibody Test) 95% Specificity
    - **+ Elevated ESR**
- **Treatment:**
  - **DMARDS** – (***Methotrexate***, ***Sulfasalazine***)
  - **NSAIDs -** For Symptomatic Control
  - **Corticosteroids:** Short-term adjuvants.

MUSCULOSKELETAL Pathology:
SEPTIC ARTHRITIS

Septic Arthritis (Infection):

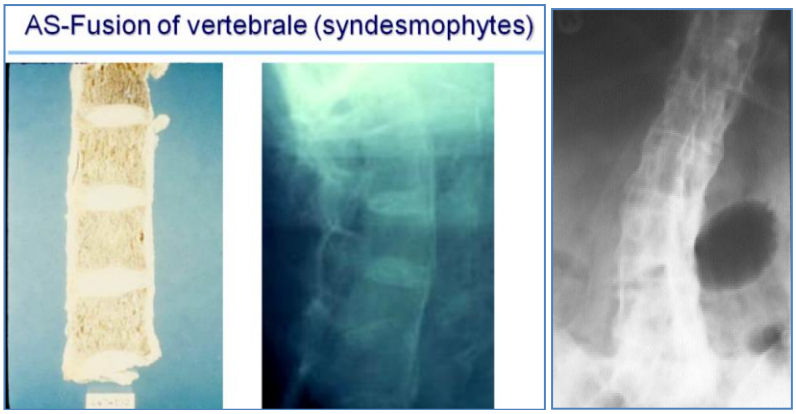
- **Aetiology:**
  - **Joint Infection**
  - **Common Bugs –** N.gonorrhoea, S.aureus, Other less commons.
- **Pathogenesis:**
  - **Routes of Spread –** Haematogenous (Commonest), Direct from Adjacent Tissue, Iatrogenic.
- **Clinical Features – A *Medical Emergency!*:**
  - **(If Gonococcal → Preceding Bacteraemia with *Maculopapulovesicular* Skin Lesions & *Migrating Polyarthritis* → Settling into Monoarthritis – Typically Knee)**
  - **Typically Severe Mono-Arthritis**. (Joint often held in slight flexion to ↓Pain)
    - Swelling
    - Erythema
    - Hot
    - ↓ROM due to Pain
  - **+ Fever + Malaise**
  - **(+/- Signs of Acute Sepsis – Fever, Chills, Dehydration, Lethargy)**
- **Diagnosis:**
  - **Joint Aspirate + MCS.**
    - (Crystals?, Gram Stain?)
  - **FBC** (↑WBC)
  - **↑ESR, CRP**
  - **Endocervical/Urethral Swab or Urine PCR for Gonococcal.**
- **Treatment:**
  - **If Gonococcal – *Azithromycin, Ceftriaxone* or *Doxycycline***
  - **If Staph – *Ampicillin*, *Erythromycin* or *Vancomycin***
  - **Analgesia**
  - **Arthroscopy – *Aspiration* & *Washout***
  - (+/- Surgical Debridement/Joint Replacement)
  - (NB: DO NOT USE Intra-Articular Steroids!!)
- **Complications:**
  - Avascular Necrosis of Femoral Head (if ↑Intra-Articular Pressure due to Pus)
  - Cartilage & Epiphyseal Destruction
  - Osteomyelitis (Bone Infection)



MUSCULOSKELETAL Pathology:
SERONEGATIVE (Non-Rheumatoid) ARTHRITIS

ANKYLOSING SPONDYLITIS – ("Fusing Spinal Arthritis"):

- **Aetiology:**
  - Genetic (HLA-B27) Association
  - 100% Concordance in Identical Twins
- **Pathogenesis:**
  - **Enthesitis (Inflammation of Ligament Insertion Points on bone)**
    - (NB: In spine: → Ossification of Outer Fibres → Bridging Syndesmophytes → Fusion)
- **Morphology:**
  - Syndesmophytes - (Bone formation between the intervertebral disks)
  - Ankylosis
- **Clinical Features:**
  - **Young Males** (3M:1F, Onset between 15-25yrs)
  - **Symptoms:**
    - **Axial:**
      - Mid-Lower Back Pain + Stiffness
      - Sacroiliitis → Persistent Buttock Pain
      - Postural Changes (↑Kyphosis)
    - **Appendicular:**
      - Asymmetric Large-Joint Arthritis (Hips & Shoulder) + Morning Stiffness:
    - **Extra-Articular Manifestations:**
      - **Ocular**: Iritis, Anterior Uveitis
      - **Heart**: Aortitis, Aortic Regurgitation, Pericarditis.
      - **Kidney**: IgA Nephropathy & Amyloidosis
- **Diagnosis:**
  - **Clinical:**
    - **↑Occiput-to-wall distance** (Kyphosis)
    - **↓ROM of Spine**
    - **↓Chest Wall Expansion**
    - **Painful Sacroiliac Joint**
  - **X-Ray:**
    - **Sacroiliac Joint:** "*Pseudowidening*" of joint due to Erosion
    - **Spine:** "*Squaring of Edges*" of Vertebral Bodies from Erosion & Sclerosis →"*Bamboo Spine*"
- **Treatment:**
  - **DMARDs (*Sulfasalazine*/*Methotrexate*) for Peripheral Arthritis**
  - ***Infliximab*** **(TNFa-Inhibitors) → Treats underlying inflammation.**
  - NSAIDs (Symptomatic Only)
  - Physio & Regular Exercise (Supportive Only)
  - **Surgery** – (Hip Replacement / Vertebral Osteotomy)
- **Prognosis:**
  - Morbidity (Due to Spinal Deformity), Not Mortality.



REACTIVE ARTHRITIS (Eg. Enteropathic Arthritis & Reiter's Syndrome):

- **= Any Arthritis FOLLOWING an INFECTION. (Eg. Rheumatic Fever, Reiter's Syndrome, etc)**
- **Aetiology:**
  - **Post-Infective – (Typically either GI or UTI):**
    - **GI:** Shigella, Salmonella, Campylobacter (Enteropathic Arthritis)
    - **UTI:** Chlamydia (Reiter's Syndrome)
  - **+ Genetic Susceptibility:**
    - HLA-B27-*Positive*, Middle-Aged Males (10M:1F, 20-40yrs)
- **Pathogenesis:**
  - Autoimmune Arthritis Initiated by Bacterial Infection
- **Clinical Features:**
  - **Onset** Within 1mth Post-Infection
  - **Duration:** Typically Self-Limiting (Weeks-Years)
  - **Symptoms:**
    - **Articular:** Asymmetric, Peripheral *Arthritis*
    - **Extra-Articular:** *Iritis/Conjunctivitis*, *Urethritis/Cervicitis (if Chlamydia)*,
- **Diagnosis:**
  - **Clinical Diagnosis Only**
  - **Reiter's Clinical Triad –** *1. Arthritis, 2. Conjunctivitis, 3. Urethritis/Cervicitis*.
  - Lab Findings are Normal
  - Cultures are Sterile
- **Treatment:**
  - **Antibiotics if Infection is Present**
  - **NSAIDs**
  - **Intra-Articular Steroid Injection**
  - **Exercise**

PSORIATIC ARTHRITIS:

- **Aetiology:**
  - Complication of Psoriasis (Unknown Aetiology – but Genetic/Immunologic Association)
- **Pathogenesis:**
  - Autoimmune T cells infiltrate the Skin & Joints → Inflammation
- **Morphology:**


- **Clinical Features:**
  - **Primary Disease – Skin:**
    - Plaque covered with Silvery Scales (Due to *Hyperkeratosis* & *Parakeratosis*)
    - Oncholysis (Nail Pitting)
  - **Multisystem Disorder:**
    - ***Symmetric Arthritis of DIP Joints** (Similar to RA) – (Seen in 30% of Psoriasis Cases)
      - + "*Dactylitis*" – (Sausage-Fingers & Sausage-Toes)
      - + (Achilles Tendonitis)
      - + (Plantar Fasciitis)
    - **Eye** – Conjunctivitis & Iritis
- **Treatment:**
  - DMARDS (***Methotrexate*** / ***Sulfasalazine***)
  - ***Corticosteroids***
  - Moisturizers
  - Phototherapy
- **Prognosis:**
  - Lifelong Condition – No Cure.

Rheumatoid Arthritis, Osteoarthritis & Gout

Case 1:

- 19yo Female
- Stiffness & Pain in Joints (Metacarpo-Phalangeal Joints, Metatarso-Phalangeal Joints & Back) all occurring at the same time
- Worse in the morning
- For long time
- No Redness/Hotness But some swelling
- No family history
- Used to play hockey
- Has been taking neurofen – Not helping much anymore.
- Noticed Dry Eyes & Dry Mouth
- **DDX:**
  - **Rheumatoid Arthritis + Sjogren's Syndrome**
  - Psoriatic Arthritis
  - SLE
  - RSI
  - Gout (If older)
- **OE:**
  - GALS
  - Hands
  - Back
- Ix:
  - ACCP – 95% Specificity (Better and cheaper than rheumatoid factor)
  - FBC
  - Uric Acid Levels (Gout)
  - ANAs (Lupus)
  - Hand, spine, feet XR
    - RA:
      - Osteophytes about the joint margins
      - Decreased Joint Space
      - Erosion
      - Increased Trabecular Thickness
    - Osteoarthritis
      - Focal Cartilage Loss
      - Subchnodral Sclerosis
    - Bone Cysts
    - Central Marginal Periosteal
    - Osteochondral Loose Bodies.
- Treatment:
  - DMARDs:
    - Sulfasalazine
    - Methotrexate
    - Imfliximab
    - Leflunomide
  - Glucocorticoids

Case 2:

- 52yr Pub Owner
- PC:
    - Walking stiffly on R-Foot
    - Sore Foot – Hard to walk on
    - 2wks duration
    - Comes and goes
    - 6mths ago started
    - No precipitating factors
    - Hurts all the time
    - Some relief with foot elevation
    - 8/10 pain on weight bearing
    - Can't wear shoes due to pain – Hurts to touch
    - Takes Panamax
    - Very Red, Very Swollen
    - Localised to the ball of the big toe.
    - Diet:
        - Eats lots of shellfish
        - Has 5-6 beers each day
        - Drinks a lot of red wine too
        - Drinks lots of tea & alcohol – Rarely drinks just water
- HPC:
    - Morbidly Obese
    - Type 2 Diabetes
- Meds:
    - Something for heart
    - Something for Blood Pressure
    - Cholesterol
    - Sugars (Type II)
    - Misses doses 2-3times/week
- FamHx:
    - Father:
        - Gout
        - Heart
    - Mother:
        - Emphysema
- Dx:
    - **Gout**

Case 3:

- 69yo
- PC:
  - Very bad joint pain – R Shoulder
  - Used to be a National Level Javelin Thrower
  - Has had several surgeries on it
  - Getting worse
  - Starting to limit range of movement in joint – cant lift further than 90
  - Has had a lot of trouble with the shoulder for >40yrs
  - Nothing really relieves the pain
  - Worse when she uses it
  - Worse towards the end of the day
  - Has broken other arm (#Radial Head) and now has some pain in the elbow
  - No Weakness in Arm
- PMH
  - None
- Meds:
  - Panadol & Neurofen
  - Glucosamine
- SurgHx:
  - R Shoulder operations
  - Arthroscopies on L Knee + washouts
  - Appendectomy
- Sochx:
  - Used to be a PE teacher
  - Lives in Townsville
- SexHx:
  - Sexually active
  - Monogomous for past 20yrs
- DDX:
  - **Osteoarthritis**
  - Rotator cuff injury
  - Bursitis
  - Frozen shoulder
  - Septic Arthritis
- Ix:
  - Examination
  - Shoulder XR
  - Rotator Cuff US

Case 4:

- A 37-year-old woman gradually developed painful wrists over 3 months; she consulted her doctor only when the pain and early morning stiffness stopped her from gardening.
- On examination, both wrists & metacarpophalangeal joints of both hands were swollen and tender but not deformed.
- She had raised C-reactive protein (CRP) level (27mg/l) (NR <10) but a normal haemoglobin and white-cell count. A latex test for rheumatoid factor was negative and antinuclear antibodies were not detected.
- **? Degenerative or Inflammatory** (morning / through the day)
- **? Mono or poly arthritis**
- Diagnosis ? early rheumatoid arthritis
- Treated with ibuprofen. Despite some initial symptomatic improvement, the pain, stiffness and swelling of the hands persisted and 1 month later both knees became similarly affected. She was referred to a rheumatologist.
- This woman now had definite X-ray evidence of *rheumatoid arthritis* and, in view of the continuing arthropathy, her treatment was changed to weekly low-dose methotrexate. This has controlled the arthritis for several years and no further erosions have developed.

Case 5:

- A 21y man presented with acute pain and swelling of one knee. On examination, the joint was tender and restricted in movement. X-ray of the knee showed periarticular osteoporosis. No history of trauma.
- He has had intermittent backache over the last 5 years, although daily exercises have limited the stiffness.
- On investigation, he had a raised ESR of 102mm/h, mild anaemia (Hb 106g/l) but no detectable serum rheumatoid factor. The knee effusion contained a polymorphonuclear leucocytosis but no organisms or rheumatoid factor. No diagnosis was made but he improved with empiric treatment with indomethacin.
- Fifteen months later he developed an iritis in his left eye, low back pain and stiffness.
- His peripheral joints were normal but pain could be elicited in both sacroiliac joints.
- tissue typing revealed that he was HLA-B27 positive.
- X-rays of his pelvis showed the classic changes of ankylosing spondylitis and He has developed bony ankylosis between the lumbar vertabrae.
- Six months later, she developed two subcutaneous small, painless, firm immobile, nodules on the left elbow.
- A test for rheumatoid factor was now positive (titre 1/64). X-rays of the hands showed bony erosions in the metacarpal heads.
- She still had a raised CRP (43mg/l) but normal serum complement (C3 and C4) levels and, she had a biopsy which showed pannus histologically.

- **Arthritis General:**
  - **Simple Diagnostic features:**
    - Pain (Due to Inflammation of Joint Capsule, Synovium &/or Periosteum)
    - Swelling (Due to Inflammation &/or Effusion)
    - Restrictive movement (Due to Pain, Fluid, Swelling or Damage)
    - Deformity (Due to Mal-alignment, Erosion, Ankylosis) – (usually a late sign)
  - **Monoarthritis (Local, Asymmetric):**
    - Eg. Septic
    - Eg. Trauma
    - Eg. Osteoarthritis
    - Eg. Tumour
    - Eg. Crystal (Gout)
  - **Polyarthritis (Chronic & Symmetrical):**
    - Eg. Autoimmune (RA, Ankylosing Spondylitis, Reiter's/Reactive)
    - Eg. Degenerative (Osteoarthritis)
    - Eg. Crystal (Gout)

Table 2. HLA-Associated Rheumatic Disease

HLA Type	Associated Conditions	Comments
B27	Ankylosing spondylitis Reiter's syndrome Psoriatic arthritis IBD arthropathy (spine)	In AS, relative risk = 70-90 In Reiter's, relative risk = 40 Psoriatic also associated with B38
DR4, DR1	Rheumatoid arthritis	93% of patients have HLA type
DR3	Sjögren's syndrome SLE Rheumatoid arthritis	DR3 associated with many non-rheumatic conditions (celiac disease, Type 1 DM, Graves' disease, chronic active hepatitis)

Degenerative Vs. Inflammatory

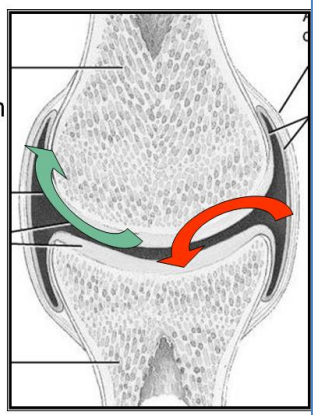
- Both sexes equal.
- Pain through the day
- No morning stiffness.
- Stiffness, less pain.
- Bony swelling.
- No soft tissue swelling
- Uni/Bilateral, Asymmetrical.

- Females more.
- Morning stiffness >1h.
- Less with movement.
- Pain & redness
- Inflammation & swelling of soft tissue.
- Late bone swelling.
- Bilateral, Symmetrical.

Differentiating Features:

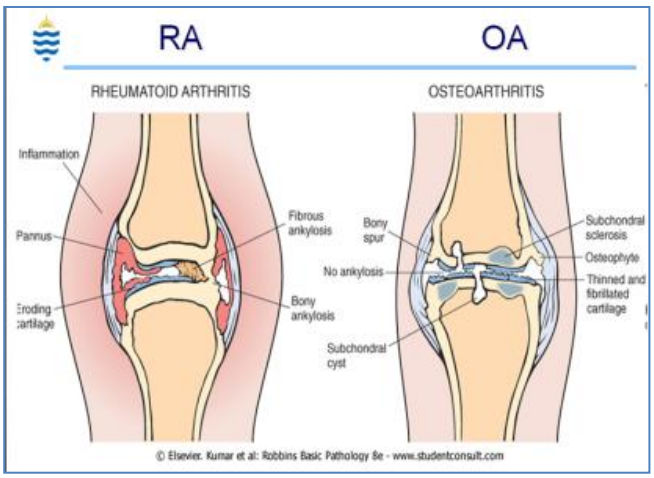
Rheumatoid Arthritis:

- Young, small joints
- Autoimmune.
- Synovial Inflammation
- **synovium → Cartilage**



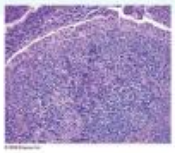
Osteoarthritis:

- Old, Large joints
- Degenerative.
- Cartilage degeneration.
- **Cartilage → Synovium**



Arthritis Comparison:

OA	RA	Gout/Pseudogout
Loss of articular cartilage. irregular joint surface, osteophytes bone cysts fibrillation of cartilage thickening of the trabeculae ('eburnation')	Synovial hyperplasia, inflammation. Lymphoplasmacytic RH nodules Pannus over cartilage Subchondral sclerosis. Fibrous /bony ankylosis.	Crystals + inflammation Gout Tophus - Urate. Pseudo: Ca pyrophosphate


A 86 year man, recurrent attacks of knee pain lasting 3 days to over week since several months usually improves with ibuprofen. Image shows knee x-ray. What is the most likely diagnosis?

A. Osteoarthritis.
B. Septic arthritis.
C. Rheumatoid arthritis.
D. Traumatic Meniscal tear.
E. Pseudogout.

A. Briefly discuss pathogenesis of this condition?
B. List 2 gross and Microscopic feature of this disease?
C. List other clinical features & how do you differentiate from Gout/RA/OA?

MCQ- Apart from male sex, The presence of which of the following is helpful in the diagnosis of ankylosing spondylitis?

1. A Serum antinuclear antibodies
2. B Rheumatoid factor in the serum
3. C HLA-B27
4. D Male sex
5. E HLA-B8

A 67 year woman, 1 day history of severe painful left big toe. No history of trauma, Enjoyed a sumptuous party last nite with her friends. His mild hypertension is well controlled by daily bendroflumethiazide tablet, otherwise well. Examination shows left toe hot, red and tender. Right toe has no pain but slight tenderness on movement. Image shows clinical photo & X-ray. What is the most likely diagnosis?

A. Osteoarthritis.
B. Septic arthritis.
C. Rheumatoid arthritis.
D. Gout.
E. Pseudogout.

A. Briefly discuss pathogenesis of this condition?
B. What condition has precipitated this attack? List more conditions?
C. Briefly describe 3 microscopic features of this condition?

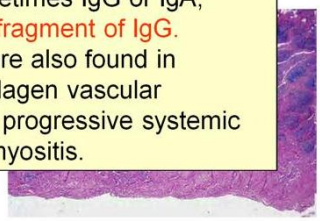
40year old woman arthritis:

- A 40-year-old woman complains of morning stiffness in her hands. On physical examination, her finger joints are painful, swollen, and warm. X-ray examination of the hands shows narrowing of the joint spaces and erosion of joint surfaces of the metacarpal/phalangeal joints. The adjacent bones show osteoporosis.

6

Image shows synovial biopsy. Laboratory studies conducted on a blood sample from this

DISCUSSION:
Some 80% of patients with classic RA are positive for rheumatoid factor (RF). This factor actually represents multiple antibodies, principally IgM, but sometimes IgG or IgA, directed against the Fc fragment of IgG. Significant titers of RF are also found in patients with related collagen vascular diseases, such as SLE, progressive systemic sclerosis, and dermatomyositis.



A 38 year old man swelling and pain in his hands, worse in the morning. P/E Fingers show tender sausage like swelling. His nails show pitting and destruction (apparently not improved by antifungal cream he is applying for 6 months). Image shows clinical photo & X-ray. What is the most likely diagnosis?

A. Fungal infection-Arthritis.
B. Rheumatoid arthritis.
C. Septic arthritis.
D. Enteropathic arthritis.
E. Psoariatic arthritis.

A. Briefly discuss Enteropathic arthritis?
B. List 3 Microscopic features? List 3 complications of this condition? (RA)
C. List types of Immune arthritis? What is sero '+ve' & sero '-ve' arthritis?

NB: The first slide is Actually Pseudogout, Not Rheumatoid Arthritis

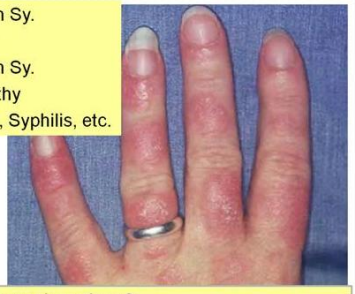
Serological findings in patients with systemic lupus erythematosus (SLE) may include:

A. **A raised serum IgG level**
B. **Antibodies to double-stranded DNA**
C. **Decreased C3 and C4 levels**
D. **A 'positive' VDRL**
E. **Antibodies to platelets**
F. **All of the above.**

0% 0% 0% 0% 0% 0%
A. B. C. D. E. F.

A 29 year old woman with SLE & photosensitivity. Presents with fourth miscarriage in the last 8 years. Past history reveals two episodes of DVT one during her third pregnancy and second during flight to USA. Image shows clinical photo. What is the most likely auto antibody causing her miscarriage?

A. Anti-Ro.	• SLE, Sjogren Sy.
B. Anti-RNP.	• SLE, MCTD
C. Anti-La.	• SLE, Sjogren Sy.
D. Anti-Jo-1.	• SLE, Myopathy
E. Anti-cardiolipin	• SLE, Behcet, Syphilis, etc.



0% 0% 0% 0% 0%
A. B. C. D. E.

A. Briefly discuss pathogenesis of her miscarriage?
B. List 3 Microscopic features?
C. List 3 complications of this condition? (RA)

A 48 year old man, 10 month history of backpain & shooting pain radiating to his left leg. It is worse on prolonged sitting, forward bending and lifting weight. P/E loss of light touch over the posterolateral thigh, extending on to posterolateral calf and lateral side of foot. Image shows his MRI. What is the most likely diagnosis?

A. Osteophyte formation (OA).
B. Bony ankylosis (RA).
C. Ankylosing spondylitis.
D. Spondylolistheis.
E. Disc prolapse.

0% 0% 0% 0% 0%
A. B. C. D. E.

A. Briefly discuss risk factors & pathogenesis of this condition?
B. Write a paragraph about pathology of ankylosing spondylitis?
C. Write a paragraph about overview of pathology of "backpain" ?

A. Image shows clinical photo & X-ray. What is the most likely diagnosis?

A. Pseudo-Gout.
B. Osteoarthritis.
C. Rheumatoid Arthritis.
D. Psoariatic Arthritis.
E. Gout.

0% 0% 0% 0% 0%
A. B. C. D. E.

A. Briefly discuss pathogenesis of this disorder?
B. List 3 Gross & 3 Microscopic features?
C. List 3 complications of this condition?

A. 18 year old boy with 4 month history of right knee pain apparently following fall during a footy match. Image shows x-ray appearance and following detailed work up resulting in major surgical resection. What is the most likely diangosis?

A. Ostesarcoma.
B. Osteomyelitis.
C. Metastases.
D. Excess osteoid formation.
E. Ewing's sarcoma

0% 0% 0% 0% 0%
A. B. C. D. E.

A. List 3 Gross & 3 Microscopic features?
B. What is the most common site of metastases ? Gene mutation?
C. What is the common risk factor if it occurs in elderly?

40year old man PAIN arm:

- A 55-year-old man presents with pain in the left arm. Laboratory studies show elevated serum levels of calcium and parathyroid hormone. An x-ray of the left arm reveals multiple small bone cysts and pathologic fractures. Biopsy of the affected bone discloses numerous giant cells in a cellular and fibrous stroma. The patient undergoes removal of a parathyroid adenoma.

W
pa
fra

A.
B.
C.
D.
E.

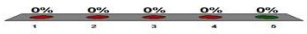
DISCUSSION:

In patients with primary hyperparathyroidism, osteoclasts are stimulated to resorb bone. As the disease progresses, the trabecular bone is resorbed, and the marrow is replaced by loose fibrosis. Cystic degeneration ultimately occurs, leading to areas of fibrosis that contain reactive woven bone, and hemosiderin-laden macrophages often display many giant cells, which are actually osteoclasts. Because of its macroscopic appearance, this lesion has been termed a brown tumor. Impaired mineralization of osteoid (choice B) is a feature of osteomalacia. Osteoporosis (choice E) is characterized by decreased, but otherwise normally mineralized, bone.

Diagnosis: Hyperparathyroidism, osteitis fibrosa cystica

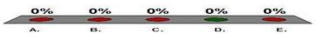
MCQ-3 Which of the following statements about rheumatoid arthritis are true?

1. Most patients progress to complete disability.
2. Oral corticosteroids form the basis of drug therapy.
3. Epstein-Barr virus is known to be the causative agent.
4. Always responds to plasma exchange therapy.
5. Serum C-reactive protein measurement is a useful measure of joint inflammation.



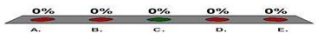
60y Man, history of recurrent arthritis since childhood. Multiple rubbery nodules on his hands (Image). Which of the following explains pathogenesis?

A. Autoimmune relapsing polychondritis
B. High dietary intake of purine-rich foods.
C. Hypercalcemia & chondrocalcinosis
D. Impaired renal excretion of uric acid
E. Increased calcium hydroxyapatite deposition.



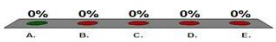
A 23y man, stiffness and pain in his lower back that causes him to awaken at night. He first noticed morning stiffness in his lower back during his college years. He also describes occasional pain in his right eye and sensitivity to light. An x-ray of the sacroiliac region shows fusion of the small joint spaces in the posterior spine and ossification of the intervertebral discs. Serologic tests for RF and antinuclear antibodies are negative. This patient most likely expresses which of the following human leukocyte antigen (HLA) haplotypes?

A. B15
B. B19
C. B27
D. B31
E. B9



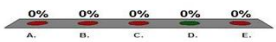
An 85-year-old man presents with a 3-week history of painful swelling of his right knee. Aspiration of joint fluid returns numerous neutrophils and crystals, which are described as rhomboid and "coffin-like." Chemical analysis shows that these crystals are composed of calcium pyrophosphate. Which of the following is the most likely diagnosis?

A. Pseudogout
B. Ankylosing spondylitis
C. Gout
D. Infectious arthritis
E. Rheumatoid arthritis



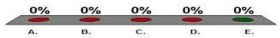
A 28-year-old man complains of burning pain on urination, as well as pain in his fingers and left eye. He also relates a recent episode of bacillary diarrhea contracted during a visit to Mexico. Physical examination confirms arthritis and conjunctivitis. The patient responds well to treatment with NSAIDs. Which of the following is the most likely diagnosis?

A. Gout
B. Pseudogout
C. Ankylosing spondylitis
D. Reiter's syndrome
E. Rheumatoid arthritis



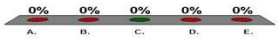
A 10-year-old boy complains of pain in his hands and feet. His temperature is 38°C (101°F). Physical examination reveals a faint pericardial friction rub. His spleen, liver, and axillary lymph nodes are enlarged. Which of the following is the most likely diagnosis?

A. Rheumatoid arthritis
B. Gaucher's disease
C. Psoriatic arthritis
D. Ankylosing spondylitis
E. Juvenile arthritis



A 24-year-old man on chronic steroid therapy for severe asthma presents with a 6-month history of increasing hip pain. This patient most likely exhibits symptoms of which of the following metabolic bone diseases?

A. Osteopetrosis.
B. Osteomalacia
C. Osteoporosis.
D. Ankylosing spondylitis
E. Paget's disease

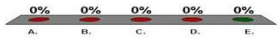


A 58-year-old woman fractures her hip after

DISCUSSION:
Osteoporosis - normally mineralized bone is decreased in mass to the point that it no longer provides adequate mechanical support. But remaining bone exhibits a normal ratio of mineralized to nonmineralized (osteoid) matrix (not choices A and C). Primary osteoporosis occurs principally in postmenopausal women (type 1) and elderly persons of both sexes (type 2). Type 1 primary osteoporosis is due to an absolute increase in osteoclast activity. The increased number of osteoclasts that appears in the early postmenopausal skeleton is the direct result of estrogen withdrawal. Type 2 osteoporosis reflects decreased osteoblast activity (therefore, not choice B). Mosaic bone formation (choice E) is a feature of Paget disease.
Diagnosis: Osteoporosis, osteopenia ← Read more…

ty.

D. Mosaic bone formation.
E. Increased osteoclast activity.



NB: Hard = Bony = Osteoarthritis
Soft = Synovitis = Inflammatory arthritis

Continue Reading For Bonus Supplementary Study Materials…

OR Orthopedics

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Hasaan Chaudhry and **Nardin Samuel,** associate editors
Alex Cressman and **Shany Gertzbein,** EBM editors
Dr. Jeremy A. Hall and **Dr. Herbert P. von Schroeder,** staff editors

Acronyms

AC	acromioclavicular
ACL	anterior cruciate ligament
AIN	anterior interosseous nerve
AP	anterior posterior
ARDS	acute respiratory distress syndrome
AVN	avascular necrosis
CA	coracoacromial
CC	coracoclavicular
CRPS	complex regional pain syndrome
DDH	developmental dysplasia of the hip
DRUJ	distal radioulnar joint
DVT	deep vein thrombosis
EtOH	ethanol/alcohol
FAI	femoroacetabular impingement
FOOSH	fall on outstretched hand
GA	general anesthetic
HO	heterotopic ossification
I&D	incision and drainage
IM	intramedullary
LCL	lateral collateral ligament
MCL	medial collateral ligament
MT	metatarsal
MTP	metatarsophalangeal
MVC	motor vehicle collision
NVS	neurovascular status
NWB	non-weight bearing
OA	osteoarthritis
ORIF	open reduction internal fixation
PCL	posterior cruciate ligament
PE	pulmonary embolism
PIN	posterior interosseous nerve
RA	rheumatoid arthritis
ROM	range of motion
RSD	reflex sympathetic dystrophy
SCFE	slipped capital femoral epiphysis
SLAP	superior lateral, anterior posterior
SN	sensitivity
THA	total hip arthroplasty
WB	weight bearing
#	fracture

Basic Anatomy Review

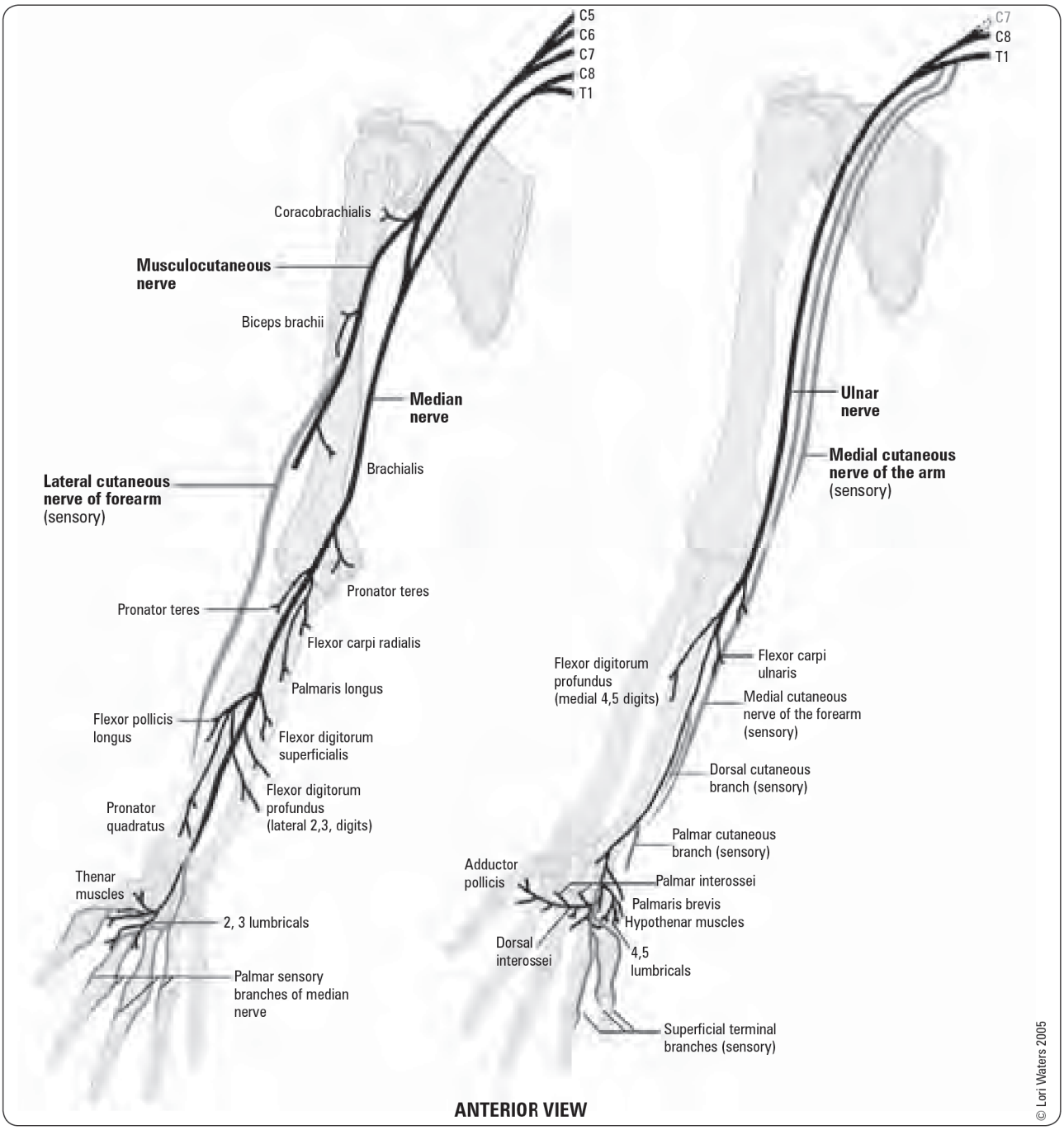


Figure 1. Median, musculocutaneous, and ulnar nerves: innervation of upper limb muscles

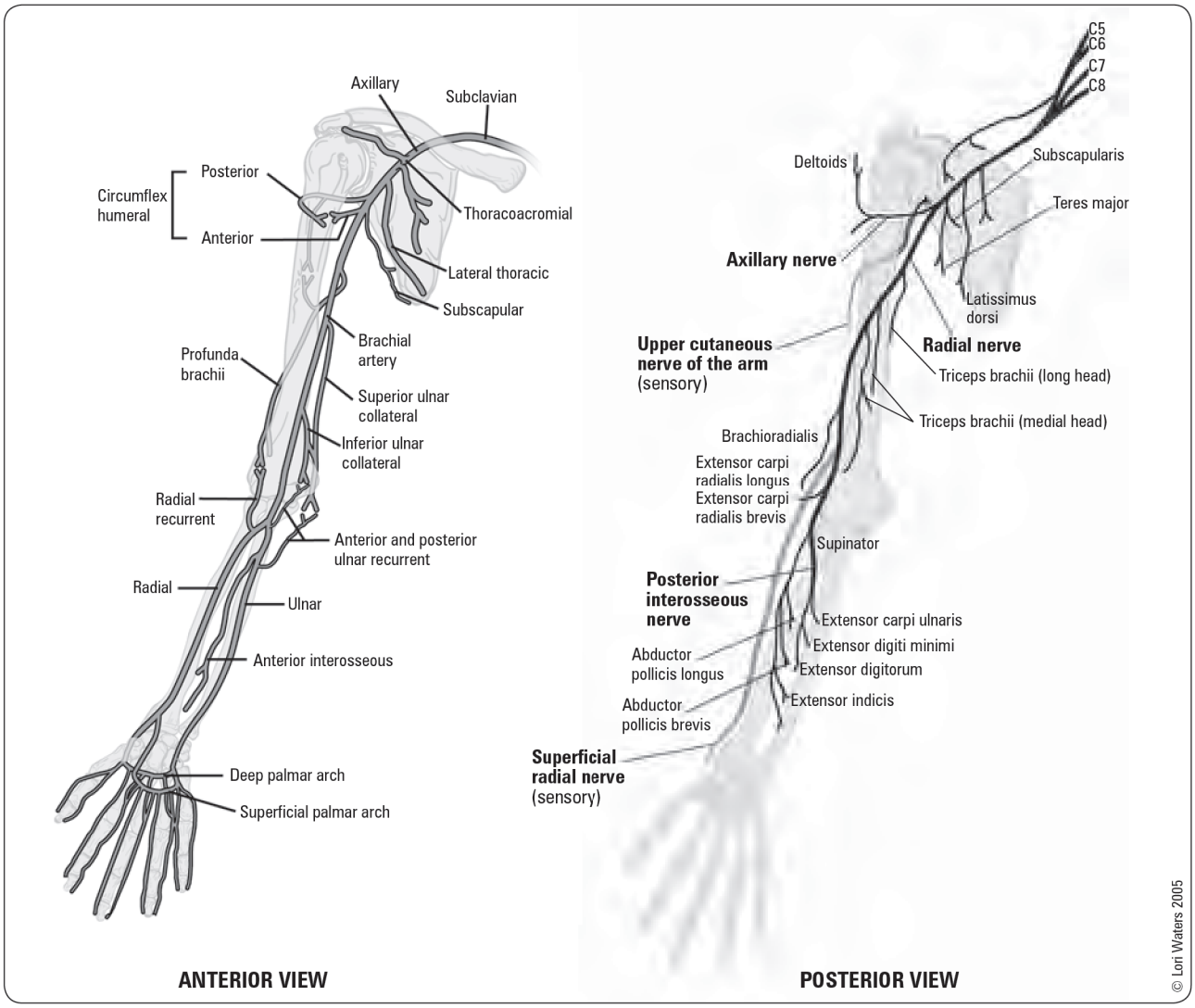


Figure 2. (Left) Blood supply to the upper limb, (Right) Axillary and radial nerves: innervation of the upper limb

Table 1. Sensory and Motor Innervation of the Nerves in the Upper and Lower Extremities

Nerve	Motor	Sensory	Nerve Roots
Axillary	Deltoid/Teres Minor	Lateral Upper Arm (Sergeant's Patch)	C5, C6
Musculocutaneous	Biceps/Brachialis	Lateral Forearm	C5, C6
Radial	Triceps Wrist/Thumb/Finger Extensors	Lateral Dorsum of the Hand Medial Upper Forearm	C5, C6, C7, C8
Median	Wrist Flexors and Abductors Flexion of the 1st-3rd Digits	Volar Thumb to Radial half of 4th Digit	C6, C7
Ulnar	Wrist Flexors and Adductors Flexion of the 4th-5th Digits	Medial Forearm Medial Dorsum and Volar of Hand (Ulnar half of 4th and 5th Digit)	C8, T1
Tibial	Ankle Plantar Flexion Knee Flexion Great Toe Flexion	Sole of Foot	L5, S1
Superficial Peroneal	Ankle Eversion	Dorsum of Foot	L5, S1
Deep Peroneal	Ankle Dorsiflexion and Inversion Great Toe Extension	1st Web Space	L5, S1
Sural		Lateral Foot	S1, S2
Saphenous		Anteromedial Ankle	L3, L4

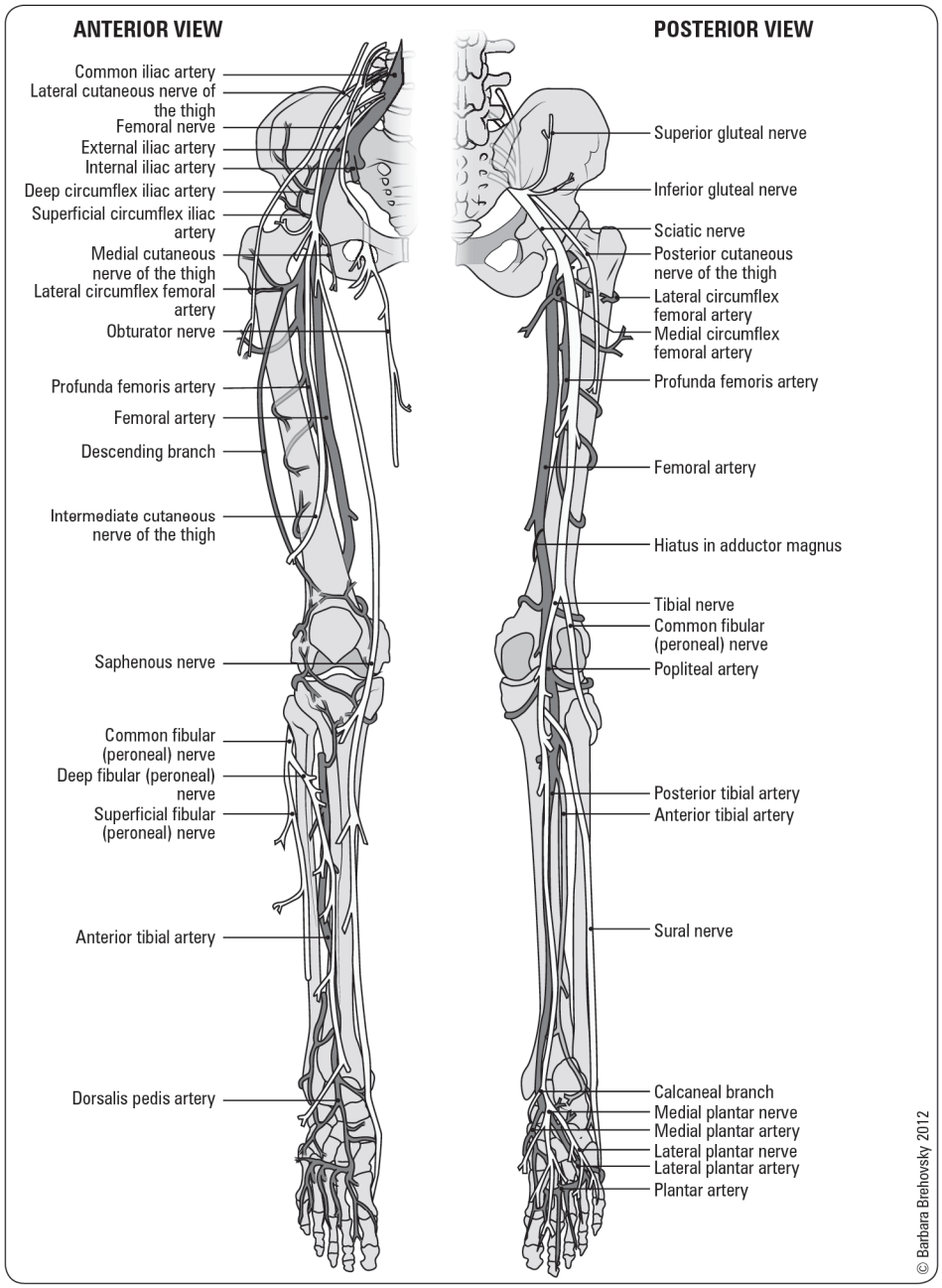


Figure 3. Nerves and arteries of lower limbs

Fractures – General Principles

Fracture Description

1. Name of Injured Bone

2. Integrity of Skin/Soft Tissue

- closed: skin/soft tissue over and near fracture is intact
- open: skin/soft tissue over and near fracture is lacerated or abraded, fracture exposed to outside environment
  - signs: continuous bleeding from puncture site or fat droplets in blood are suggestive of an open fracture

3. Location
- epiphyseal: end of bone, forming part of the adjacent joint
- metaphyseal: the flared portion of the bone at the ends of the shaft
- diaphyseal: the shaft of a long bone (proximal, middle, distal)
- physis: growth plate

4. Orientation/Fracture Pattern
- transverse: fracture line perpendicular to long axis of bone; result of direct high energy force
- oblique: angular fracture line; result of angular or rotational force
- butterfly: fracture site fragment which looks like a butterfly
- segmental: a separate segment of bone bordered by fracture lines; result of high energy force
- spiral: complex, multi-planar fracture line; result of rotational force, low energy
- comminuted/multi-fragmentary: >2 fracture fragments
- intra-articular: fracture line crosses articular cartilage and enters joint
- avulsion: tendon or ligament tears/pulls off bone fragment; often in children, high energy
- compression/impacted: impaction of bone; typical sites are vertebrae or proximal tibia
- torus: a buckle fracture of one cortex, often in children (see Figure 51, OR42)
- greenstick: an incomplete fracture of one cortex, often in children (see Figure 51, OR42)
- pathologic: fracture through bone weakened by disease/tumour

5. Alignment of Fracture Fragments
- nondisplaced: fracture fragments are in anatomic alignment
- displaced: fracture fragments are not in anatomic alignment
- distracted: fracture fragments are separated by a gap (opposite of impacted)
- impacted: fracture fragments are compressed, resulting in shortened bone
- angulated: direction of fracture apex (e.g. varus/valgus)
- translated/shifted: percentage of overlapping bone at fracture site
- rotated: fracture fragment rotated about long axis of bone

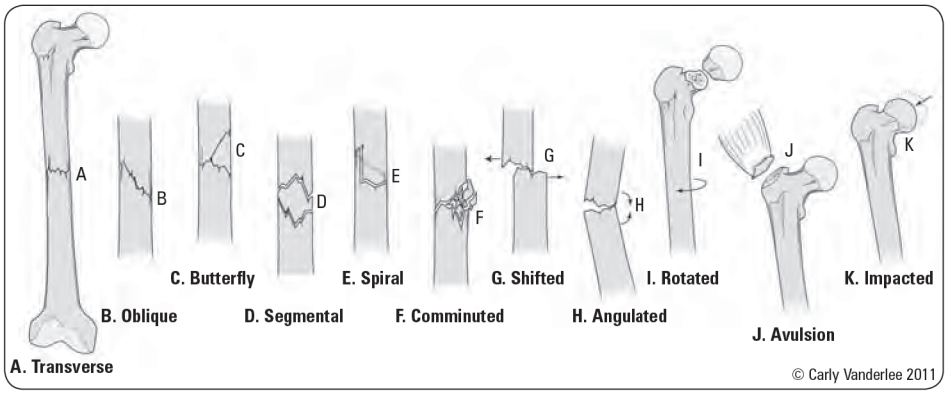


Figure 4. Fracture types

Displacement
Refers to position of the distal fragment relative to the proximal fragment

Quick Motor Nerve Exam
"Thumbs Up": PIN (Radial Nerve)
"OK Sign": AIN (Median Nerve)
"Spread Fingers": Ulnar Nerve

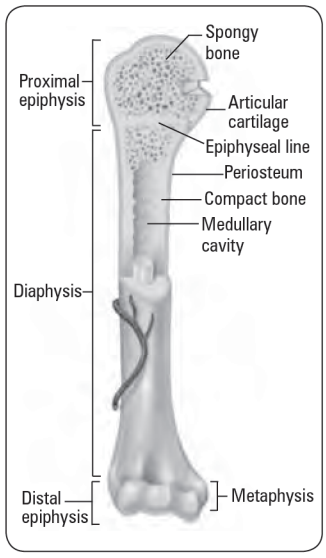


Figure 5. Schematic diagram of the long bone

Approach to Fractures

1. Clinical Assessment
- ABCs, primary survey and secondary survey (ATLS protocol)
  - rule out other fractures/injuries
  - rule out open fracture
- AMPLE history (minimum): **A**llergies, **M**edications, **P**ast medical history, **L**ast meal, **E**vents surrounding injury
  - mechanism of injury
  - previous significant injury or surgery to affected area
  - consider pathologic fracture with history of only minor trauma
- physical exam: look (deformity, soft tissue integrity); feel (maximal tenderness, NVS-document best possible neurovascular exam, avoid ROM/moving injured area to prevent exacerbation)

2. Analgesia
3. Imaging (see *Orthopedic X-Ray Imaging*, OR7)
4. Splint Extremity
5. Management: Closed vs. Open Reduction
1. obtain the reduction (for appropriate IV sedation see Table 27, OR50)
   - closed reduction
     - apply traction in the long axis of the limb
     - reverse the mechanism that produced the fracture
     - reduce with IV sedation and muscle relaxation (fluoroscopy can be used if available)

X-Ray Rule of 2s
2 sides = bilateral
2 views = AP + lateral
2 joints = joint above + below
2 times = before + after reduction

Reasons for Splinting
- Pain control
- Reduces further damage to vessels, nerves, and skin and may improve vascular status
- Decreases risk of inadvertently converting closed to open fracture
- Facilitates patient transport

- indications for open reduction
  - "NO CAST"
  - other indications include
    - failed closed reduction
    - not able to cast or apply traction due to site (e.g. hip fracture)
    - pathologic fractures
    - potential for improved function with ORIF
- ALWAYS re-check and document NVS after reduction and obtain post-reduction x-ray

2. maintain the reduction
   - external stabilization: splints, casts, traction, external fixator
   - internal stabilization: percutaneous pinning, extramedullary fixation (screws, plates, wires), IM fixation (rods)
   - follow-up: evaluate bone healing
3. rehabilitate to regain function and avoid joint stiffness

Indications for Open Reduction

NO CAST
Non-union
Open fracture
Neurovascular **C**ompromise
Displaced intra-**A**rticular fracture
Salter-Harris 3,4,5
Poly**T**rauma

Figure 6. Heterotopic ossification of femoral diaphysis after femur fracture and IM nailing

Fracture Healing

Normal Healing

Weeks 0-3	Hematoma, macrophages surround fracture site
Weeks 3-6	Osteoclasts remove sharp edges, callus forms within hematoma
Weeks 6-12	Bone forms within the callus, bridging fragments
Months 6-12	Cortical gap is bridged by bone
Years 1-2	Normal architecture is achieved through remodelling

Figure 7. Stages of bone healing

Evaluation of Healing: Tests of Union

- clinical: no longer tender to palpation or stressing on physical exam
- x-ray: trabeculae cross fracture site, visible callus bridging site on at least 3 of 4 cortices

General Fracture Complications

Table 2. General Fracture Complications

	Early	Late
Local	Compartment syndrome Neurological injury Vascular injury Infection Implant failure Fracture blisters	Mal-/non-union AVN Osteomyelitis HO Post-traumatic OA Joint stiffness/adhesive capsulitis CRPS type I/RSD
Systemic	Sepsis DVT PE ARDS secondary to fat embolism Hemorrhagic shock	

Wolff's Law
Bone remodels itself to over time in response to mechanical load to better withstand loading stressors placed upon it

Heterotopic Ossification
The formation of bone in abnormal locations (e.g. in muscle), secondary to pathology

Articular Cartilage

Properties

- 2-4 mm layer covering ends of articulating bones, provides nearly frictionless surface
- avascular (nutrition from synovial fluid), aneural, alymphatic
- composed of: collagen (90% is type II; gives tensile strength), water, proteoglycans (gives compressive strength), and chondrocytes

ARTICULAR CARTILAGE DEFECTS

Etiology

- overt trauma, repetitive minor trauma (such as repetitive ankle sprains or patellar maltracking); common sports injury
- degenerative conditions such as early stage OA or osteochondritis dissecans

Avascular Necrosis
Ischemia of bone due to disrupted blood supply; commonly in bones covered by cartilage or with distal to proximal blood supply

Fracture Blister
Formation of vesicles or bullae that occur on edematous skin overlying a fractured bone

Clinical Features
- similar to symptoms of OA (joint line pain with possible effusion, etc.)
- often have predisposing factors, such as ligament injury, malalignment of the joint (varus/valgus), obesity, bone deficiency (AVN, osteochondritis dissecans, ganglion bone cysts), inflammatory arthropathy, and familial osteoarthropathy
- may have symptoms of locking or catching related to the torn/displaced cartilage

Varus/Valgus Angulation
Varus = Apex away from midline
Valgus = Apex toward midline

Investigations
- x-ray (to rule out bony defects and check alignment)
- MRI
- diagnostic arthroscopy (treatment is often guided by what is seen during arthroscopy)

Table 3. Outerbridge Classification of Chondral Defects

Grade	Chondral Damage
I	Softening and swelling of cartilage
II	Fragmentation and fissuring < 1/2" in diameter
III	Fragmentation and fissuring > 1/2" in diameter
IV	Erosion of cartilage down to bone

Treatment
- individualized
  - patient factors (age, skeletal maturity, activity level, etc.)
  - defect factors (Outerbridge Classification, subchondral bone involvement, etc.)
- non-operative
  - rest, NSAIDs, bracing
- operative
  - microfracture, osteochondral grafting (autograft or allograft), autologous chondrocyte implantation

Orthopedic X-Ray Imaging

CRPS/RSD
An exaggerated response to an insult in the extremities; characterized by symptoms of hyperalgesia and allodynia, with signs of autonomic dysfunction (temperature asymmetry, mottling, hair or nail changes)

General Principles
- x-ray 1 joint above and 1 below
- obtain at least 2 orthogonal views ± specialized views

Table 4. Orthopedic X-Ray Imaging

Site	Injury	X-Ray Views
Shoulder	Anterior dislocation Posterior dislocation AC Frozen shoulder	AP Axillary ± stress view with 10 lb in hand Trans-scapular Zanca view (10-15 cephalic tilt)
Arm	Humerus #	AP Lateral Trans-scapular Axillary
Elbow/Forearm	Supracondylar # Radial head # Monteggia # Night stick # Galeazzi #	AP Lateral
Wrist	Colles' # Smith # Scaphoid #	AP Lateral Scaphoid (wrist extension and ulnar deviation x 2 wk)
Pelvis	Pelvic #	AP pelvis Inlet and outlet views Judet views (obturator and iliac oblique for acetabular #)
Hip	Femoral head/neck # Intertrochanteric # Arthritis SCFE FAI	AP Lateral Frog-leg lateral Dunn

Table 4. Orthopedic X-Ray Imaging (continued)

Site	Injury	X-Ray Views
Knee	Knee dislocation Femur/tibia # Patella # Patella dislocation Patella femoral syndrome Tibia shaft #	AP standing, lateral Skyline – tangential view with knees flexed at 45° to see patellofemoral joint
Ankle	Ankle #	AP Lateral Mortise view: ankle at 15° of internal rotation
Foot	Talar # Calcanial #	AP Lateral Harris Axial
Spine	Compression # Burst # Cervical spine #	AP spine AP odontoid Lateral Oblique Swimmer's view: lateral view with arm abducted 180° to evaluate C7-T1 junction if lateral view is inadequate Lateral flexion/extension view: evaluate subluxation of cervical vertebrae

Buck's Traction
A system of weights, pulleys, and ropes that are attached to the end of a patient's bed exerting a longitudinal force on the distal end of a fracture, improving its length, alignment, and rotation

Orthopedic Emergencies

Trauma Patient Workup

Etiology
- high energy trauma e.g. MVC, fall from height
- may be associated with spinal injuries or life-threatening visceral injuries

Clinical Features
- local swelling, tenderness, deformity of the limbs, and instability of the pelvis or spine
- decreased level of consciousness, hypotension/hypovolemia
- consider involvement of EtOH or other substances

Investigations
- trauma survey (see Emergency Medicine, ER2, ER15)
- x-rays: lateral cervical spine, AP chest, AP pelvis, AP and lateral of all bones suspected to be injured
- other views of pelvis: AP, inlet, and outlet; Judet views for acetabular fracture (for classification of pelvic fractures see Table 18, OR28)

Treatment
- ABCDEs and initiate resuscitation for life threatening injuries
- assess genitourinary injury (rectal exam/vaginal exam mandatory)
- external or internal fixation of all fractures
- DVT prophylaxis

Complications
- **hemorrhage – life threatening** (may produce signs and symptoms of hypovolemic shock)
- fat embolism syndrome (SOB, hypoxemia, petechial rash, thrombocytopenia, and neurological symptoms)
- venous thrombosis – DVT and PE
- bladder/urethral/bowel injury
- neurological damage
- persistent pain/stiffness/limp/weakness in affected extremities
- post-traumatic OA of joints with intra-articular fractures
- sepsis if missed open fracture

Orthopedic Emergencies

VON CHOP
Vascular compromise
Open fracture
Neurological compromise/cauda equina syndrome
Compartment syndrome
Hip dislocation
Osteomyelitis/septic arthritis
Unstable **P**elvic fracture

Antibiotics for Preventing Infection in Open Limb Fractures
Cochrane DB Syst Rev 2004;1:CD003764
Purpose: To review the evidence regarding the effectiveness of antibiotics in the initial treatment of open fractures of the limbs.
Methods: Randomized or quasi randomized controlled trials comparing antibiotic treatment with placebo or no treatment in preventing acute wound infection were identified and reviewed. Data were extracted and pooled for analysis.
Results: Eight studies (n=1,106) were reviewed. The use of antibiotics had a protective effect against early infection compared with no antibiotics or placebo (RRR=0.43, 95% CI 0.29, 0.65; ARR=0.07, 95% CI 0.03=0.10).
Conclusions: Antibiotics reduce the incidence of early infections in open fractures of the limbs.

Open Fractures

- fractured bone and hematoma in communication with the external environment

Emergency Measures
- ABCs, primary survey and resuscitation as needed
- removal of obvious foreign material
- irrigate with normal saline if grossly contaminated

33% of patients with open fractures have multiple injuries

- cover wound with sterile dressings
- immediate IV antibiotics
- tetanus toxoid or immunoglobulin as needed
- reduce and splint fracture
- NPO and prepare for OR (blood work, consent, ECG, CXR)
  - operative irrigation and debridement within 6-8 h to decrease risk of infection
  - traumatic wound often left open to drain but vacuum-assisted closure dressing may be used
  - re-examine with repeat irrigation and debridement in 48 h

Table 5. Gustilo Classification of Open Fractures

Gustilo Grade	Length of Open Wound	Description	Prophylactic Antibiotic Regimen
I	<1 cm	Minimal contamination and soft tissue injury Simple or minimally comminuted fracture	First generation cephalosporin (cefazolin) for 3 d If allergy use floroquinolone If MRSA positive use vancomycin
II	1-10 cm	Moderate contamination Moderate soft tissue injury	As per Grade I
III*	>10 cm	IIIA: Extensive soft tissue injury with adequate ability of soft tissue to cover wound IIIB: Extensive soft tissue injury with periosteal stripping and bone exposure; inadequate soft tissue to cover wound IIIC: Vascular injury/compromise	First generation cephalosporin (cefazolin) for 3 d plus Gram-negative coverage (gentamicin) for at least 3 d For soil contamination, penicillin is added for clostridial coverage

*Any high energy, comminuted fracture, shot gun, farmyard/soil/water contamination, exposure to oral flora, or fracture >8 h old is immediately classified as Grade III

Controversies in Initial Management of Open Fractures
Scand J Surg 2014;103(2):132-137
Study: Literature review examining the initial management of open fractures. 40 studies included.
Findings:
- A first generation cephalosporin (or clindamycin) should be administered upon arrival. In general, 24 h of antibiotics after each debridement is sufficient to reduce infection rates.
- Although cultures are taken from delayed (>24 h) or infected injuries, it may not be necessary to routinely take post-debridement cultures in open fractures.
- Open fractures should be debrided as soon as possible although the "6-hr rule" is not generally valid.
- Wounds should be closed within 7 d once soft tissue has stabilized and all non-viable tissue removed.
- Negative pressure wound therapy (NPWT) has been shown to decrease infection rates in open fractures.

Cauda Equina Syndrome

- see Neurosurgery, NS26

Cauda equina syndrome is a surgical emergency

Compartment Syndrome

Definition

- increased interstitial pressure in an anatomical compartment (forearm, calf) where muscle and tissue are bounded by fascia and bone (fibro-osseous compartment) with little room for expansion
- interstitial pressure exceeds capillary perfusion pressure leading to muscle necrosis (in 4-6 h) and eventually nerve necrosis

Etiology

- intracompartmental: fracture (particularly tibial shaft fractures, pediatric supracondylar fractures, and forearm fractures), reperfusion injury, crush injury, ischemia
- extracompartmental: constrictive dressing (circumferential cast, poor positioning during surgery), circumferential burn

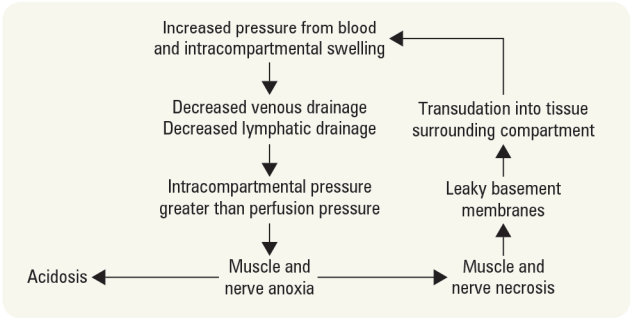


Figure 8. Pathogenesis of compartment syndrome

5 Ps of Compartment Syndrome

Pain: out of proportion for injury and not relieved by analgesics
- Increased pain with passive stretch of compartment muscles

Pallor: late finding
Paresthesia
Paralysis: late finding
Pulselessness: late finding

Clinical Features

- pain out of proportion to injury (typically first symptom)
- pain with active contraction of compartment
- pain with passive stretch (most sensitive)
- swollen, tense compartment
- suspicious history

Most important sign is increased pain with passive stretch. Most important symptom is pain out of proportion to injury

- **5 Ps**: late sign – do not wait for these to develop to make the diagnosis!

Investigations
- usually not necessary as compartment syndrome is a clinical diagnosis
- in children or unconscious patients where clinical exam is unreliable, compartment pressure monitoring with catheter AFTER clinical diagnosis is made (normal = 0 mmHg; elevated ≥30 mmHg or [measured pressure – dBP] ≤30 mmHg)

Treatment
- non-operative
  - remove constrictive dressings (casts, splints), elevate limb at the level of the heart
- operative
  - urgent fasciotomy
  - 48-72 h post-operative: wound closure ± necrotic tissue debridement

Complications
- Volkmann's ischemic contracture: ischemic necrosis of muscle, followed by secondary fibrosis and finally calcification; especially following supracondylar fracture of humerus
- rhabdomyolysis, renal failure secondary to myoglobinuria

Osteomyelitis

- bone infection with progressive inflammatory destruction

Etiology
- most commonly caused by *Staphylococcus aureus*
- mechanism of spread: hematogenous (most common) vs. direct-inoculation vs. contiguous focus
- risk factors: recent trauma/surgery, immunocompromised patients, DM, IV drug use, poor vascular supply, peripheral neuropathy

Clinical Features
- symptoms: pain and fever
- on exam: erythema, tenderness, edema common ± abscess/draining sinus tract; impaired function/WB

Diagnosis
- see Medical Imaging, MI24
- workup includes: WBC and diff, ESR, CRP, blood culture, aspirate culture/bone biopsy

Table 6. Treatment of Osteomyelitis

Acute Osteomyelitis	Chronic Osteomyelitis
IV antibiotics 4-6 wk; started empirically and adjusted after obtaining blood and aspirate cultures ± surgery (I&D) for abscess or significant involvement ± hardware removal (if present)	Surgical debridement Antibiotics: both local (e.g. antibiotic beads) and systemic (IV)

Rapid progression of signs and symptoms (over hours) necessitates need for serial examinations

Plain Film Findings of Osteomyelitis
- Soft tissue swelling
- Lytic bone destruction*
- Periosteal reaction (formation of new bone, especially in response to #)*

*Generally not seen on plain films until 10-12 d after onset of infection

Acute osteomyelitis is a medical emergency which requires an early diagnosis and appropriate antimicrobial and surgical treatment

Septic Joint

- joint infection with progressive destruction if left untreated
- risk factors: young/elderly (age >80 yr), RA, prosthetic joint, recent joint surgery, skin infection/ulcer, IV drug use, previous intra-articular corticosteroid injection, immune compromise (cancer, DM, alcoholism)

Etiology
- most commonly caused by *Staphylococcus aureus* in adults
- consider coagulase-negative *Staphylococcus* in patients with prior joint replacement
- consider *Neisseria gonorrhoeae* in sexually active adults and newborns
- most common route of infection is hematogenous

Clinical Features
- inability/refusal to bear weight, localized joint pain, erythema, warmth, swelling, pain on active and passive ROM, ± fever

Investigations
- x-ray (to rule out fracture, tumour, metabolic bone disease), ESR, CRP, WBC, blood cultures
- joint aspirate: cloudy yellow fluid, WBC >50,000 with >90% neutrophils, protein level >4.4 mg/dL, joint glucose level < 60% blood glucose level, no crystals, positive Gram stain results
- listen for heart murmur (to reduce suspicion of infective endocarditis, use Duke Criteria)

Most commonly affected joints in descending order
knee → hip → elbow → ankle→ sternoclavicular joint

Plain Film Findings in a Septic Joint
- Early (0-3 d): usually normal; may show soft-tissue swelling or joint space widening from localized edema
- Late (4-6 d): joint space narrowing and destruction of cartilage

Serial C-reactive protein (CRP) can be used to monitor response to therapy

Treatment
- IV antibiotics, empiric therapy (based on age and risk factors), adjust following joint aspirate C&S results
- non-operative
  - therapeutic joint aspiration, serially if necessary (if early diagnosis and joint superficial)
- operative
  - arthroscopic/open irrigation and irrigation and drainage ± decompression

Shoulder

Shoulder Dislocation

- complete separation of the glenohumeral joint; may be anterior or posterior

Investigations
- anterior dislocation x-rays (AP, trans-scapular, axillary views)
- posterior dislocation x-rays (AP, trans-scapular, axillary) or CT scan

Table 7. Anterior and Posterior Shoulder Dislocation

	Anterior Shoulder Dislocation (>90%)	Posterior Shoulder Dislocation (5%)
MECHANISM		
	Abducted arm is externally rotated/hyperextended, or blow to posterior shoulder Involuntary, usually traumatic; voluntary, atraumatic	Adducted, internally rotated, flexed arm FOOSH 3 Es (epileptic seizure, EtOH, electrocution) Blow to anterior shoulder
CLINICAL FEATURES		
Symptoms	Pain, arm slightly abducted and externally rotated with inability to internally rotate	Pain, arm is held in adduction and internal rotation; external rotation is blocked
Shoulder Exam	"Squared off" shoulder Positive apprehension test: patient looks apprehensive with gentle shoulder abduction and external rotation to 90° since humeral head is pushed anteriorly and recreates feeling of anterior dislocation (see Figure 13) Positive relocation test: a posteriorly directed force applied during the apprehension test relieves apprehension since anterior subluxation is prevented Positive sulcus sign: presence of subacromial indentation with distal traction on humerus indicates inferior shoulder instability (see Figure 13)	Anterior shoulder flattening, prominent coracoid, palpable mass posterior to shoulder Positive posterior apprehension ("jerk") test: with patient supine, flex elbow 90° and adduct, internally rotate the arm while applying a posterior force to the shoulder; patient will "jerk" back with the sensation of subluxation (see Figure 13) Note: the posterior apprehension test is used to test for recurrent posterior instability, NOT for acute injury
Neurovascular Exam Including	Axillary nerve: sensory patch over deltoid and deltoid contraction Musculocutaneous nerve: sensory patch on lateral forearm and biceps contraction	Full neurovascular exam as per anterior shoulder dislocation
RADIOGRAPHIC FINDINGS		
Axillary View	Humeral head is anterior	Humeral head is posterior
Trans-scapular 'Y' View	Humeral head is anterior to the centre of the "Mercedes-Benz"sign	Humeral head is posterior to centre of "Mercedes-Benz" sign
AP View	Sub-coracoid lie of the humeral head is most common	Partial vacancy of glenoid fossa (vacant glenoid sign) and >6 mm space between anterior glenoid rim and humeral head (positive rim sign), humeral head may resemble a lightbulb due to internal rotation (lightbulb sign)
Hill-Sachs and Bony Bankart Lesions	± Hill-Sachs lesion: compression fracture of posterior humeral head due to forceful impaction of an anteriorly dislocated humeral head against the glenoid rim (see Figure 12) ± bony Bankart lesion: avulsion of the anterior glenoid labrum (with attached bone fragments) from the glenoid rim (see Figure 12)	± reverse Hill-Sachs lesion (75% of cases): divot in anterior humeral head ± reverse bony Bankart lesion: avulsion of the posterior glenoid labrum from the bony glenoid rim

Posterior Shoulder Dislocation
Up to 60-80% are missed on initial presentation due to poor physical exam and radiographs

There are 4 Joints in the Shoulder
glenohumeral, AC, sternoclavicular (SC), scapulothoracic

Shoulder passive ROM: abduction – 180°, adduction – 45°, flexion – 180°, extension – 45°, int. rotation – level of T4, ext. rotation – 40-45°

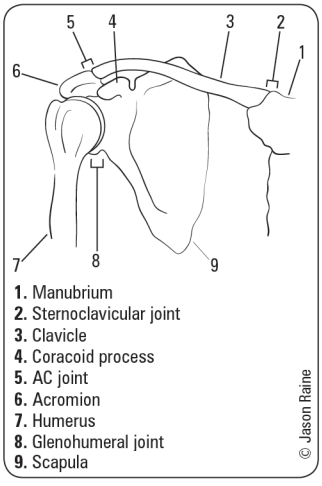


Figure 9. Shoulder joints

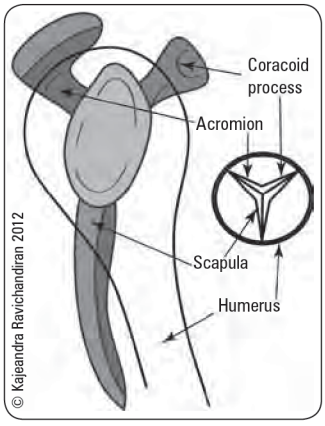


Figure 10. Mercedes-Benz

Table 7. Anterior and Posterior Shoulder Dislocation (continued)

	Anterior Shoulder Dislocation (>90%)	Posterior Shoulder Dislocation (5%)
TREATMENT		
	Closed reduction with IV sedation and muscle relaxation	Closed reduction with sedation and muscle relaxation
	Traction-countertraction: assistant stabilizes torso with a folded sheet wrapped across the chest while the surgeon applies gentle steady traction	Inferior traction on a flexed elbow with pressure on the back of the humeral head
	Stimson: while patient lies prone with arm hanging over table edge, hang a 5 lb weight on wrist for 15-20 min	
	Hippocratic method: place heel into patient's axilla and apply traction to arm	
	Cunningham's method: low risk, low pain; if not successful try above methods	
	Obtain post-reduction x-rays	
	Check post-reduction NVS	Obtain post-reduction x-rays
	Sling x 3 wk (avoid abduction and external rotation), followed by shoulder rehabilitation (dynamic stabilizer strengthening)	Check post-reduction NVS
		Sling in abduction and external rotation x 3 wk, followed by shoulder rehabilitation (dynamic stabilizer strengthening)

Factors Causing Shoulder Instability
- Shallow glenoid
- Loose capsule
- Ligamentous laxity

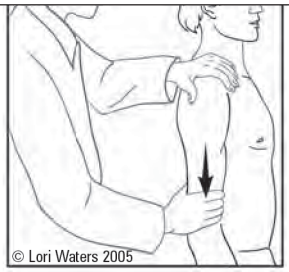
Frequency of Dislocations
- Anterior shoulder > Posterior shoulder
- Posterior hip > Anterior hip

The glenohumeral joint is the most commonly dislocated joint in the body since stability is sacrificed for motion

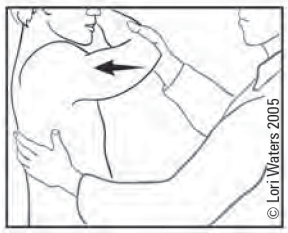
Prognosis
- recurrence rate depends on age of first dislocation
  - <20 yr = 65-95%; 20-40 yr = 60-70%; >40 yr = 2-4%

Specific Complications
- rotator cuff or capsular or labral tear (Bankart/SLAP lesion), shoulder stiffness
- injury to axillary nerve/artery, brachial plexus
- recurrent/unreduced dislocation (most common complication)

Anterior apprehension sign



Sulcus sign



Posterior apprehension sign

Traction-Countertraction

Figure 12. Shoulder maneuvers

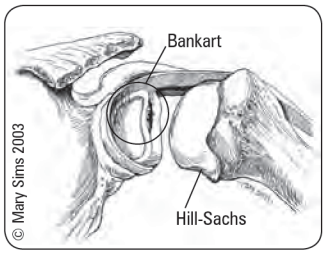


Figure 11. Posterior view of anterior dislocation causing Hill-Sachs and Bankart lesions

Rotator Cuff Disease

- rotator cuff consists of 4 muscles that act to stabilize humeral head within the glenoid fossa

Table 8. Rotator Cuff Muscles

Muscle	Muscle Attachments		Nerve Supply	Muscle Function
	Proximal	Distal		
Supraspinatus	Scapula	Greater tuberosity of humerus	Suprascapular nerve	Abduction
Infraspinatus	Scapula	Greater tuberosity of humerus	Suprascapular nerve	External rotation
Teres Minor	Scapula	Greater tuberosity of humerus	Axillary nerve	External rotation
Subscapularis	Scapula	Lesser tuberosity of humerus	Subscapular nerve	Internal rotation and adduction

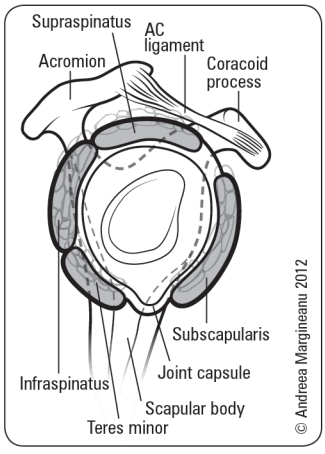


Figure 13. Muscles of the rotator cuff

SPECTRUM OF DISEASE: IMPINGEMENT, TENDONITIS, MICRO OR MACRO TEARS

Etiology

- outlet/subacromial impingement: "painful arc syndrome", compression of rotator cuff tendons (primarily supraspinatus) and subacromial bursa between the head of the humerus and the undersurface of acromion, AC joint, and CA ligament
  - leads to bursitis, tendonitis, and if left untreated, can lead to rotator cuff thinning and tear
- anything that leads to a narrow subacromial space
  - glenohumeral muscle weakness leading to abnormal motion of humeral head
  - scapular muscle weakness leading to abnormal motion of acromion
  - acromial abnormalities such as congenital narrow space or osteophyte formation or Type III acromion morphology

Bigliani Classification of Acromion Morphology
- Type I – flat
- Type II – curved
- Type III – hooked

Clinical Features

- insidious onset, but may present as an acute exacerbation of chronic disease, night pain and difficulty sleeping on affected side
- pain worse with active motion (especially overhead); passive movement generally permitted
- weakness and loss of ROM especially between 90°-130° (e.g. trouble with overhead activities)
- tenderness to palpation over greater tuberosity
- rule out bicep tendinosis: Speed and Yergason's tests; SLAP lesion: O'Brien's test

Screening Out Rotator Cuff Tears
- No night pain (SN 87.7%)
- No painful arc (SN 97.5%)
- No impingement signs (SN 97.2%)
- No weakness

Returning to the bedside: Using the history and physical examination to identify rotator cuff tears *JAM Geri Soc* 2000;48:1633-1637

Investigations

- x-ray: AP view may show high riding humerus relative to glenoid indicating large tear, evidence of chronic tendonitis
- MRI: coronal/sagittal oblique and axial orientations are useful for assessing full/partial tears and tendinopathy ± arthrogram: geyser sign (injected dye leaks out of joint through rotator cuff tear)
- arthrogram: can assess full thickness tears, difficult to assess partial tears

Rotator Cuff Muscles

SITS
Supraspinatus
Infraspinatus
Teres minor
Subscapularis

Treatment

- non-operative
  - physiotherapy, NSAIDs ± steroid injection
  - for mild ("wear") or moderate ("tear") cases
- operative
  - indication: severe ("repair")
    - impingement that is refractory to 2-3 mo physiotherapy and 1-2 corticosteroid injections
  - arthroscopic or open surgical repair (ie. acromioplasty, rotator cuff repair)

Table 9. Rotator Cuff Special Tests

Test	Examination	Positive Test
Jobe's Test	Supraspinatus: place the shoulder in 90° of abduction and 30° of forward flexion and internally rotate the arm so that the thumb is pointing toward the floor	Weakness with active resistance suggests a supraspinatus tear
Lift-off Test	Subscapularis: internally rotate arm so dorsal surface of hand rests on lower back; patient instructed to actively lift hand away from back against examiner resistance (use Belly Press Test if too painful)	Inability to actively lift hand away from back suggests a subscapularis tear
Posterior-Cuff Test	Infraspinatus and teres minor: arm positioned at patient's side in 90° of flexion; patient instructed to externally rotate arm against the resistance of the examiner	Weakness with active resistance suggests posterior cuff tear
Neer's Test	Rotator cuff impingement: passive shoulder flexion	Pain elicited between 130-170° suggests impingement
Hawkins-Kennedy Test	Rotator cuff impingement: shoulder flexion to 90° and passive internal rotation	Pain with internal rotation suggests impingement
Painful Arc Test	Rotator cuff tendinopathy: patient instructed to actively abduct the shoulder	Pain with abduction >90° suggests tendinopathy

Ruling in Rotator Cuff Tears – 98% probability of rotator cuff tear if all 3 of the following are present:
- Supraspinatus weakness
- External rotation weakness
- Positive impingement sign(s)

Diagnosis of rotator cuff tears. *Lancet* 2001; 357:769-770

Does this Patient with Shoulder Pain have Rotator Cuff Disease? The Rational Clinical Examination Systematic Review
JAMA 2013;310:837-847
Study: 5 studies of sufficient quality including 30-203 shoulders and a prevalence of RCD ranging from 33-81%.
Results/Conclusions: Among pain provocation tests, a positive painful arc test had the greatest specificity and sensitivity (SP 81%, SN 71%) Among strength tests, a positive external rotation lag test and internal rotation lag test were the most accurate for full-thickness tears (SP 47%, SN 94%; SP 97%, SN 83% respectively). The internal rotation lag test was therefore also the most accurate for identifying patients without a full-thickness tear. A positive drop arm test is helpful to identify patients with RCD (SN 24%, SP 93%).

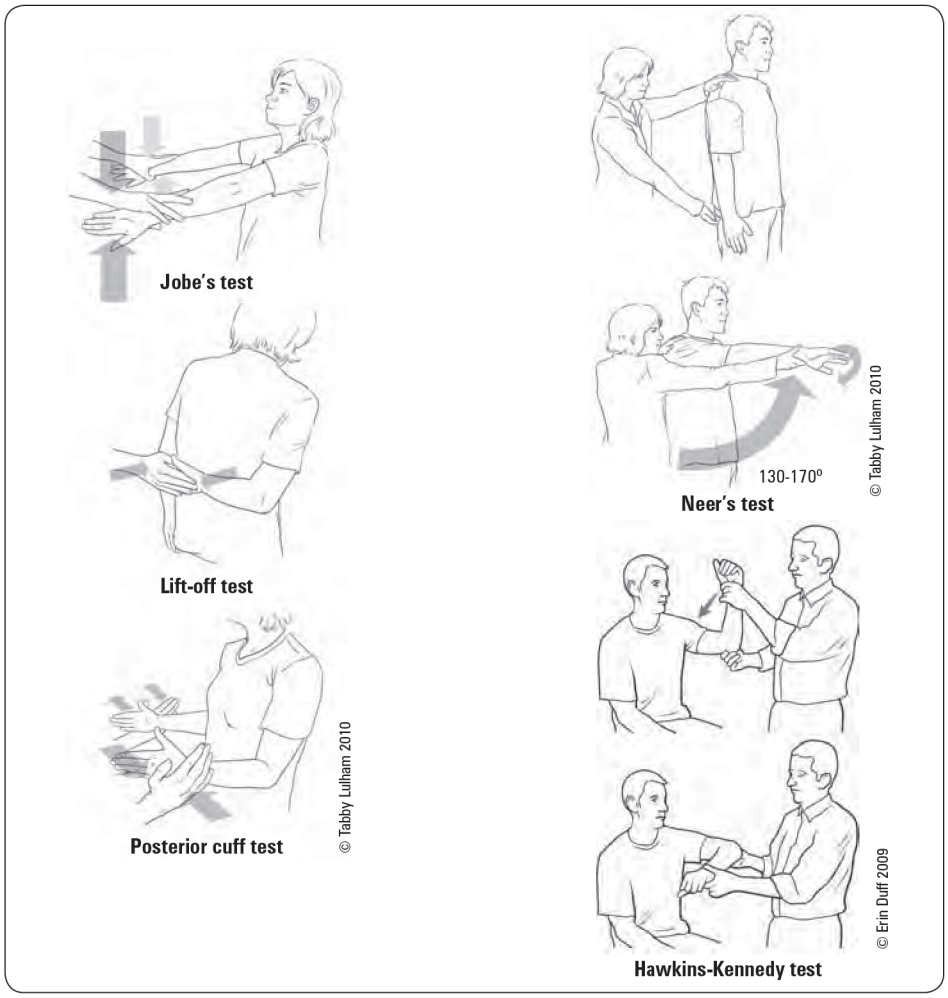


Figure 14. Rotator cuff tests

Acromioclavicular Joint Pathology

- subluxation or dislocation of AC joint
- 2 main ligaments attach clavicle to scapula: AC and CC ligaments

Mechanism
- fall onto shoulder with adducted arm or direct trauma to point of shoulder

Clinical Features
- pain with adduction of shoulder and/or palpation over AC joint
- palpate step deformity between distal clavicle and acromion (with dislocation)
- limited ROM

Pneumothorax or pulmonary contusion are potential complications of severe AC joint dislocation

Investigations
- x-rays: bilateral AP, Zanca view (10-15° cephalic tilt), axillary

Treatment
- **non-operative**
  - sling 1-3 wk, ice, analgesia, early ROM and rehabilitation
- **operative**
  - indication: Rockwood Class IV-VI (III if labourer or high level athlete)
  - number of different approaches involving AC/CC ligament reconstruction or screw/hook plate insertion

Table 10. Rockwood Classification of Acromioclavicular Joint Separation

Grade	Features	Treatment
I	Joint sprain, absence of complete tear of either ligament	Non-operative
II	Complete tear of AC ligament, incomplete tear of CC ligament, without marked elevation of lateral clavicular head	Non-operative
III	Complete tear of AC and CC ligaments, >5 mm elevation at AC joint, superior aspect of acromion is below the inferior aspect of the clavicle	Most non-operative, operative if labourer or high level athlete Will heal with step deformity, although most fully functional in 4-6 mo
IV-VI	Based on the anatomical structure the displaced clavicle is in proximity with	Operative in most cases

Clavicle Fracture

- incidence: proximal (5%), middle (80%), or distal (15%) third of clavicle
- common in children (unites rapidly without complications)

Mechanism
- fall on shoulder (87%), direct trauma to clavicle (7%), FOOSH (6%)

Clinical Features
- pain and tenting of skin
- arm is clasped to chest to splint shoulder and prevent movement

Investigations
- evaluate NVS of entire upper limb
- x-ray: AP, 45° cephalic tilt (superior/inferior displacement), 45° caudal tilt (AP displacement)
- CT: useful for medial physeal fractures and sternoclavicular injury

Treatment
- medial and middle third clavicle fractures
  - figure-of-eight sling x 1-2 wk
  - early ROM and strengthening once pain subsides
  - if ends overlap >2 cm consider ORIF
- distal third clavicle fractures
  - undisplaced (with ligaments intact): sling x 1-2 wk
  - displaced (CC ligament injury): ORIF

Specific Complications (see *General Fracture Complications*, OR6)
- cosmetic bump usually only complication
- shoulder stiffness, weakness with repetitive activity
- pneumothorax, brachial plexus injuries, and subclavian vessel (all very rare)

Associated Injuries with Clavicle Fractures
- Up to 9% of clavicle fractures are associated with other fractures (most commonly rib fractures)
- Majority of brachial plexus injuries are associated with proximal third fractures

Frozen Shoulder (Adhesive Capsulitis)

- disorder characterized by progressive pain and stiffness of the shoulder usually resolving spontaneously after 18 mo

Mechanism
- primary adhesive capsulitis
  - idiopathic, usually associated with DM
  - usually resolves spontaneously in 9-18 mo
- secondary adhesive capsulitis
  - due to prolonged immobilization
  - shoulder-hand syndrome: CRPS/RSD characterized by arm and shoulder pain, decreased motion, and diffuse swelling
  - following MI, stroke, shoulder trauma
  - poorer outcomes

Clinical Features
- gradual onset (weeks to months) of diffuse shoulder pain with:
  - decreased active AND passive ROM
  - pain worse at night and often prevents sleeping on affected side
  - increased stiffness as pain subsides: continues for 6-12 mo after pain has disappeared

Investigations
- x-ray: AP (neutral, internal/external rotation), scapular Y, axillary
  - may be normal, or may show demineralization from disease

Conditions Associated with an Increased Incidence of Adhesive Capsulitis
- Prolonged immobilization (most significant)
- Female gender
- Age >49 yr
- DM (5x)
- Cervical disc disease
- Hyperthyroidism
- Stroke
- MI
- Trauma and surgery
- Autoimmune disease

Stages of Adhesive Capsulitis
1. Painful phase: gradual onset, diffuse pain (lasts 6-9 mo)
2. Stiff phase: decreased ROM impacting functioning (lasts 4-9 mo)
3. Thawing phase: gradual return of motion (lasts 5-26 mo)

Treatment
- Freezing Phase
  - active and passive ROM (physiotherapy)
    - NSAIDs and steroid injections if limited by pain
- Thawing Phase
  - manipulation under anesthesia and early physiotherapy
    - arthroscopy for debridement/decompression

Humerus

Proximal Humeral Fracture

Mechanism
- young: high energy trauma (MVC)
- elderly: FOOSH from standing height in osteoporotic individuals

Clinical Features
- proximal humeral tenderness, deformity with severe fracture, swelling, painful ROM, bruising extends down arm and chest

Investigations
- test axillary nerve function (deltoid contraction and skin over deltoid)
- x-rays: AP, trans-scapular, axillary are essential
- CT scan: to evaluate for articular involvement and fracture displacement

Classification
- Neer classification is based on 4 fracture fragments
- displaced: displacement >1 cm and/or angulation >45°
- the Neer system regards displacement, not the fracture line, as meeting criteria for a 'part' in the classification scheme
- ± dislocated/subluxed: humeral head dislocated/subluxed from glenoid

Treatment
- treat osteoporosis if needed
- non-operative
  - nondisplaced: broad arm sling immobilization, begin ROM within 14 d to prevent stiffness
  - minimally displaced (85% of patients) - closed reduction with sling immobilization x 2 wk, gentle ROM
- operative
  - ORIF (anatomic neck fractures, displaced, associated dislocated glenohumeral joint)
  - hemiarthroplasty may be necessary, especially in elderly

Specific Complications (see *General Fracture Complications*, OR6)
- AVN, nerve palsy (45% _ typically axillary nerve), malunion, post-traumatic arthritis

Neer Classification

Based on 4 parts of humerus
- Greater Tuberosity
- Lesser Tuberosity
- Humeral Head
- Shaft

One-part fracture: any of the 4 parts with none displaced

Two-part fracture: any of the 4 parts with 1 displaced

Three-part fracture: displaced fracture of surgical neck + displaced greater tuberosity or lesser tuberosity

Four-part fracture: displaced fracture of surgical neck + both tuberosities

70-80% of proximal humeral fractures are non-displaced and managed non-operatively. Of displaced fractures, 20% are two-part, 5% are three-part, and <1% are four-part

Anatomic neck fractures disrupt blood supply to the humeral head and AVN of the humeral head may ensue

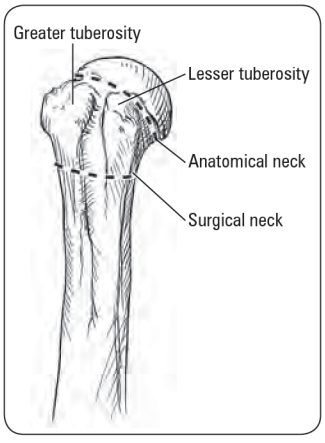


Figure 15. Fractures of the proximal humerus

Humeral Shaft Fracture

Mechanism
- high energy: direct blows/MVC (especially young); low energy: FOOSH, twisting injuries, metastases (in elderly)

Clinical Features
- pain, swelling, weakness ± shortening, motion/crepitus at fracture site
- must test radial nerve function before and after treatment: look for drop wrist, sensory impairment dorsum of hand

Investigations
- x-ray: AP and lateral radiographs of the humerus including the shoulder and elbow joints

Treatment
- in general, humeral shaft fractures are treated non-operatively
- **non-operative**
  - ± reduction; can accept deformity due to compensatory ROM of shoulder
  - hanging cast (weight of arm in cast provides traction across fracture site) with collar and cuff sling immobilization until swelling subsides, then Sarmiento functional brace, followed by ROM
- operative
  - indications: open fracture, neurovascular injury, unacceptable fracture alignment, polytrauma, segmental fracture, pathological fracture, "floating elbow" (simultaneous unstable humeral and forearm fractures), intra-articular
  - ORIF: plating (most common), IM rod insertion, external fixation

Acceptable Humeral Shaft Deformities for Non-Operative Treatment
- <20° anterior angulation
- <30° varus angulation
- <3 cm of shortening

Specific Complications (see *General Fracture Complications*, OR6)
- radial nerve palsy: expect spontaneous recovery in 3-4 mo, otherwise send for EMG
- non-union: most frequently seen in middle 1/3
- decreased ROM
- compartment syndrome

Risk of radial nerve and brachial artery injury

Distal Humeral Fracture

Mechanism
- young: high energy trauma (MVC)
- elderly: FOOSH

Clinical Features
- elbow pain and swelling
- assess brachial artery

Investigations
- x-ray: AP and lateral of humerus and elbow
- CT scan: helpful when suspect shear fracture of capitulum or trochlea

Classification
- supracondylar, distal single column, distal bicolumnar and coronal shear fractures

Treatment
- goal is to restore ROM 30-130° flexion (unsatisfactory outcomes in 25%)
- non-operative
  - cast immobilization (in supination for lateral condyle fracture; pronation for medial condyle fractures)
- operative
  - indications: displaced, supracondylar, bicolumnar
  - closed reduction and percunatneous pinning; ORIF; total elbow arthroplasty (bicolumnar in elderly)

Three Joints at the Elbow
- Humeroradial joint
- Humeroulnar joint
- Radioulnar joint

Elbow

Supracondylar Fracture

- subclass of distal humerus fracture: extra-articular, fracture proximal to capitulum and trochlea, usually transverse
- most common in pediatric population (peak age ~7 yr old), rarely seen in adults
- AIN injury commonly associated with extension type

Mechanism
- >96% are extension injuries via FOOSH (e.g. fall off monkey bars); <4% are flexion injuries

Clinical Features
- pain, swelling, point tenderness
- neurovascular injury: assess median and radial nerves, radial artery (check radial pulse)

Investigations
- x-ray: AP, lateral of elbow
  - disruption of anterior humeral line suggests supracondylar fracture

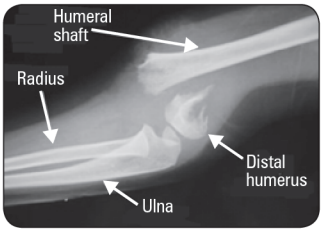


Figure 16. X-ray of transverse displaced supracondylar fracture of humerus with elbow dislocation

Normal carrying angle of elbow is ~10° of valgus

Terrible Triad
- Radial head fracture
- Coronoid fracture
- Elbow dislocation

Treatment
- reduction indications: evidence of arterial obstruction, unacceptable angulation, displaced (>50%)
- non-operative
  - nondisplaced: long arm plaster slab in 90° flexion x 3 wk
- operative
  - indications: displaced, vascular injury, open fracture
  - requires percutaneous pinning followed by limb cast with elbow flexed <90°
  - in adults, ORIF is necessary

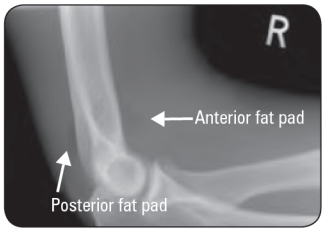


Figure 17. X-ray of fat pad sign

Specific Complications (see *General Fracture Complications*, OR6)
- stiffness is most common
- brachial artery injury (kinking can occur if displaced fracture), median or ulnar nerve injury, compartment syndrome (leads to Volkmann's ischemic contracture), malalignment cubitus varus (distal fragment tilted into varus)

Radial Head Fracture

- a common fracture of the upper limb in young adults

Mechanism
- FOOSH with elbow extended and forearm pronated

Clinical Features
- marked local tenderness on palpation over radial head (lateral elbow)
- decreased ROM at elbow, ± mechanical block to forearm pronation and supination
- pain on pronation/supination

Investigations
- x-ray: enlarged anterior fat pad ("sail sign") or the presence of a posterior fat pad indicates effusion which could occur with occult radial head fractures

Table 11. Classification and Treatment of Radial Head Fractures

Mason Class	Radiographic Description	Treatment
1	Nondisplaced fracture	Elbow slab or sling x 3-5 d with early ROM
2	Displaced fracture	ORIF if: angulation >30°, involves ≥1/3 of the radial head, or if ≥3 mm of joint incongruity exists
3	Comminuted fracture	Radial head excision ± prosthesis (if ORIF not feasible)
4	Comminuted fracture with posterior elbow dislocation	Radial head excision ± prosthesis

Specific Complications (see *General Fracture Complications*, OR6)
- myositis ossificans – calcification of muscle
- recurrent instability (if MCL injured and radial head excised)

To avoid stiffness do not immobilize elbow joint >2-3 wk

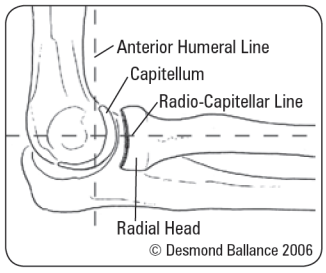


Figure 18. Lateral view of elbow

The anterior humeral line refers to an imaginary line drawn along the anterior surface of the humeral cortex that passes through the middle third of the capitellum when extended inferiorly. In subtle supracondylar fractures the anterior humeral line is disrupted, typically passing through the anterior third of the capitellum

Olecranon Fracture

Mechanism
- direct trauma to posterior aspect of elbow (fall onto the point of the elbow) or FOOSH

Clinical Features
- localized pain, palpable defect
- ± loss of active extension due to avulsion of triceps tendon

Investigations
- x-ray: AP and lateral (require true lateral to determine fracture pattern)

Treatment
- non-operative
  - non-displaced (<2 mm, stable): cast x 3 wk (elbow in 90° flexion) then gentle ROM
- operative
  - displaced: ORIF (plate and screws or tension band wiring) and early ROM if stable

Elbow Dislocation

- third most common joint dislocation after shoulder and patella
- anterior capsule and collateral ligaments disrupted

Mechanism
- elbow hyperextension via FOOSH or valgus/supination stress during elbow flexion
- usually the radius and ulna are dislocated together, or the radius head dislocates and the ulna remains ("Monteggia")
- 80% are posterior/posterolateral, anterior are rare and usually devastating

Clinical Features
- elbow pain, swelling, deformity
- flexion contracture
- ± absent radial or ulnar pulses

Investigations
- x-ray: AP and lateral views

Treatment
- assess NVS before reduction: brachial artery, median and ulnar nerves (can become entrapped during manipulation)

Elbow Dislocation
The radio-capitellar line refers to an imaginary line along the longitudinal axis of the radius that passes through the centre of the capitellum regardless of the degree of elbow flexion. If the radio-capitellar line does not pass through the centre of the capitellum a dislocation should be suspected

- non-operative
  - closed reduction under conscious sedation (post-reduction x-rays required)
  - Parvin's method: patient lies prone with arm hanging down; apply gentle traction downwards on wrist, as olecranon slips distally, gently lift up the arm at elbow to reduce joint
  - long-arm splint with forearm in neutral rotation and elbow in 90° flexion
  - early ROM (<2 wk)
- operative
  - indications: complex dislocation or persistent instability after closed reduction
  - ORIF

Specific Complications (see *General Fracture Complications*, OR6)
- stiffness (loss of extension), intra-articular loose body, neurovascular injury (ulnar nerve, median nerve, brachial artery), radial head fracture
- recurrent instability uncommon

Mason Class 2 Radial Head Fracture
CT reconstruction provides the best detail and ability to appreciate the anatomic orientation of the fracture pattern, enhancing surgical planning and prognosis

Epicondylitis

- lateral epicondylitis = "tennis elbow", inflammation of the common extensor tendon as it inserts into the lateral epicondyle
- medial epicondylitis = "golfer's elbow", inflammation of the common flexor tendon as it inserts into the medial epicondyle

Tennis Elbow = la**T**eral epicondylitis; pain associated with ex**T**ension of wrist

Mechanism
- repeated or sustained contraction of the forearm muscles/chronic overuse

Clinical Features
- point tenderness over humeral epicondyle and/or distal to it
- pain upon resisted wrist extension (lateral epicondylitis) or wrist flexion (medial epicondylitis)
- generally a self-limited condition, but may take 6-18 mo to resolve

Treatment
- non-operative (very good outcomes)
  - rest, ice, NSAIDs
  - use brace/strap
  - physiotherapy, stretching, and strengthening
  - corticosteroid injection
- operative
  - indication: failed 6-12 mo conservative therapy
  - percutaneous or open release of common tendon from epicondyle

Elbow Joint Injection
Inject at the centre of the triangle formed by the lateral epicondyle, radial head, and olecranon

Forearm

Radius and Ulna Shaft Fractures

Mechanism
- high energy direct or indirect (MVA, fall from height, sports) trauma
- fractures usually accompanied by displacement due to high force

Clinical Features
- deformity, pain, swelling
- loss of function in hand and forearm

Investigations
- x-ray: AP and lateral of forearm ± oblique of elbow and wrist
- CT if fracture is close to joint

In all isolated ulna fractures, assess proximal radius to rule out a Monteggia fracture

Treatment
- goal is anatomic reduction since imperfect alignment significantly limits forearm pronation and supination
- ORIF with plates and screws; closed reduction with immobilization usually yields poor results for displaced forearm fractures (except in children)

Complications (see *General Fracture Complications*, OR6)
- soft tissue contracture resulting in limited forearm rotation – surgical release of tissue may be warranted

Monteggia Fracture

- more common and better prognosis in the pediatric age group when compared to adults
- fracture of the proximal ulna with radial head dislocation and proximal radioulnar joint injury

Mechanism
- direct blow on the posterior aspect of the forearm
- hyperpronation
- fall on the hyperextended elbow

Clinical Features
- pain, swelling, decreased rotation of forearm ± palpable lump at the radial head
- ulna angled apex anterior and radial head dislocated anteriorly (rarely the reverse deformity occurs)

Investigations
- x-ray: AP, lateral elbow, wrist and forearm

Treatment
- adults: ORIF of ulna with indirect radius reduction in 90% of patients (ORIF of radius if unsuccessful)
- splint and early post-operative ROM if elbow completely stable, otherwise immobilization in plaster with elbow flexed for 6 wk
- pediatrics: attempt closed reduction and immobilization in plaster with elbow flexed for Bado Type I-III, surgery for Type IV

Specific Complications (see *General Fracture Complications*, OR6)
- PIN: most common nerve injury; observe for 3 mo as most resolve spontaneously
- radial head instability/redislocation
- radioulnar synostosis

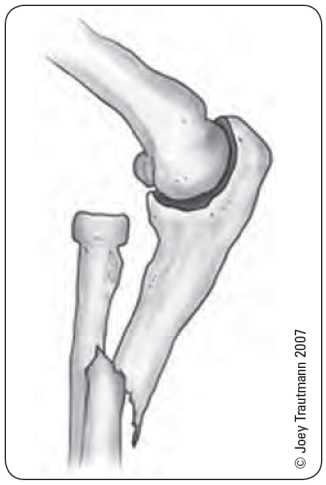


Figure 19. Monteggia fracture

Bado Type Classification of Monteggia Fractures
Based on the direction of displacement of the dislocated radial head, generally the same direction as the apex of the ulnar fracture
Type I: anterior dislocation of radial head and proximal/middle third ulnar fracture (60%)
Type II: posterior dislocation of radial head and proximal/middle third ulnar fracture (15%)
Type III: lateral dislocation of radial head and metaphyseal ulnar fracture (20%)
Type IV – combined: proximal fracture of the ulna and radius, dislocation of the radial head in any direction (<5%)

Nightstick Fracture

- isolated fracture of ulna without dislocation of radial head

Mechanism
- direct blow to forearm (e.g. holding arm up to protect face)

Treatment
- non-operative
  - non-displaced
  - below elbow cast (x 10 d) followed by forearm brace (~8 wk)
- operative
  - displaced
  - ORIF if >50% shaft displacement or >10° angulation

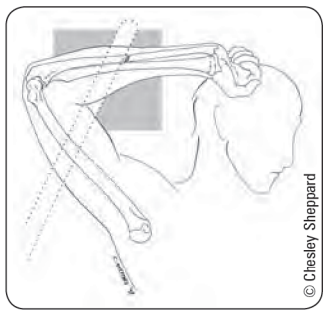


Figure 20. Nightstick fracture

Galeazzi Fracture

- fracture of the distal radial shaft with disruption of the DRUJ
- most commonly in the distal 1/3 of radius near junction of metaphysis/diaphysis
- 3x more common than Monteggia fracture

Mechanism
- hand FOOSH with axial loading of pronated forearm or direct wrist trauma

Clinical Features
- pain, swelling, deformity and point tenderness at fracture site

Investigations
- x-ray: AP, lateral elbow, wrist and forearm
  - shortening of distal radius >5 mm relative to the distal ulna
  - widening of the DRUJ space on AP
  - dislocation of radius with respect to ulna on true lateral

Treatment
- all cases are operative
  - ORIF of radius; afterwards assess DRUJ stability by balloting distal ulna relative to distal radius
    - if DRUJ is stable and reducible, splint for 10-14 d with early ROM encouraged
    - if DRUJ is unstable, ORIF or percutaneous pinning with long arm cast in supination x 6 wk

For all isolated radius fractures assess DRUJ to rule out a Galeazzi fracture

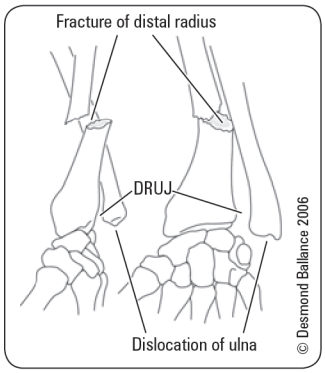


Figure 21. Galeazzi fracture

Wrist

Colles' Fracture

- extra-articular transverse distal radius fracture (~2 cm proximal to the radiocarpal joint) with dorsal displacement ± ulnar styloid fracture
- most common fracture in those >40 yr, especially in women and those with osteoporotic bone

Mechanism
- FOOSH

Clinical Features
- "dinner fork" deformity
- swelling, ecchymoses, tenderness

Investigations
- x-ray: AP and lateral wrist

Treatment
- goal is to restore radial height (13 mm), radial inclination (22°), volar tilt (11°) as well as DRUJ stability and useful forearm rotation
- non-operative
  - closed reduction (think opposite of the deformity)
    - hematoma block (sterile prep and drape, local anesthetic injection directly into fracture site) or conscious sedation
    - closed reduction: 1) traction with extension (exaggerate injury), 2) traction with ulnar deviation, pronation, flexion (of distal fragment – not at wrist)
    - dorsal slab/below elbow cast for 5-6 wk
    - x-ray x 1 wk for 3 wk and at cessation of immobilization to ensure reduction is maintained
  - obtain post-reduction films immediately; repeat reduction if necessary
- operative
  - indication: failed closed reduction, or loss of reduction
  - percutaneous pinning, external fixation or ORIF

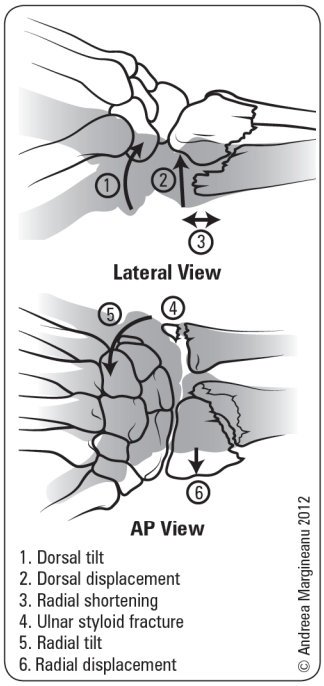


Figure 22. Colles' fracture and associated bony deformity

Smith's Fracture

- volar displacement of the distal radius (i.e. reverse Colles' fracture)

Mechanism
- fall onto the back of the flexed hand

Investigations
- x-ray: AP and lateral wrist

Treatment
- usually unstable and needs ORIF
- if patient is poor operative candidate, may attempt non-operative treatment
  - closed reduction with hematoma block (reduction opposite of Colles')
  - long-arm cast in supination x 6 wk

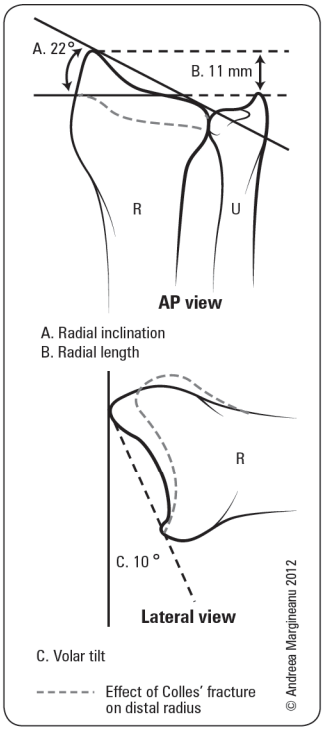


Figure 23. Normal wrist angles + wrist angles in Colles' fracture
Note the relative shortening of the radius relative to the ulna on AP view in Colles' fracture

Complications of Wrist Fractures

- most common complications are poor grip strength, stiffness, and radial shortening
- distal radius fractures in individuals <40 yr of age are usually highly comminuted and are likely to require ORIF
- 80% have normal function in 6-12 mo

Table 12. Early and Late Complications of Wrist Fractures

Early	Late
Difficult reduction ± loss of reduction	Malunion, radial shortening
Compartment syndrome	Painful wrist secondary to ulnar prominence
Extensor pollicis longus tendon rupture	Frozen shoulder ("shoulder-hand syndrome")
Acute carpal tunnel syndrome	Post-traumatic arthritis
Finger swelling with venous block	Carpal tunnel syndrome
Complications of a tight cast/splint	CRPS/RSD

Indications for surgical management of Colles' fracture
- displaced intra-articular fracture
- comminuted
- severe osteoporosis
- dorsal angulation >5° or volar tilt >20°
- >5 mm radial shortening

Scaphoid Fracture

Epidemiology
- common in young men; not common in children or in patients beyond middle age
- most common carpal bone injured
- may be associated with other carpal or wrist injuries (e.g. Colles' fracture)

Mechanism
- FOOSH: impaction of scaphoid on distal radius, most commonly resulting in a transverse fracture through the waist (65%), distal (10%), or proximal (25%) scaphoid

Clinical Features
- pain with resisted pronation
- tenderness in the anatomical "snuff box", over scaphoid tubercle, and pain with long axis compression into scaphoid
- usually nondisplaced

Investigations
- x-ray: AP, lateral, scaphoid views with wrist extension and ulnar deviation
- ± CT or MRI
- bone scan rarely used
- **note:** a fracture may not be radiologically evident up to 2 wk after acute injury, so if a patient complains of wrist pain and has anatomical snuff box tenderness but a negative x-ray, treat as if positive for a scaphoid fracture and repeat x-ray 2 wk later to rule out a fracture; if x-ray still negative order CT or MRI

Treatment
- early treatment critical for improving outcomes
- non-operative
  - non-displaced (<1 mm displacement/<15° angulation): long-arm thumb spica cast x 4 wk then short arm cast until radiographic evidence of healing is seen (2-3 mo)
- operative
  - displaced: ORIF with headless/countersink compression screw is the mainstay treatment

Specific Complications (see *General Fracture Complications*, OR6)
- most common: non-union/mal-union (use bone graft from iliac crest or distal radius with fixation to heal)
- AVN of the proximal fragment
- delayed union (recommend surgical fixation)
- scaphoid nonunion advanced collapse (SNAC) – chronic nonunion leading to advanced collapse and arthritis of wrist

Prognosis
- proximal fifth fracture: AVN rate 100%; proximal third fracture: AVN rate 33%
- waist fractures have healing rates of 80-90%
- distal third fractures have healing rates close to 100%

ORIF Colles' Fracture if Post-Reduction Demonstrates
- Radial shortening >3 mm or,
- Dorsal tilt >10° or,
- Intra-articular displacement/step-off >2 mm

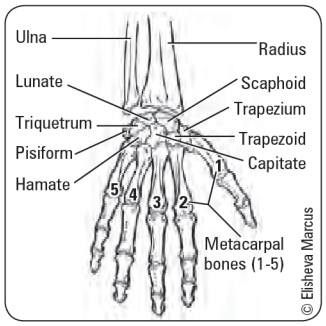


Figure 24. Carpal bones

Scaphoid Fracture Special Tests
Tender snuff box: 100% sensitivity, but 29% specific as positive with many other injuries of radial aspect of wrist with FOOSH

Figure 25. ORIF left scaphoid

The proximal pole of the scaphoid receives as much as 100% of its arterial blood supply from the radial artery that enters at the distal pole. A fracture through the proximal third disrupts this blood supply and results in a high incidence of AVN/non-union

Hand

- see Plastic Surgery, PL26

Spine

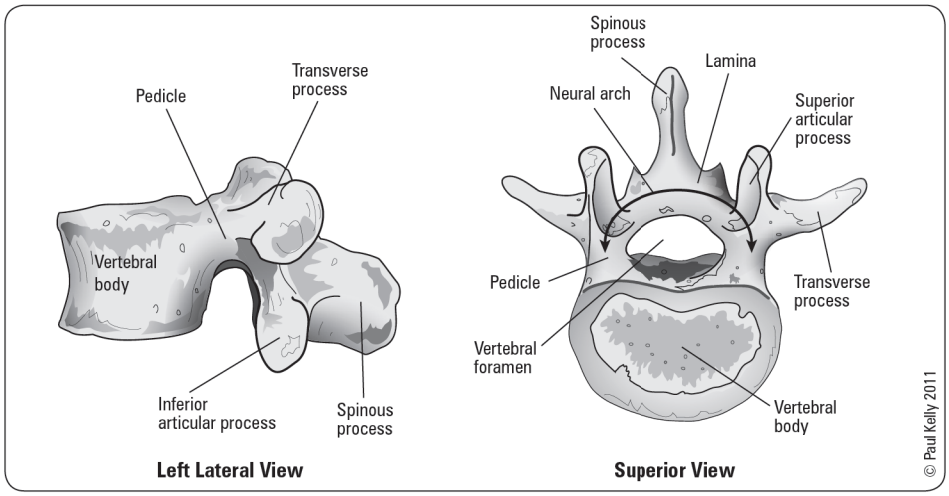


Figure 26. Schematic diagram of vertebral anatomy
Adapted from: Moore KL, Agur AMR. *Essential Clinical Anatomy,* 3rd ed. Philadephia: Lippincott Williams and Wilkins, 2007. p274

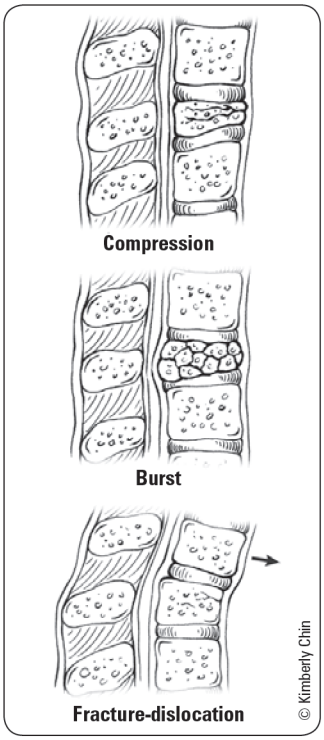


Figure 27. Compression, burst, and dislocation fractures

Fractures of the Spine

- see Neurosurgery, NS32

Cervical Spine

General Principles

- C1 (atlas): no vertebral body, no spinous process
- C2 (axis): odontoid = dens
- 7 cervical vertebrae; 8 cervical nerve roots
- nerve root exits above vertebra (i.e. C4 nerve root exits above C4 vertebra), C8 nerve root exits below C7 vertebra
- radiculopathy = impingement of nerve root
- myelopathy = impingement of spinal cord

Special Testing

- compression test: pressure on head worsens radicular pain
- distraction test: traction on head relieves radicular symptoms
- Valsalva test: Valsalva maneuver increases intrathecal pressure and causes radicular pain

Table 13. Cervical Radiculopathy/Neuropathy

Root	C5	C6	C7	C8
Motor	Deltoid Biceps Wrist extension	Biceps Brachioradialis	Triceps Wrist flexion Finger extension	Interossei Digital flexors
Sensory	Axillary nerve (patch over lateral deltoid)	Thumb	Index and middle finger	Ring and little finger
Reflex	Biceps	Biceps Brachioradialis	Triceps	Finger jerk

X-Rays for C-Spine

- AP spine: alignment
- AP odontoid: atlantoaxial articulation
- lateral
  - vertebral alignment: posterior vertebral bodies should be aligned (translation >3.5 mm is abnormal)
  - angulation: between adjacent vertebral bodies (>11° is abnormal)
  - disc or facet joint widening
  - anterior soft tissue space (at C3 should be ≤3 mm; at C4 should be ≤8-10 mm)
- oblique: evaluate pedicles and intervertebral foramen
- ± swimmer's view: lateral view with arm abducted 180° to evaluate C7-T1 junction if lateral view is inadequate
- ± lateral flexion/extension view: evaluate subluxation of cervical vertebrae

Canadian C-Spine Rule
Used to guide imaging for alert (GCS = 15) and stable patients with suspected C-spine injury
Obtain radiography if:
- Age ≥65
- Paresthesia in the extremities
- Inability to rotate neck >45° to the left and right
- Dangerous mechanism of injury (e.g. high speed MVC, fall from elevation >5 ft, etc.)

Canadian CT Head and C-Spine (CCC) Study Group. Canadian C-Spine Rule Study for alert and stable trauma patients. I. Background and rationale. *CJEM* 2002;4:84-90

Canadian Cervical Spine Rule Compared with Computed Tomography: A Prospective Analysis
J Trauma 2011;71:352-355
Study: 3,201 blunt trauma patients screened with CCS. All patients received complete C-spine CT.
Results: 192 patients with C-spine fracture and 3,009 without fracture on CT. The sensitivity of CCS was 100% (192/192) and specificity 0.6% (18/3009) with a PPV of 6.03% (192/3182) and NPV of 100% (18/18).
Conclusions: CCS is very sensitive but not specific to determine the need for subsequent radiographic evaluation after blunt trauma.

Differential Diagnosis of C-Spine Pain
- neck muscle strain, cervical spondylosis, cervical stenosis, RA (spondylitis), traumatic injury, whiplash, myofascial pain syndrome

C-SPINE INJURY
- see Neurosurgery, NS33

ABC'S Approach to the Lateral C-Spine X-Ray
A – Alignment/angulation
B – Bony Deformity
C – Cartilage
S – Soft Tissue

C-Spine X-Ray in Trauma
Must see C7-T1

All trauma patients with suspected C-spine injury require immediate immobilization of C-spine at scene of accident with spine board, C-collar, and sandbags

Thoracolumbar Spine

General Principles
- spinal cord terminates at conus medullaris (L1)
- individual nerve roots exit below pedicle of vertebra (i.e. L4 nerve root exits below L4 pedicle)

Special Tests
- straight leg raise: passive lifting of leg (30-70°) reproduces radicular symptoms of pain radiating down posterior/lateral leg to knee ± into foot
- Lasegue maneuver: dorsiflexion of foot during straight leg raise makes symptoms worse or, if leg is less elevated, dorsiflexion will bring on symptoms
- femoral stretch test: with patient prone, flexing the knee of the affected side and passively extending the hip results in radicular symptoms of unilateral pain in anterior thigh

Table 14. Lumbar Radiculopathy/Neuropathy

Root	L4	L5	S1
Motor	Quadriceps (knee extension + hip adduction) Tibialis anterior (ankle inversion + dorsiflexion)	Extensor hallucis longus Gluteus medius (hip abduction)	Peroneus longus + brevis (ankle eversion) Gastrocnemius + soleus (plantar flexion)
Sensory	Medial malleolus	1st dorsal webspace and lateral leg	Lateral foot
Screening Test	Squat and Rise	Heel Walking	Walking on Toes
Reflex	Knee (patellar)	Medial hamstring*	Ankle (Achilles)
Test	Femoral stretch	Straight leg raise	Straight leg raise

*Unreliable

Differential Diagnosis of Back Pain
1. mechanical or nerve compression (>90%)
   - degenerative (disc, facet, ligament)
   - peripheral nerve compression (disc herniation)
   - spinal stenosis (congenital, osteophyte, central disc)
   - cauda equina syndrome
2. others (<10%)
   - neoplastic (primary, metastatic, multiple myeloma)
   - infectious (osteomyelitis, TB)
   - metabolic (osteoporosis)
   - traumatic fracture (compression, distraction, translation, rotation)
   - spondyloarthropathies (ankylosing spondylitis)
   - referred (aorta, renal, ureter, pancreas)

DEGENERATIVE DISC DISEASE
- loss of vertebral disc height with age results in
  - bulging and tears of annulus fibrosus
  - change in alignment of facet joints
  - osteophyte formation

Mechanism
- compression over time with age

Clinical Features
- axial back pain without radicular symptoms
- pain worse with axial loading and bending
- negative straight leg raise

Investigations
- X-ray, MRI, provocative discography

Treatment
- non-operative
  - staying active with modified activity
  - back strengthening
  - NSAIDs
  - do not treat with opioids; no proven efficacy of spinal traction or manipulation
- operative – rarely indicated
  - decompression ± fusion
  - no difference in outcome between non-operative and surgical management at 2 yr

Table 15. Types of Low Back Pain

	Mechanical Back Pain		Direct Nerve Root Compression	
	Disc Origin	**Facet Origin**	**Spinal Stenosis**	**Root Compression**
Pain Dominance	Back	Back	Leg	Leg
Aggravation	Flexion	Extension, standing, walking	Exercise, extension, walking, standing	Flexion
Onset	Gradual	More sudden	Congenital or acquired	Acute leg ± back pain
Duration	Long (weeks, months)	Shorter (days, weeks)	Acute or chronic history (weeks to months)	Short episodes Attacks (minutes)
Treatment	Relief of strain, exercise	Relief of strain, exercise	Relief of strain, exercise	Relief of strain, exercise + surgical decompression if progressive or severe deficit

SPINAL STENOSIS
- narrowing of spinal canal <10 mm
- congenital (idiopathic, osteopetrosis, achondroplasia) or acquired (degenerative, iatrogenic – post spinal surgery, ankylosing spondylosis, Paget's disease, trauma)

Clinical Features
- ± bilateral back and leg pain
- neurogenic claudication
- ± motor weakness
- normal back flexion; difficulty with back extension (Kemp sign)
- positive Straight leg raise, pain not worse with Valsalva

Investigations
- CT/MRI reveals narrowing of spinal canal, but gold standard = CT myelogram

Treatment
- non-operative
  - vigorous physiotherapy (flexion exercises, stretch/strength exercises), NSAIDs, lumbar epidural steroids
- operative
  - indication: non-operative failure >6 mo
  - decompressive surgery

Table 16. Differentiating Claudication

	Neurogenic	Vascular
Aggravation	With standing or exercise Walking distance variable	Walking set distance
Alleviation	Change in position (usually flexion, sitting, lying down)	Stop walking
Time	Relief in ~10 min	Relief in ~2 min
Character	Neurogenic ± neurological deficit	Muscular cramping

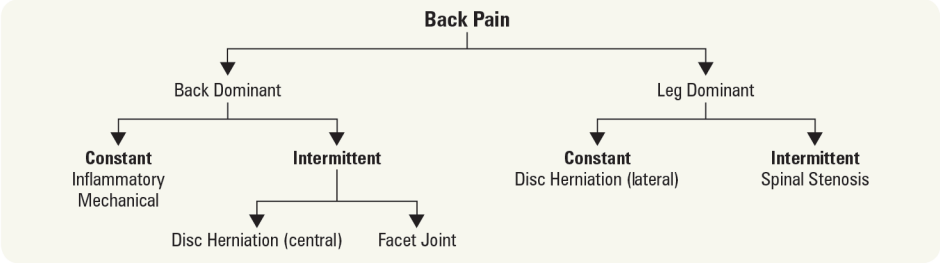


Figure 28. Approach to back pain

Red Flags for

BACK PAIN
Bowel or bladder dysfunction
Anesthesia (saddle)
Constitutional symptoms/malignancy
Khronic disease
Paresthesias
Age >50 yr
IV drug use
Neuromotor deficits

MECHANICAL BACK PAIN

- back pain NOT due to prolapsed disc or any other clearly defined pathology

Clinical Features

- dull backache aggravated by activity and prolonged standing
- morning stiffness
- no neurological signs

Treatment

- symptomatic (analgesics, physiotherapy)
- prognosis: symptoms may resolve in 4-6 wk, others become chronic

LUMBAR DISC HERNIATION

- tear in annulus fibrosus allows protrusion of nucleus pulposus causing either a central, posterolateral, or lateral disc herniation, most commonly at L5-S1 > L4-5 > L3-4
- 3:1 male to female
- only 5% become symptomatic
- usually a history of flexion-type injury

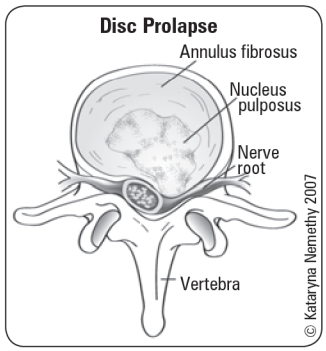


Figure 29. Disc herniation causing nerve root compression

Clinical Features

- back dominant pain (central herniation) or leg dominant pain (lateral herniation)
- tenderness between spinous processes at affected level
- muscle spasm ± loss of normal lumbar lordosis
- neurological disturbance is segmental and varies with level of central herniation
  - motor weakness (L4, L5, S1)
  - diminished reflexes (L4, S1)
  - diminished sensation (L4, L5, S1)
- positive straight leg raise
- positive contralateral SLR
- positive Lasegue and Bowstring sign
- cauda equina syndrome (present in 1-10%) – surgical emergency

Cauda equina syndrome and ruptured aortic aneurysms are causes of low back pain that are considered surgical emergencies

Investigations

- x-ray, MRI, consider a post-void residual volume to check for urinary retention; post-void >100 mL should heighten suspicion for cauda equine syndrome

Neurogenic claudication is position dependent; vascular claudication is exercise dependent

Treatment

- non-operative
  - symptomatic
    - extension protocol
    - NSAIDS
- operative
  - indication: progressive neurological deficit, failure of symptoms to resolve within 3 mo or cauda equina syndrome due to central disc herniation
  - surgical discectomy
- prognosis
- 90% of patients improve in 3 mo with non-operative treatment

MRI abnormalities (e.g. spinal stenosis, disc herniation) are quite common in both asymptomatic and symptomatic individuals and are not necessarily an indication for intervention without clinical correlation

SPONDYLOLYSIS

- defect in the pars interarticularis with no movement of the vertebral bodies

Mechanism

trauma: gymnasts, weightlifters, backpackers, loggers, labourers

Clinical Features

activity-related back pain, pain with unilateral extension (Michelis' test)

Sciatica
- Most common symptom of radiculopathy (L4-S3)
- Leg dominant, constant, burning pain
- Pain radiates down leg ± foot
- Most common cause = disc herniation

Investigations
- oblique x-ray: "collar" break in the "Scottie dog's" neck
- bone scan
- CT scan

Treatment
- non-operative
  - activity restriction, brace, stretching exercise

ADULT ISTHMIC SPONDYLOLISTHESIS
- defect in pars interarticularis causing a forward slip of one vertebra on another usually at L5-S1, less commonly at L4-5

Mechanism
- congenital (children), degenerative (adults), traumatic, pathological, teratogenic

Clinical Features
- lower back pain radiating to buttocks relieved with sitting
- neurogenic claudication
- L5 radiculopathy
- Meyerding Classification (percentage of slip)

Investigations
- x-ray (AP, lateral, obliques flexion-extension views), MRI

Treatment
- non-operative
  - activity restriction, bracing, NSAIDS
- operative
  - see Table 17

Table 17. Classification and Treatment of Spondylolisthesis

Class	Percentage of Slip	Treatment
1	0-25%	Symptomatic operative fusion only for intractable pain
2	25-50	Same as above
3	50-75	Decompression for spondylolisthesis and spinal fusion
4	75-100	Same as above
5	>100	Same as above

Specific Complications
- may present as cauda equina syndrome due to roots being stretched over the edge of L5 or sacrum

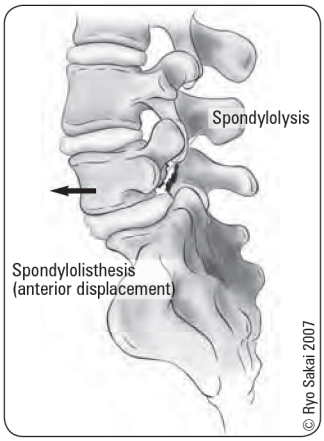


Figure 30. Spondylolysis, spondylolisthesis

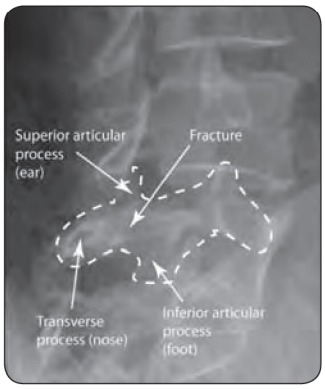


Figure 31. "Scottie dog" fracture

Pelvis

Pelvic Fracture

Mechanism
- young: high energy trauma, either direct or by force transmitted longitudinally through the femur
- elderly: fall from standing height, low energy trauma
- **lateral compression**, vertical shear, or anteroposterior compression fractures

Clinical Features
- pain, inability to bear weight
- local swelling, tenderness
- deformity of lower extremity
- pelvic instability

Investigations
- x-ray: AP pelvis, inlet and outlet views, Judet views (obturator and iliac oblique for acetabular fracture)
  - 6 cardinal radiographic lines of the acetabulum: ilioischial line, iliopectineal line, tear drop, roof, posterior rim, anterior rim
- CT scan useful for evaluating posterior pelvic injury and acetabular fracture
- assess genitourinary injury (rectal exam, vaginal exam, hematuria, blood at urethral meatus)
  - if involved, the fracture is considered an open fracture

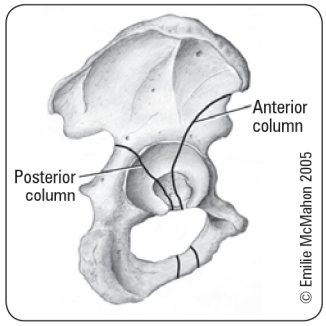


Figure 32. Pelvic columns

Possible Radiological Findings
- Pubic rami fractures: superior/inferior
- Pubic symphysis diastasis: common in AP compression (N=5 mm)
- Sacral fractures: common in lateral compression
- SI joint diastasis: common in AP compression (N=1-4 mm)
- Disrupted anterior column (iliopectineal line) or posterior column (ilioischial line)
- "Teardrop" displacement: acetabular fracture
- Iliac, ischial avulsion fractures
- Displacement of the major fragment: superior (VS), open book (APC), bucket handle (LC)

Classification

Table 18. Tile Classification of Pelvic Fractures

Type	Stability	Description
A	Rotationally stable Vertically stable	A1: fracture not involving pelvic ring (ex: avulsion or iliac wing fracture) A2: minimally displaced fracture of pelvic ring (e.g. ramus fracture) A3: transverse sacral fracture
B	Rotationally unstable Vertically stable	B1: open book (external rotation) B2: lateral compression – ipsilateral B2-1: with anterior ring rotation/displacement through ipsilateral rami B2-2: with anterior ring rotation/displacement through non-ipsilateral rami (bucket-handle) B3: Bilateral
C	Rotationally unstable Vertically unstable	C1: unilateral C1-1: iliac fracture, C1-2: sacroiliac fracture-dislocation C1-3: sacral fracture C2: bilateral with 1 side type B and 1 side type C C3: bilateral both sides type C

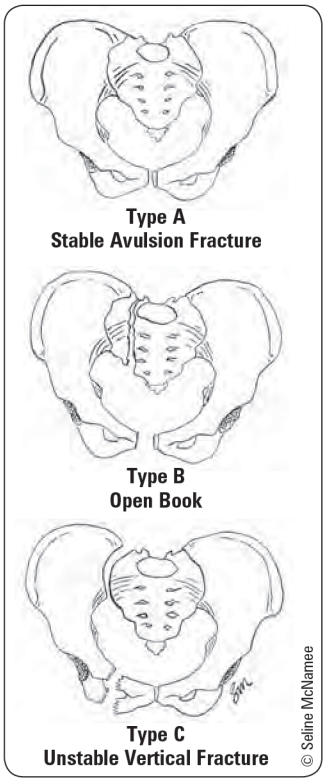


Figure 33. Illustration of the Tile classification of pelvic fractures

Treatment
- ABCDEs
- non-operative treatment: protected weight bearing
  - indication: stable fracture
- emergency management
  - IV fluids/blood
  - pelvic binder/sheeting
  - external fixation vs. emergent angiography/embolization
  - ± laparotomy (if FAST/DPL positive)
- operative treatment: ORIF
  - indications:
  - unstable pelvic ring injury
  - disruption of anterior and posterior SI ligament
  - symphysis diastasis >2.5 cm
  - vertical instability of the posterior pelvis
  - open fracture

Complications (see *General Fracture Complications*, OR6)
- **hemorrhage** (life-threatening)
- injury to rectum or urogenital structures
- obstetrical difficulties, sexual and voiding dysfunction
- persistent SI joint pain
- post-traumatic arthritis of the hip with acetabular fractures
- high risk of DVT/PE

Hip

Hip Dislocation

- full trauma survey (see Emergency Medicine, *Initial Patient Assessment/Management*, ER2)
- examine for neurovascular injury PRIOR to open or closed reduction
- reduce hip dislocations ASAP (ideally within 6 h) to decrease risk of AVN of the femoral head
- hip precautions (no extreme hip flexion, adduction, internal or external rotation) for 6 wk post-reduction
- see *Hip Dislocation Post-Total Hip Arthroplasty*, OR30

Up to 50% of patients with hip dislocations suffer fractures elsewhere at the time of injury

ANTERIOR HIP DISLOCATION
- mechanism: posteriorly directed blow to knee with hip widely abducted
- clinical features: shortened, abducted, externally rotated limb
- treatment
  - closed reduction under conscious sedation/GA
  - post-reduction CT to assess joint congruity

POSTERIOR HIP DISLOCATION
- most frequent type of hip dislocation
- mechanism: severe force to knee with hip flexed and adducted
  - e.g. knee into dashboard in MVC
- clinical features: shortened, adducted, internally rotated limb
- treatment

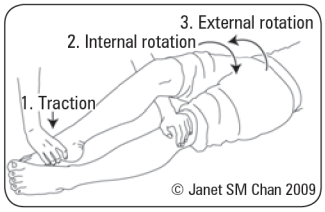


Figure 34. Rochester method

- closed reduction under conscious sedation/GA only if no associated femoral neck fracture or ipsilateral displacement
- ORIF if unstable, intra-articular fragments or posterior wall fracture
- post-reduction CT to assess joint congruity and fractures
- if reduction is unstable, put in traction x 4-6 wk

CENTRAL HIP FRACTURE DISLOCATION
- traumatic injury where femoral head is pushed medially through acetabulum

COMPLICATIONS FOR ALL HIP DISLOCATIONS
- post-traumatic OA
- AVN of femoral head
- fracture of femoral head, neck, or shaft
- sciatic nerve palsy in 25% (10% permanent)
- HO
- thromboembolism – DVT/PE

Rochester Method to Reduce Dislocations
- Patient lying supine with hip and knee flexed on injured side
- Surgeon stands on patient's injured side
- Surgeon passes one arm under patient's flexed knee, reaching to place that hand on patient's other knee (thus supporting patient's injured leg)
- With other hand, surgeon grasps patient's ankle on injured side, applying traction, while assistant stabilizes pelvis
- Reduction via traction, internal rotation, then external rotation once femoral head clears acetabular rim

Hip Fracture

General Features
- acute onset of hip pain
- unable to weight-bear
- shortened and externally rotated leg
- painful ROM

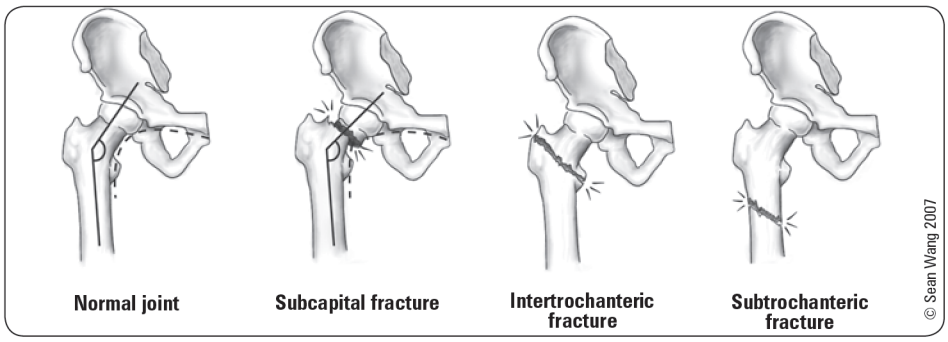


Figure 35. Subcapital, intertrochanteric, subtrochanteric fractures

X-Ray Features of Subcapital Hip Fractures
- Disruption of Shenton's line (a radiographic line drawn along the upper margin of the obturator foramen, extending along the inferomedial side of the femoral neck)
- Altered neck-shaft angle (normal is 120-130°)

DVT Prophylaxis in Hip Fractures
LMWH (i.e. enoxaparin 40 mg SC bid), fondaparinux, low dose heparin on admission, do not give <12 h before surgery

Table 19. Overview of Hip Fractures

Fracture Type	Definition	Mechanism	Special Clinical Features	Investigations	Treatment	Complications
Femoral Neck (Subcapital)	Intracapsular (See *Garden Classification*, Table 20)	Young: MVC, fall from height Elderly: fall from standing, rotational force	Same as general	X-Ray: AP hip, AP pelvis, cross table lateral hip		DVT, non-union, AVN, dislocation
Intertrochanteric **Stable: intact posteromedial cortex** **Unstable: non-intact posteromedial cortex**	Extracapsular fracture including the greater and lesser trochanters and transitional bone between the neck and shaft	Same as femoral neck fracture Direct or indirect force transmitted to the intertrochanteric area	Ecchymosis at back of upper thigh	X-Ray: AP pelvis, AP/lateral hip	Closed reduction under fluoroscopy then dynamic hip screw or IM nail	DVT, varus displacement of proximal fragment, malrotation, non-union, failure of fixation device
Subtrochanteric	Fracture begins at or below the lesser trochanter and involves the proximal femoral shaft	Young: high energy trauma Elderly: osteopenic bone + fall, pathological fracture	Ecchymosis at back of upper thigh	X-Ray: AP pelvis, AP/lateral hip and femur	Closed/open under fluoroscopy then plate fixation or IM nail	Malalignment, non-union, wound infection

Table 20. Garden Classification of Femoral Neck Fractures

Type	Displacement	Extent	Alignment	Trabeculae	Treatment
I	None	"Incomplete"	Valgus or neutral	Malaligned	Internal fixation to prevent displacement (valgus impacted fracture)
II	None	Complete	Neutral	Aligned	Internal fixation to prevent displacement
III	Some	Complete	Varus	Malaligned	Young: ORIF Elderly: hemi-/total hip arthroplasty
IV	Complete	Complete	Varus	Aligned	Young: ORIF Elderly: hemi-/total hip arthroplasty

AVN of Femoral Head
- Distal to proximal blood supply along femoral neck to head (medial and lateral femoral circumflex arteries)
- Susceptible to AVN if blood supply disrupted
- Etiology: femoral neck fracture, chronic systemic steroid use, SCFE, Legg-Calvé-Perthes, SLE, RA

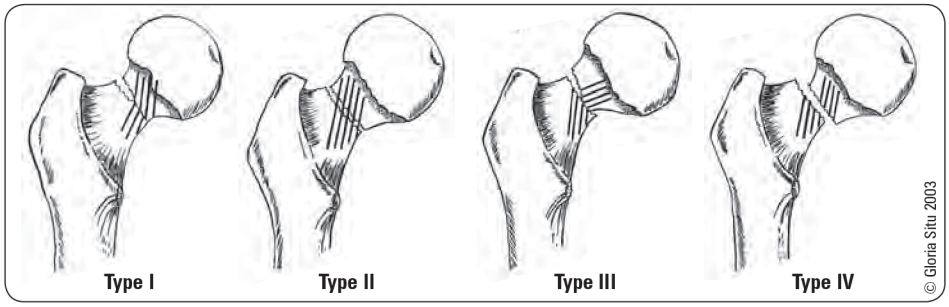


Figure 36. Garden classification of femoral neck fractures

Arthritis of the Hip

Etiology
- OA, inflammatory arthritis, post-traumatic arthritis, late effects of congenital hip disorders, or septic arthritis

Clinical Features
- pain (groin, medial thigh) and stiffness aggravated by activity, better with rest in OA
- RA: morning stiffness >1 h, multiple joint swelling, hand nodules
- decreased ROM (internal rotation is lost first)
- crepitus
- effusion
- ± fixed flexion contracture leading to apparent limb shortening (Thomas test)
- ± Trendelenburg sign

Investigations
- x-ray: weight bearing views of affected joint
  - OA: joint space narrowing, subchondral sclerosis, subchondral cysts, osteophytes
  - RA: osteopenia, erosion, joint space narrowing, subchondral cysts, symmetric joint space narrowing
- blood work: ANA, RF

Treatment
- non-operative
  - weight reduction, activity modification, physiotherapy, analgesics, walking aids
- operative
  - indication: advanced disease
  - realign = osteotomy; replace = arthroplasty; fuse = arthrodesis
- complications with arthroplasty: component loosening, dislocation, HO, thromboembolism, infection, neurovascular injury, limb length discrepancy
- arthroplasty is standard of care in most patients with hip arthritis

Hip Dislocation Post-Total Hip Arthroplasty

- occurs in 1-4% of primary THA and 10-16% of revision THAs
- risk factors: neurological impairment, post-traumatic arthritis, revision surgery, substance abuse

Mechanism
- THA that is unstable when hip is flexed, adducted and internally rotated, or extended and externally rotated (avoid flexing hip >90° or crossing legs for ~6 wk after surgery)

Investigations
- x-ray: AP pelvis, AP and lateral hip

Treatment
- non-operative
  - closed reduction: external abduction splint to prevent hip adduction (most often)
- operative
- indication: 2 or more dislocations with evidence of polyethylene wear, malalignment, hardware failure
  - revision THA
  - conversion to hemiarthroplasty with a larger femoral head
  - resection arthroplasty is a last resort

Complications
- sciatic nerve palsy in 25% (10% permanent)
- HO
- infection

DVT Prophylaxis in Elective THA
(continue 10-35 d post-operative)
Fondaparinux, low molecular weight heparin, or coumadin

Femur

Femoral Diaphysis Fracture

Mechanism
- high energy trauma (MVC, fall from height, gunshot wound)
- in children, can result from low energy trauma (spiral fracture)

Clinical Features
- shortened, externally rotated leg (if fracture displaced)
- inability to weight-bear
- often open injury, always a Gustilo III (see Table 5, OR9)
- Winquist and Hansen classification

Investigations
- x-ray: AP pelvis, AP/lateral hip, femur, knee

Treatment
- stabilize patient
- non-operative (uncommon)
  - indication: non-displaced femoral shaft fractures in co-morbid patients
  - long leg cast
- operative
  - ORIF with anterograde IM nail (most common) or retrograde IM nail, external fixator for unstable patients, open fractures, or highly vascular areas, or plate and screws for open growth plates within 24 h
  - early mobilization and strengthening

Complications
- hemorrhage requiring transfusion
- fat embolism leading to ARDS
- extensive soft tissue damage
- ipsilateral hip dislocation/fracture (2-6%)
- nerve injury

It is important to rule out ipsilateral femoral neck fracture as they occur in 2-6% of femoral diaphysis fractures and are reportedly missed in 19-31% of cases

Distal Femoral Fracture

- fractures from articular surface to 5cm above metaphyseal flare

Mechanism
- direct high energy force or axial loading
- three types: extra articular, partial articular, complete articular

Clinical Features
- extreme pain
- knee effusion (hemarthrosis)
- shortened, externally rotated leg if displaced
- neurovascular deficits can occur with displaced fracture

Investigations
- x-ray: AP, lateral, traction views (AP, lateral, oblique,
- CT, angiography if diminished pulses

Treatment
- non-operative (uncommon)
  - indication: non-displaced fracture
    - hinged knee brace
- operative
  - indication: displaced fracture, intra-articular fracture, non-union
- ORIF or retrograde IM nail if supracondylar and non-comminuted
- early mobilization and strengthening

Complications (see *General Fracture Complications*, OR6)
- femoral artery tear
- popliteal artery injury
- nerve injury
- extensive soft tissue injury
- angulation deformities

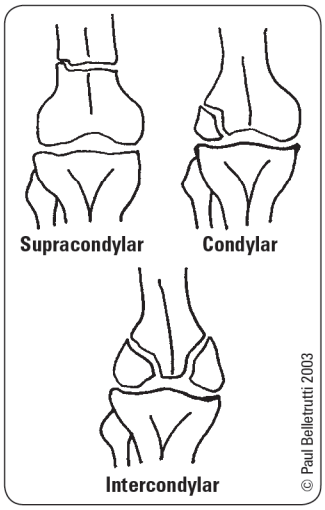


Figure 37. Distal femoral fractures

Knee

Evaluation of Knee

Common Complaints

- general orthopedic history
- also inquire about common knee symptoms
  - locking: mechanical block to extension
    - torn meniscus/loose body in joint
  - pseudo-locking: limited ROM without mechanical block
    - effusion, muscle spasm after injury, arthritis
  - painful clicking (audible)
    - torn meniscus
  - giving way: instability
    - cruciate ligament or meniscal tear, patellar dislocation

Special Tests of the Knee

- **anterior and posterior drawer tests**
  - demonstrate ACL and PCL, respectively
    - knee flexed at 90°, foot immobilized, hamstrings released
    - if able to sublux tibia anteriorly (anterior drawer test), then ACL may be torn
    - if able to sublux tibia posteriorly (posterior drawer test), then PCL may be torn
    - anterior drawer test for ACL: 3.8 positive likelihood ratio, 0.30 negative likelihood ratio
- **Lachmann test**
  - demonstrates torn ACL
  - hold knee in 10-20° flexion, stabilizing the femur
  - try to sublux tibia anteriorly on femur
  - similar to anterior drawer test, more reliable due to less muscular stabilization
  - for ACL: 25.0 positive likelihood ratio, 0.1 negative likelihood ratio
- **Thessaly test**
  - demonstrates meniscal tear
  - patient stands flat footed on one leg while the examiner provides his or her hands for balance. The patient then flexes the knee to 20° and rotates the femur on the tibia medially and laterally three times while maintaining the 20° flexion
  - positive for a meniscal tear if the patient experiences medial or lateral joint line discomfort
  - for medial meniscus: 29.67 positive likelihood ratio, 0.11 negative likelihood ratio
  - for lateral meniscus: 23.0 positive likelihood ratio, 0.083 negative likelihood ratio
- **posterior sag sign**
  - demonstrates torn PCL
  - may give a false positive anterior draw sign
  - flex knees and hips to 90°, hold ankles and knees
  - view from the lateral aspect
  - if one tibia sags posteriorly compared to the other, its PCL is torn
- **pivot shift sign**
  - demonstrates torn ACL
  - start with the knee in extension
  - internally rotate foot, slowly flex knee while palpating and applying a valgus force
  - normal knee will flex smoothly
  - if incompetent ACL, tibia will sublux anteriorly on femur at start of maneuver. During flexion, the tibia will reduce and externally rotate about the femur (the "pivot")
  - reverse pivot shift (start in flexion, externally rotate, apply valgus and extend knee) suggests torn PCL
  - composite assessment for ACL: 25.0 positive likelihood ratio, 0.04 negative likelihood ratio
  - composite assessment for PCL: 21.0 positive likelihood ratio, 0.05 negative likelihood ratio
- **collateral ligament stress test**
  - palpate ligament for "opening" of joint space while testing
  - with knee in full extension, apply valgus force to test MCL, apply varus force to test LCL
  - repeat tests with knee in 20° flexion to relax joint capsule
  - opening in 20° flexion due to MCL damage only
  - opening in 20° of flexion and full extension is due to MCL, cruciate, and joint capsule damage
- **tests for meniscal tear**
  - joint line tenderness
    - joint line pain when palpated
    - palpate one side at a time and watch patient's eyes
    - for meniscal tear: 0.9 positive likelihood ratio, 1.1 negative likelihood ratio
  - crouch compression test
    - joint line pain when squatting (anterior pain suggests patellofemoral pathology)

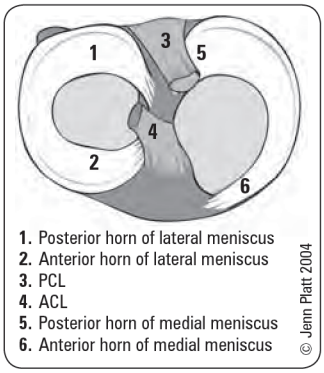


Figure 38. Diagram of the right tibial plateau

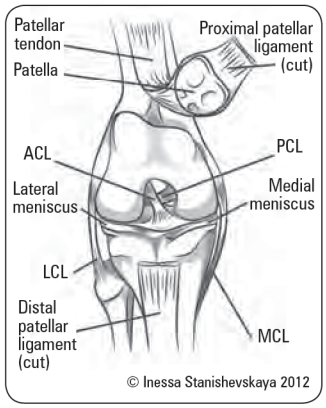


Figure 39. Knee ligament and anatomy

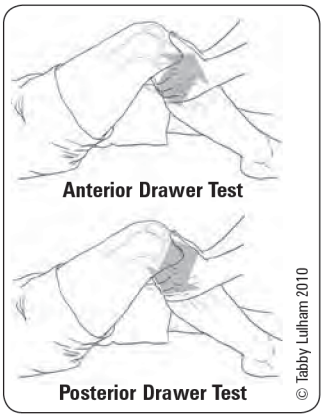


Figure 40. Anterior and posterior drawer test

6 Degrees of Freedom of the Knee

- Flexion and extension
- External and internal rotation
- Varus and valgus angulation
- Anterior and posterior glide
- Medial and lateral shift
- Compression and distraction

On physical exam of the knee, do not forget to evaluate the hip

- McMurray's test useful collaborative information
  - with knee in flexion, palpate joint line for painful "pop/click"
  - internally rotate foot, varus stress, and extend knee to test lateral meniscus
  - externally rotate foot, valgus stress, and extend knee to test medial meniscus
  - for meniscal tear: 1.3 positive likelihood ratio, 0.8 negative likelihood ratio
- composite assessment for meniscal tears: 2.7 positive likelihood ratio, 0.4 negative likelihood ratio

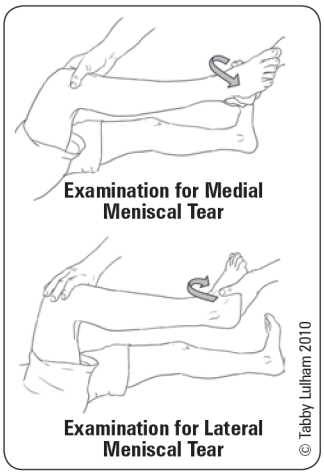


Figure 41. McMurray test

X-Rays
- AP standing, lateral
- skyline: tangential view with knees flexed at 45° to see patellofemoral joint
- 3-foot standing view: useful in evaluating leg length and varus/valgus alignment
- Ottawa Knee Rules (see Emergency Medicine, ER16)

Cruciate Ligament Tears

- ACL tear much more common than PCL tear

Table 21. Comparison of ACL and PCL Injuries

	Anterior Cruciate Ligament	Posterior Cruciate Ligament
Anatomy	From medial wall of lateral femoral condyle to the anteromedial and posterolateral intercondyloid eminence of the tibial plateau	Lateral wall of medial femoral condyle to posterior intercondyloid eminence of the tibial plateau
Mechanism	Sudden deceleration Hyperextension and internal rotation of tibia on femur (i.e. "plant and turn")	Sudden posterior displacement of tibia when knee is flexed or hyperextended (e.g. dashboard MVC injury)
History	Audible "pop" Immediate swelling Knee "giving way" Inability to continue activity	Audible "pop" Immediate swelling Pain with push off Cannot descend stairs
Physical	Effusion (hemarthrosis) Posterolateral joint line tenderness Positive anterior drawer Positive Lachmann Pivot shift Test for MCL, meniscal injuries	Effusion (hemarthrosis) Anteromedial joint line tenderness Positive posterior drawer Reverse pivot shift Other ligamentous, bony injuries
Treatment	Stable knee with minimal functional impairment: immobilization 2-4 wk with early ROM and strengthening High demand lifestyle: ligament reconstruction	Unstable knee or young person/high-demand lifestyle: ligament reconstruction

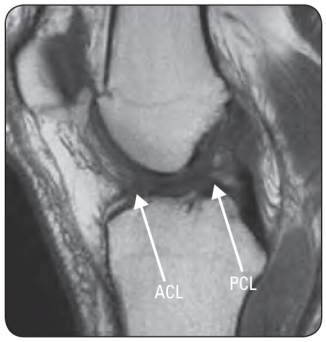


Figure 42. T1 MRI of torn ACL and PCL

Collateral Ligament Tears

Mechanism
- valgus force to knee = MCL tear
- varus force to knee = LCL tear

Clinical Features
- swelling/effusion
- tenderness above and below joint line medially (MCL) or laterally (LCL)
- joint laxity with varus or valgus force to knee
  - laxity with endpoint suggests partial tear
  - laxity with no endpoint suggests a complete tear
- test for other injuries (e.g. O'Donoghue's unhappy triad), common peroneal nerve injury

O'Donoghue's Unhappy Triad
- ACL rupture
- MCL rupture
- Meniscal damage (medial and/or lateral)

Investigations
- x-ray: AP and lateral; MRI

Treatment
- non-operative
  - partial tear: immobilization x 2-4 wk with early ROM and strengthening
  - complete tear: immobilization at 30° flexion
- operative
  - indication: multiple ligamentous injuries
  - surgical repair of ligaments

Partial ligamentous tears are much more painful than complete ligamentous tears

Meniscal Tears

- medial tear much more common than lateral tear

Mechanism
- twisting force on knee when it is partially flexed (e.g. stepping down and turning)
- requires moderate trauma in young person but only mild trauma in elderly due to degeneration

Clinical Features
- immediate pain, difficulty weight-bearing, instability, and clicking
- increased pain with squatting and/or twisting
- effusion (hemarthrosis) with insidious onset (24-48 h after injury)
- joint line tenderness medially or laterally
- locking of knee (if portion of meniscus mechanically obstructing extension)

Investigations
- MRI, arthroscopy

Treatment
- non-operative
  - indication: not locked
  - ROM and strengthening (NSAIDs)
- operative
  - indication: locked or failed non-operative treatment
  - arthroscopic repair/partial meniscectomy

Meniscal repair is done if tear is peripheral with good vascular supply, is a longitudinal tear and 1-4cm in length

Partial meniscectomy is done with tears not amenable to repair (complex, degenerative, radial)

Tissue Sources for ACL Reconstruction
- Hamstring
- Middle 1/3 patellar tendon (bone-patellar-bone)
- Allograft (e.g. cadaver)

ACL tear more common than PCL tear
MCL tear more common than LCL tear

Quadriceps/Patellar Tendon Rupture

Mechanism
- sudden forceful contraction of quadriceps during an attempt to stop
- more common in obese patients and those with pre-existing degenerative changes in tendon
  - DM, SLE, RA, steroid use, renal failure on dialysis

Clinical Features
- inability to extend knee or weight-bear
- possible audible "pop"
- patella in lower or higher position with palpable gap above or below patella respectively
- may have an effusion

Investigations
- ask patient to straight leg raise (unable with complete rupture)
- knee x-ray to rule out patellar fracture, MRI to distinguish between complete and partial tears
- lateral view: patella alta with patella tendon rupture, patella baja (infera) with quadriceps tendon rupture

Treatment
- non-operative
  - indication: incomplete tears with preserved extension of knee
  - immobilization in brace
- operative
  - indication: complete ruptures with loss of extensor mechanism
- early surgical repair: better outcomes compared with delayed repair (>6 wk post injury)
- delayed repair complicated by quadriceps contracture, patella migration, and adhesions

Patella alta = high riding patella
Patella baja (infera) = low riding patella

Dislocated Knee

Mechanism
- high energy trauma
- by definition, caused by tears of multiple ligaments

Clinical Features
- classified by relation of tibia with respect to femur
  - anterior, posterior, lateral, medial, rotary
- knee instability
- effusion
- pain
- ischemic limb
- Schenck classification

Investigations
- x-ray: AP, lateral, skyline
  - associated radiographic findings include tibial plateau fracture dislocations, proximal fibular fractures, and avulsion of fibular head
- ankle brachial index (abnormal if <0.9)
- arteriogram or CT angiogram if abnormal vascular exam (such as abnormal pedal pulses)

Treatment
- urgent closed reduction
  - complicated by interposed soft tissue
- assessment of peroneal nerve, tibial artery, and ligamentous injuries
- emergent operative repair if vascular injury, open fracture or dislocation, non-reducible dislocation, compartment syndrome
- knee immobilization x 6-8 wk

Specific Complications
- high incidence of associated injuries
  - popliteal artery tear
  - peroneal nerve injury
  - capsular tear
- chronic: instability, stiffness, post-traumatic arthritis

Patella

Patellar Fracture

Mechanism
- direct blow to the patella: fall, MVC (dashboard)
- indirect trauma by sudden flexion of knee against contracted quadriceps

Clinical Features
- marked tenderness
- inability to extend knee or straight leg raise
- proximal displacement of patella
- patellar deformity
- ± effusion/hemarthrosis

Investigations
- x-rays: AP, lateral, skyline
- do not confuse with bipartite patella: congenitally unfused ossification centres with smooth margins on x-ray at superolateral corner

Treatment
- non-operative
  - indication: non-displaced (step-off <2-3 mm and fracture gap <1-4 mm)
    - straight leg immobilization 1-4 wk with hinged knee brace, weight bearing as tolerated
    - progress in flexion after 2-3 wk
    - physiotherapy: quadriceps strengthening when pain has subsided
- operative
  - indication: displaced (>2mm), comminuted, disrupted extensor mechanism
  - ORIF, if comminuted may require partial/complete patellectomy
- goal: restore extensor mechanism with maximal articular congruency

Patellar Dislocation

Mechanism
- usually a non-contact twisting injury
- lateral displacement of patella after contraction of quadriceps at the start of knee flexion in an almost straight knee joint
- direct blow, e.g. knee/helmet to knee collision

Risk Factors
- young, female
- obesity
- high-riding patella (patella alta)
- knock-knees (genu valgus)
- Q-angle (quadriceps angle) ≥20°
- shallow intercondylar groove
- weak vastus medialis
- tight lateral retinaculum
- ligamentous laxity (Ehlers-Danlos)

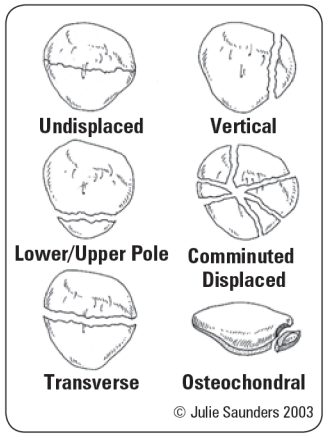


Figure 43. Types of patellar fractures

Complications
- Symptomatic wiring
- Loss of reduction
- Osteonecrosis (proximal fragment)
- Hardware failure
- Knee stiffness
- Nonunion
- Infection

Patellar Open Reduction and Internal Fixation
- Longitudinal midline excision over patella
- Longitudinal cannulated screws with tension-band wiring fixation
- Preserve patellar bone
- Antibiotic, debridement, early fixation in open fracture

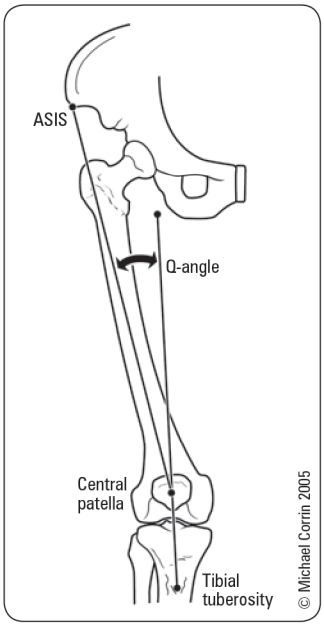


Figure 44. Q-angle
The angle between a vertical line through the patella and tibial tuberosity and a line from the ASIS to the middle patella; the larger the angle the greater the amount of lateral force on the knee (normal <20°)

Clinical Features
- knee catches or gives way with walking
- severe pain, tenderness anteromedially from rupture of capsule
- weak knee extension or inability to extend leg unless patella reduced
- positive patellar apprehension test
  - passive lateral translation results in guarding and patient apprehension
- often recurrent, self-reducing
- concomitant MCL injury
- increased Q-angle
- J-sign

J-sign: associated with patella alta, increased lateral translation in extension which pops into groove as the patella engages the trochlea early in flexion

Investigations
- x-rays: AP, lateral, skyline view of patella
  - check for fracture of medial patella (most common) and lateral femoral condyle

Treatment
- non-operative first
  - NSAIDs, activity modification, and physical therapy
  - short-term immobilization for comfort then 6 wk controlled motion
  - progressive weight bearing and isometric quadriceps strengthening
- operative
  - indication: if recurrent or if loose bodies present
  - surgical tightening of medial capsule and release of lateral retinaculum, possible tibial tuberosity transfer, or proximal tibial osteotomy

Patellofemoral Syndrome (Chondromalacia Patellae)

- syndrome of anterior knee pain associated with idiopathic articular changes of patella

Risk Factors
- malalignment causing patellar maltracking (Q angle ≥20°, genu valgus)
- post-trauma
- deformity of patella or femoral groove
- recurrent patellar dislocation, ligamentous laxity
- excessive knee strain (athletes)

Mechanism
- softening, erosion and fragmentation of articular cartilage, predominantly medial aspect of patella
- commonly seen in active young females

Clinical Features
- deep, aching anterior knee pain
  - exacerbated by prolonged sitting (theatre sign), strenuous athletic activities, stair climbing, squatting or kneeling
- insidious onset and vague in nature
- sensation of instability, pseudolocking
- pain with extension against resistance through terminal 30-40°
- pain with compression of patella with knee ROM or resisted knee extension
- swelling rare, minimal if present
- palpable crepitus

Pain with firm compression of patella into medial femoral groove is pathognomonic of patellofemoral syndrome

Investigations
- x-ray: AP, lateral, skyline – may find chondrosis, lateral patellar tilt, patella alta/baja, or shallow sulcus
- CT-scan
- MRI – best to assess articular cartillage

Treatment
- non-operative
  - continue non-impact activities; rest and rehabilitation
  - NSAIDs
  - physiotherapy: vastus medialis and core strengthening
- operative
  - indication: failed non-operative treatment
  - tibial tubercle elevation
  - arthroscopic shaving/debridement
  - lateral release of retinaculum

Tibia

Tibial Plateau Fracture

Mechanism
- varus/valgus load ± axial loading (e.g. fall from height)
- femoral condyles driven into proximal tibia
- can result from minor trauma in osteoporotics

Clinical Features
- frequency: lateral > bicondylar > medial
- medial fractures require higher energy – often have concomitant vascular injuries
- knee effusion
- inability to bear weight
- swelling
- associated with compartment syndrome, ACL injury and meniscal tears
- Schatzker classification

Schatzker Classification

Type	Description
I	Involvement of lateral plateau split fracture
II	Lateral split-depressed fracture
III	Involvement of lateral plateau: pure depression fracture
IV	Medial plateau fracture
V	Bicondylar plateau fracture
VI	Bicondylar with metaphyseal/diaphyseal involvement

Investigations
- x-ray: AP, lateral, oblique
- CT: pre-operative planning, identify articular depression and comminution
- ABI if any differences in pulses between extremities

Treatment

Approach #1 (based on amount of depression seen on x-ray)	**Non-operative indication** (if depression on x-ray is <3 mm): straight leg immobilization x 4-6 wk with progressive ROM weight bearing **Operative indication** (if depression is >3 mm): ORIF often requiring bone grafting to elevate depressed fragment
Approach #2 (based on varus/valgus instability)	**Non-operative indication** (if minimal varus/valgus instability [<15°]): straight leg immobilization x 4-6 wk with progressive ROM weight bearing **Operative indication** (if significant varus/valgus instability [>15°]): ORIF often requiring bone grafting to elevate depressed fragment

Low Molecular Weight Heparin for Prevention of Venous Thromboembolism in Patients with Lower-Leg Immobilization
Cochrane DB Syst Rev 2014;4:CD006681
Purpose: To evaluate the effectiveness of LMWH as VTE prophylaxis in patients with lower-leg immobilization in an ambulant setting.
Selection Criteria: RCTs and CCTs comparing LMWH to no prophylaxis or placebo in patients immobilized with a plaster cast or brace.
Results/Conclusions: 6 RCTs, 1,490 patients. Incidence of VTE was 4.3-40% in patients immobilized for >1wk without thromboprophylaxis or with placebo. With daily LMWH subcutaneous injections, incidence was 0-37% (OR 0.49, 95% CI 0.34-0.72). There were no reports of heparin-induced thrombocytopenia. The use of LMWH in outpatients with lower-leg immobilization significantly reduces the number of VTE events.

Specific Complications (see *General Fracture Complications*, OR6)
- ligamentous injuries
- meniscal lesions
- AVN
- infection
- OA

Tibial Shaft Fracture

- most common long bone and open fracture

Mechanism
- low energy pattern: torsional injury
- high energy: including MVC, falls, sporting injuries

Clinical Features
- pain, inability to bear weight
- open vs. closed
- amount of displacement
- NVS

Investigations
- x-ray: AP, lateral, skyline
  - full length, plus knee and ankle

Treatment
- non-operative
  - indication: closed and minimally displaced or adequate closed reduction
    - long leg cast x 8-12 wk, functional brace after
- operative
  - indication: displaced or open
    - if displaced and closed: ORIF with reamed IM nail, plate and screws, or external fixator
    - if open: antibiotics, I&D, external fixation or IM nail and vascularized coverage of soft tissue defects (often heal poorly)

Figure 45. Tibial shaft fracture treated with IM nail and screws

Tibial shaft fractures have high incidence of compartment syndrome and are often associated with soft tissue injuries

Specific Complications (see *General Fracture Complications*, OR6)
- high incidence of neurovascular injury and compartment syndrome
- poor soft tissue coverage (critical to outcome)

Ankle

Evaluation of Ankle and Foot Complaints

Special Tests
- anterior drawer: examiner attempts to displace the foot anteriorly against a fixed tibia
- talar tilt: foot is stressed in inversion and angle of talar rotation is evaluated by x-ray

X-Ray
- AP, lateral
- mortise view: ankle at 15° of internal rotation
  - gives true view of ankle joint
  - joint space should be symmetric with no talar tilt
- Ottawa Ankle Rules should guide x-ray use (see Emergency Medicine, ER17); nearly 100% sensitivity
- ± CT to better characterize fractures

Ottawa Ankle Rules (see Emergency Medicine, ER17)
X-rays are only required if:
Pain in the malleolar zone AND bony tenderness over the posterior aspect of the medial or lateral malleolus OR inability to weight bear both immediately after injury and in the ER

Ankle Fracture

Mechanism
- pattern of fracture depends on the position of the ankle when trauma occurs
- generally involves
  - ipsilateral ligamentous tears or transverse bony avulsion
  - contralateral shear fractures (oblique or spiral)
- classification systems
  - Danis-Weber
  - Lauge-Hansen: based on foot's position and motion relative to leg

Danis-Weber Classification
- based on level of fibular fracture relative to syndesmosis
- **Type A** (infra-syndesmotic)
  - pure inversion injury
  - avulsion of lateral malleolus below plafond or torn calcaneofibular ligament
  - ± shear fracture of medial malleolus
- **Type B** (trans-syndesmotic)
  - external rotation and eversion (most common)
  - ± avulsion of medial malleolus or rupture of deltoid ligament
  - spiral fracture of lateral malleolus starting at plafond
- **Type C** (supra-syndesmotic)
  - pure external rotation
  - avulsion of medial malleolus or torn deltoid ligament
  - ± posterior malleolus avulsion with posterior tibio-fibular ligament
  - fibular fracture is above plafond (called Maisonneuve fracture if at proximal fibula)
  - frequently tears syndesmosis

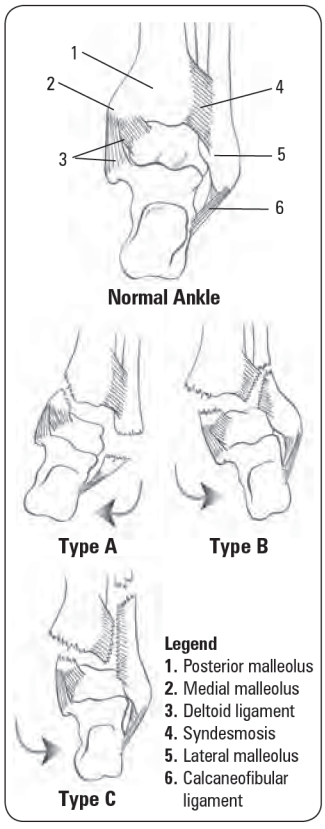


Figure 46. Ring principle of the ankle and Danis-Weber classification

Treatment
- non-operative
  - indication: non-displaced, no history of dislocation, usually lateral sided injury only
  - below knee cast , NWB
- operative
  - indications
    - any fracture-dislocation: restore vascularity, minimize articular injury, reduce pain and skin pressure
    - most of type B, and all of type C
    - trimalleolar (medial, posterior, lateral) fractures
    - talar tilt >10°
    - medial clear space on x-ray greater than superior clear space
    - open fracture/open joint injury
  - ORIF

Complications
- high incidence of post-traumatic arthritis
- wrinkle test: skin shows wrinkles, to determine if soft tissue swelling has resolved to an extent to reduce complications

Ligamentous Injuries

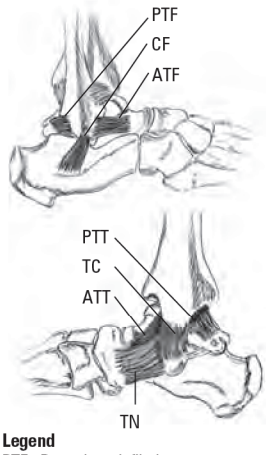
- see Figure 48 for ankle ligaments

Medial Ligament Complex (deltoid ligament)
- eversion injury
- usually avulses medial or posterior malleolus and strains syndesmosis

Lateral Ligament Complex (Anterior Talofibular, Calcaneofibular, Posterior Talofibular)
- inversion injury, >90% of all ankle sprains
- ATF most commonly and severely injured if ankle is plantar flexed
- swelling and tenderness anterior to lateral malleolus
- ++ ecchymoses
- positive ankle anterior drawer
- may have significant medial talar tilt on inversion stress x-ray

Treatment
- non-operative
  - microscopic tear (Grade I)
    - rest, ice, compression, elevation (RICE)
  - macroscopic tear (Grade II)
    - strap ankle in dorsiflexion and eversion x 4-6 wk
    - physiotherapy: strengthening and proprioceptive retraining
  - complete tear (Grade III)
    - below knee walking cast x 4-6 wk
    - physiotherapy: strengthening and proprioceptive retraining
    - surgical intervention may be required if chronic symptomatic instability develops

With a history of trauma from axial loading of lower limb always consider spinal injuries, femoral neck, tibial plateau, and talar/calcaneal fractures



Legend
PTF: Posterior talofibular
CF: Calcaneofibular
ATF: Anterior talofibular
PTT: Posterior tibiotalar
TC: Tibiocalcaneal
ATT: Anterior tibiotalar
TN: Tibionavicular

Figure 47. Ankle ligament complexes

Foot

Talar Fracture

Mechanism
- axial loading or hyperdorsiflexion (MVC, fall from height)
- 60% of talus covered by articular cartilage
- talar neck is most common fracture of talus (50%)
- tenuous blood supply runs distal to proximal along talar neck
  - high risk of AVN with displaced fractures

Investigations
- x-ray: AP, lateral, Canale view
- CT to better characterize fracture
- MRI can clearly define extent of AVN

Treatment
- non-operative
  - indication: non-displaced
  - NWB below knee cast x 6 weeks
- operative
  - indication: displaced (Hawkin's Classification)
  - ORIF (high rate of nonunion, AVN)
  - neck fracture: Pin (nondisplaced) or ORIF

Calcaneal Fracture

- most common tarsal fracture

Mechanism
- high energy, axial loading: fall from height onto heels
- 10% of fractures associated with compression fractures of thoracic or lumbar spine (rule out spine injury)
- 75% intra-articular and 10% are bilateral

Calcaneal Fracture Treatment Principles
- Avoid wound complications (10-25%)
- Restore articular congruity
- Restore normal calcaneal width and height
- Maximum functional recovery may take longer than 12 mo

Clinical Features
- marked swelling, bruising on heel/sole
- wider, shortened, flatter heel when viewed from behind
- varus heel

Investigations
- x-rays: AP, lateral, oblique (Broden's view) Harris axial
- loss of Bohler's angle
- CT: gold-standard, assess intra-articular extension

Treatment
- closed vs. open reduction is controversial
- NWB cast x 3 mo with early ROM and strengthening

Achilles Tendonitis

Mechanism
- chronic inflammation from activity or poor-fitting footwear
- may also develop heel bumps (retrocalcaneobursitis or Haglund deformity)

Haglund Deformity: an enlargement of the posterior-superior tuberosity of the calcaneus

Clinical Features
- pain, stiffness, and crepitus with ROM
- thickened tendon, palpable bump

Investigations
- x-ray: lateral, evaluate bone spur and calcification; U/S, MRI (to assess degenerative change)

Treatment
- non-operative
  - rest, NSAIDs, shoe wear modification
  - heel sleeves and pads are mainstay of non-operative treatment
  - gentle gastrocnemius-soleus stretching, eccentric training with physical therapy, deep tissue calf massage
  - orthotics, open back shoes
  - shockwave therapy in chronic tendonitis
  - DO NOT inject steroids (risk of tendon rupture)

Achilles Tendon Rupture

Mechanism
- loading activity, stop-and-go sports (e.g. squash, tennis, basketball)
- secondary to chronic tendonitis, steroid injection

Complications of Achilles Tendon Rupture
- Infection
- Sural nerve injury
- Re-rupture: surgical repair decreases likelihood of re-rupture compared to non-operative management

Clinical Features
- audible pop, sudden pain with push off movement
- sensation of being kicked in heel when trying to plantar flex
- palpable gap
- apprehensive toe off when walking
- weak plantar flexion strength
- Thompson test: with patient prone, plantar flexion when calf is squeezed by examiner
  - no passive plantar flexion is positive test = ruptured tendon

The most common site of Achilles tendon rupture is 2-6 cm from its insertion where the blood supply is the poorest

Investigations
- x-ray (to rule out other pathology), U/S or MRI (for partial vs complete ruptures)

Treatment
- non-operative
  - indication: low demand or elderly
  - cast foot in plantar flexion (to relax tendon) x 8-12 wk
- operative
  - indication: high demand
  - surgical repair, then cast as above x 6-8 wk

Plantar Fasciitis (Heel Spur Syndrome)

- inflammation of plantar aponeurosis at calcaneal origin
- common in athletes (especially runners, dancers)
- also associated with obesity, DM, seronegative and seropositive arthritis

Mechanism
- repetitive strain injury causing microtears and inflammation of plantar fascia
- common in athletes (especially runners, dancers)
- also associated with obesity, DM, seronegative and seropositive arthritis

Clinical Features
- insidious onset of heel pain, pain when getting out of bed and stiffness
- intense pain when walking from rest that subsides as patient continues to walk, worse at end of day with prolonged standing
- swelling, tenderness over sole
- greatest at medial calcaneal tubercle and 1-2 cm distal along plantar fascia
- pain with toe dorsiflexion (stretches fascia)

Investigations
- plain radiographs to rule out fractures
- often see bony exostoses (heel spurs) at insertion of fascia into medial calcaneal tubercle
- spur is secondary to inflammation, not the cause of pain

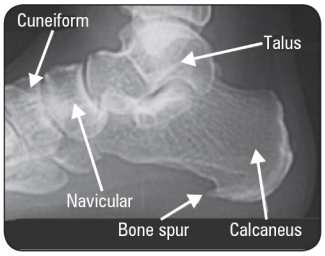


Figure 48. X-ray of bony heel spur

Treatment
- non-operative
  - pain control and stretching programs are first line
  - rest, ice, NSAIDs, steroid injection
  - physiotherapy: Achilles tendon and plantar fascia stretching, extracorporeal shockwave therapy
  - orthotics with heel cup – to counteract pronation and disperse heel strike forces
- operative
  - indication: failed non-operative treatment
  - endoscopic surgical release of fascia
  - spur removal is not required

Bunions (Hallux Valgus)

- bony deformity characterized by medial displacement of first metatarsal and lateral deviation of hallux

Mechanism
- valgus alignment on 1st MTP (hallux valgus) causes eccentric pull of extensor and intrinsic muscles
- many associated deformities in foot from altered mechanics
- reactive exostosis forms with thickening of the skin creating a bunion
- most often associated with poor-fitting footwear (high heel and narrow toe box)
- can be hereditary (70% have family history)
- 10x more frequent in women

Clinical Features
- painful bursa over medial eminence of 1st MT head
- pronation (rotation inward) of great toe
- numbness over medial aspect of great toe

Investigations
- x-ray: standing AP/lateral/sesamoid view, NWB oblique

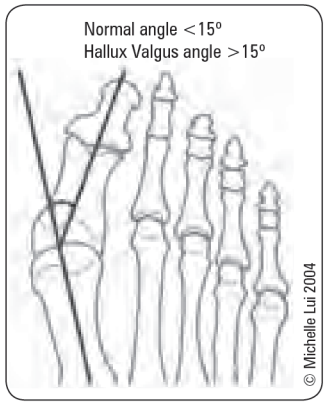


Figure 49. Hallux valgus

Treatment
- indications: painful corn or bunion, overriding 2nd toe
- non-operative (first line)
  - properly fitted shoes (low heel) and toe spacer
- operative: goal is to restore normal anatomy, not cosmetic reasons alone
  - osteotomy with realignment of 1st MTP joint (Chevron Procedure)
  - arthrodesis

Metatarsal Fracture

- as with the hand, 1st, 4th, 5th MT are relatively mobile, while the 2nd and 3rd are fixed
- use Ottawa Foot Rules to determine need for x-ray

Table 22. Types of Metatarsal Fractures

Fracture Type	Mechanism	Clinical	Treatment
Avulsion of Base of 5th MT	Sudden inversion followed by contraction of peroneus brevis	Tender base of 5th MT	Requires ORIF if displaced
Midshaft 5th MT (Jones Fracture)	Stress injury	Painful shaft of 5th MT	*NWB BK cast x 6 wk ORIF if athlete
Shaft 2nd, 3rd MT (March Fracture)	Stress injury	Painful shaft of 2nd or 3rd MT	Symptomatic
1st MT	Trauma	Painful 1st MT	ORIF if displaced otherwise *NWB BK cast x 3 wk then walking cast x 2 wk
Tarso-MT Fracture – Dislocation (Lisfranc Fracture)	Fall onto plantar flexed foot or direct crush injury	Shortened forefoot prominent base	ORIF

*NWB BK = Non weight bearing, below knee

Ottawa Ankle and Foot Rules (see Emergency Medicine, ER17)
X-rays only required if:
Pain in the midfoot zone AND bony tenderness over the navicular or base of the fifth metatarsal OR inability to weight bear both immediately after injury and in the ER

Greenstick fractures are easy to reduce but can redisplace while in cast due to intact periosteum

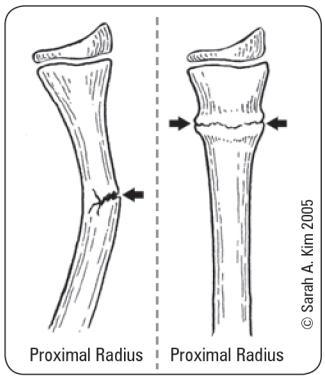


Figure 50. Greenstick (left) and torus (right) fractures

Pediatric Orthopedics

Fractures in Children

- type of fracture
  - thicker, more active periosteum results in pediatric specific fractures: greenstick (one cortex), torus (i.e. 'buckle', impacted cortex) and plastic (bowing)
  - distal radius fracture most common in children (phalanges second), the majority are treated with closed reduction and casting
  - adults fracture through both cortices
- epiphyseal growth plate
  - weaker part of bone, susceptible to fractures
  - plate often mistaken for fracture on x-ray and vice versa (x-ray opposite limb for comparison), especially in elbow
  - tensile strength of bone < ligaments in children, therefore clinician must be confident that fracture and/or growth plate injury have been ruled out before diagnosing a sprain
  - intra-articular fractures have worse consequences in children because they usually involve the growth plate
- anatomic reduction
  - gold standard with adults
  - may cause limb length discrepancy in children (overgrowth)
  - accept greater angular deformity in children (remodelling minimizes deformity)
- time to heal
  - shorter in children
- always be aware of the possibility of child abuse
  - make sure stated mechanism compatible with injury
  - high index of suspicion with fractures in non-ambulating children (<1 yr); look for other signs, including x-ray evidence of healing fractures at different sites and different stages of healing

Ossification Centres of the Elbow

CRITOE
Capitellum: 1 yr
Radial head: 4 yr
Internal (medial) epicondyle: 6 yr
Trochlea: 8 yr
Olecranon: 10 yr
External (lateral) epicondyle: 12 yr
(± 1 yr)

Stress Fractures

Mechanism
- insufficiency fracture
  - stress applied to a weak or structurally deficient bone
- fatigue fracture
  - repetitive, excessive force applied to normal bone
- most common in adolescent athletes
- tibia is most common site

Diagnosis
- localized pain and tenderness over the involved bone
- plain films may not show fracture for 2 wk
- bone scan positive in 12-15 d

Treatment
- rest from strenuous activities to allow remodelling (can take several months)

Evaluation of the Limping Child

- see Pediatrics, P91

Epiphyseal Injury

Table 23. Salter-Harris Classification of Epiphyseal Injury

SALT(E)R–Harris Type	Description	Treatment
I (**S**traight through; **S**table)	Transverse through growth plate	Closed reduction and cast immobilization (except SCFE – ORIF); heals well, 95% do not affect growth
II (**A**bove)	Through metaphysis and along growth plate	Closed reduction and cast if anatomic; otherwise ORIF
III (**L**ow)*	Through epiphysis to plate and along growth plate	Anatomic reduction by ORIF to prevent growth arrest, avoid fixation across growth plate
IV (**T**hrough and through)*	Through epiphysis and metaphysis	Closed reduction and cast if anatomic; otherwise ORIF
V (**R**am)*	Crush injury of growth plate	High incidence of growth arrest; no specific treatment

* Types III – IV are more likely to cause growth arrest and progressive deformity

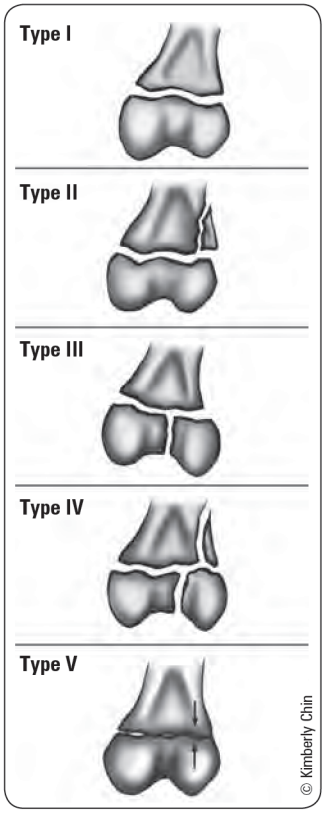


Figure 51. Salter-Harris classification

Slipped Capital Femoral Epiphysis

- type I Salter-Harris epiphyseal injury at proximal hip
- most common adolescent hip disorder, peak incidence at pubertal growth spurt
- risk factors: male, obese (#1 factor), hypothyroid (risk of bilateral involvement)

Etiology

- multifactorial
  - genetic: autosomal dominant, blacks > caucasians
  - cartilaginous physis hypertrophies too rapidly under growth hormone effects
  - sex hormone secretion, which stabilizes physis, has not yet begun
  - overweight: mechanical stress
  - trauma: causes acute slip

Clinical Features

- acute: sudden, severe pain with limp
- chronic (typically): groin and anterior thigh pain, may present with knee pain
  - positive Trendelenburg sign on affected side, due to weakened gluteal muscles
- tender over joint capsule
- restricted internal rotation, abduction, flexion
  - Whitman's sign: obligatory external rotation during passive flexion of hip
- Loder classification: stable vs. unstable (provides prognositic information)
  - unstable means patient cannot ambulate even with crutches

In SCFE, bilateral involvement occurs in about 25%

Investigations

- x-ray: AP, frog-leg, lateral radiographs both hips
  - posterior and medial slip of epiphysis
  - disruption of Klein's line
  - AP view may be normal or show widened/lucent growth plate compared with opposite side

SCFE – Klein's Line
On AP view, line drawn along superolateral border of femoral neck should cross at least a portion of the femoral epiphysis. If it does not, suspect SCFE

Treatment

- operative
  - mild/moderate slip: stabilize physis with pins in current position
  - severe slip: ORIF or pin physis without reduction and osteotomy after epiphyseal fusion

Complications

- AVN (roughly half of unstable hips), chondrolysis (loss of articular cartilage, resulting in narrowing of joint space), pin penetration, premature OA, loss of ROM

Developmental Dysplasia of the Hip

- abnormal development of hip resulting in dysplasia and subluxation/dislocation of hip
- most common orthopedic disorder in newborns

Etiology
- due to ligamentous laxity, muscular underdevelopment, and abnormal shallow slope of acetabular roof
- spectrum of conditions that lead to hip subluxation and dislocation
  - dislocated femoral head completely out of acetabulum
  - dislocatable head in socket
  - head subluxates out of joint when provoked
  - dysplastic acetabulum, more shallow and more vertical than normal
- painless (if painful suspect septic dislocation)

Physical Exam
- diagnosis is clinical
  - limited abduction of the flexed hip (<50-60°)
  - affected leg shortening results in asymmetry in skin folds and gluteal muscles, wide perineum
  - Barlow's test (for dislocatable hip)
    - flex hips and knees to 90° and grasp thigh
    - fully adduct hips, push posteriorly to try to dislocate hips
  - Ortolani's test (for dislocated hip)
    - initial position as above but try to reduce hip with fingertips during abduction
    - positive test: palpable clunk is felt (not heard) if hip is reduced
  - Galeazzi's sign
    - knees at unequal heights when hips and knees flexed
    - dislocated hip on side of lower knee
    - difficult test if child <1 yr
    - Trendelenburg test and gait useful if older (>2 yr)

Investigations
- U/S in first few months to view cartilage (bone is not calcified in newborns until 4-6 mo)
- follow up radiograph after 3 mo
- x-ray signs (at 4-6 mo): false acetabulum, acetabular index >25°, broken Shenton's line, femoral neck above Hilgenreiner's line, ossification centre outside of inner lower quadrant (quadrants formed by intersection of Hilgenreiner's and Perkin's line)

Treatment
- 0-6 mo: reduce hip using Pavlik harness to maintain abduction and flexion
- 6-18 mo: reduction under GA, hip spica cast x 2-3 mo (if Pavlik harness fails)
- >18 mo: open reduction; pelvic and/or femoral osteotomy

Complications
- redislocation, inadequate reduction, stiffness
- AVN of femoral head

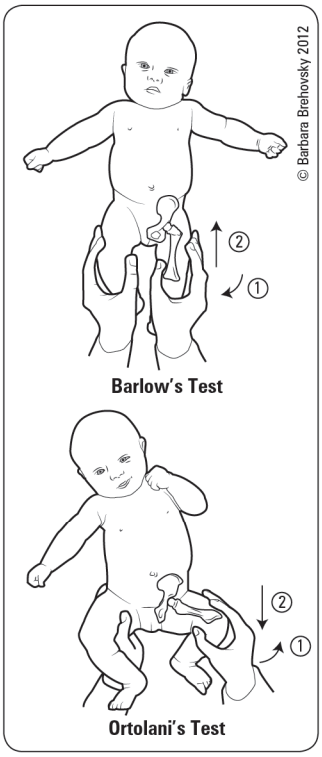


Figure 52. Barlow's test (checks if hips are dislocatable) **and Ortolani's test** (checks if hips are dislocated)

5 Fs that Predispose to Developmental Dysplasia of the Hip

Family history
Female
Frank breech
First born
Le**F**t hip

Legg-Calvé-Perthes Disease (Coxa Plana)

- ideopathic AVN of femoral head, presents at 4-8 yr of age
- 12% bilateral, M>F = 5:1, 1/1,200
- associations
  - family history
  - low birth weight
  - abnormal pregnancy/delivery
  - ADHD in 33% of cases, delayed bone age in 89%
  - second-hand smoke exposure
  - Asian, Inuit, Central European
- key features
  - AVN of proximal femoral epiphysis, abnormal growth of the physis, and eventual remodelling of regenerated bone

Clinical Features
- child with antalgic or Trendelenburg gait ± pain
- intermittent knee, hip, groin, or thigh pain
- flexion contracture (stiff hip): decreased internal rotation and abduction of hip
- limb length discrepancy (late)

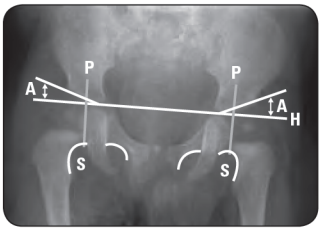


Figure 53. Pelvic x-ray and reference lines and angles for assessment of DDH

Triradiate Cartilage
y-shaped epiphyseal plate at junction of ilium, ischium and pubis

Hilgenreiner's Line
Line running between triradiate cartilages

Perkin's Line
Line through lateral margin of acetabulum, perpendicular to Hilgenreiner's Line

Shenton's Line
Arced line along inferior border of femoral neck and superior margin of obturator foramen

Acetabular Index
Angle between Hilgenreiner's Line and line from triradiate cartilage to point on lateral margin of acetabulum

Investigations
- x-ray: AP pelvis, frog leg laterals
  - may be negative early (if high index of suspicion, move to bone scan or MRI)
  - eventually, characteristic collapse of femoral head (diagnostic)

Most common in adolescent athletes, especially jumping/sprinting sports

Treatment
- goal is to preserve ROM and keep femoral head contained in acetabulum
- non-operative
  - physiotherapy: ROM exercises
  - brace in flexion and abduction x 2-3 yr (controversial)
- non-operative
  - femoral or pelvic osteotomy (>8 yr of age or severe)
    - prognosis better in males, <5 yr, <50% of femoral head involved, abduction >30°
- 60% of involved hips do not require operative intervention
- natural history is early onset OA and decreased ROM

Children diagnosed with coxa plana <6 yr of age have improved prognosis

Osgood-Schlatter Disease

- inflammation of patellar ligament at insertion point on tibial tuberosity
- M>F
- age of onset: boys 12-15 yr; girls 8-12 yr

Mechanism
- repetitive tensile stress on insertion of patellar tendon over the tibial tuberosity causes minor avulsion at the site and subsequent inflammatory reaction (tibial tubercle apophysitis)

Clinical Features
- tender lump over tibial tuberosity
- pain on resisted leg extension
- anterior knee pain exacerbated by jumping or kneeling, relieved by rest

Investigations
- x-ray: lateral knee: fragmentation of the tibial tubercle, ± ossicles in patellar tendon

Treatment
- benign, self-limited condition, does not resolve until growth halts
- marjority non-operative
  - may restrict activities such as basketball or cycling
  - NSAIDs, rest, flexibility, isometric strengthening exercises
  - casting if symptoms do not resolve with conservative management
- operative: ossicle excision in refractory cases (patient is skeletally mature with persistent symptoms)

Congenital Talipes Equinovarus (Club Foot)

- congenital foot deformity
- muscle contractures resulting in CAVE deformity
- bony deformity: talar neck medial and plantar deviated; varus calcaneus and rotated medially around talus; navicular and cuboid medially displaced
- 1-2/1,000 newborns, 50% bilateral, occurrence M>F, severity F>M

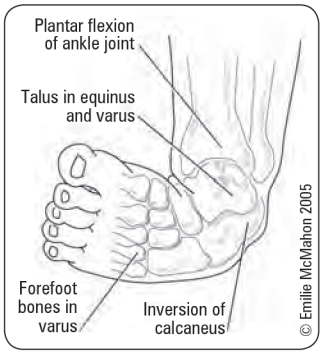


Figure 54. The club foot – depicting the gross and bony deformity

Etiology
- intrinsic causes (neurologic, muscular, or connective tissue diseases) vs. extrinsic (intrauterine growth restriction), may be idiopathic, neurogenic, or syndrome-associated
- fixed deformity

Physical Exam
- examine hips for associated DDH
- examine knees for deformity
- examine back for dysraphism (unfused vertebral bodies)

Treatment
- largely non-operative via Ponseti Technique (serial manipulation and casting)
  - correct deformities in CAVE order
    - change strapping/cast q1-2wk
    - surgical release in refractory case (rare)
      - delayed until 3-4 mo of age
- 3 yr recurrence rate = 5-10%
- mild recurrence common; affected foot is permanently smaller/stiffer than normal foot with calf muscle atrophy

CAVE deformity
- midfoot **C**avus
- forefoot **A**dductus
- hindfoot **V**arus
- hindfoot **E**quinus

Scoliosis

- lateral curvature of spine with vertebral rotation
- age: 10-14 yr
- more frequent and more severe in females

Etiology
- idiopathic: most common (90%)
- congenital: vertebrae fail to form or segment
- neuromuscular: UMN or LMN lesion, myopathy
- postural: leg length discrepancy, muscle spasm
- other: osteochondrodystrophies, neoplastic, traumatic

Clinical Features
- ± back pain
- primary curve where several vertebrae affected
- secondary curves above and below fixed 1° curve to try and maintain normal position of head and pelvis
- asymmetric shoulder height when bent forward
- Adam's test: rib hump when bent forward
- prominent scapulae, creased flank, asymmetric pelvis
- associated posterior midline skin lesions in neuromuscular scolioses
  - café-au-lait spots, dimples, neurofibromas
  - axillary freckling, hemangiomas, hair patches
- associated pes cavus or leg atrophy
- apparent leg length discrepancy

Investigations
- x-ray: 3-foot standing, AP, lateral
  - measure curvature: Cobb angle
  - may have associated kyphosis

Treatment
- based on Cobb angle
  - <25°: observe for changes with serial radiographs
  - >25° or progressive: bracing (many types) that halt/slow curve progression but do NOT reverse deformity
  - >45°, cosmetically unacceptable or respiratory problems: surgical correction (spinal fusion)

Scoliosis screening is not recommended in Canada (Grieg A, et al. 2010; Health Canada, 1994)

In structural or fixed scoliosis, bending forwards makes the curve more obvious

Postural scoliosis can be corrected by correcting the underlying problem

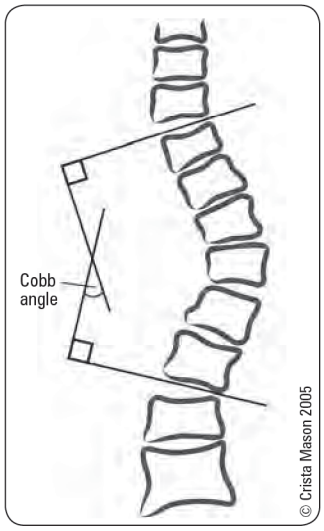


Figure 55. Cobb angle – used to monitor the progression of the scoliotic curve

Bone Tumours

- primary bone tumours are rare after 3rd decade
- metastases to bone are relatively common after 3rd decade

Clinical Features
- malignant (primary or metastasis): local pain and swelling (wk – mo), worse on exertion and at night, ± soft tissue mass
- benign: usually asymptomatic
- minor trauma often initiating event that calls attention to lesion

Table 24. Distinguishing Benign from Malignant Bone Lesions on X-Ray

Benign	Malignant
No periosteal reaction	Acute periosteal reaction • Codman's triangle • "Onion skin" • "Sunburst"
Thick endosteal reaction	Broad border between lesion and normal bone
Well developed bone formation	Varied bone formation
Intraosseous and even calcification	Extraosseous and irregular calcification

Adapted from: Buckholtz RW, Heckman JD. Rockwood and Green's Fractures in Adults. Volume 1. Philadephia: Lippincott Williams & Wilkins, 2001. p558

Diagnosis
- routine x-ray findings
  - location (which bone, diaphysis, metaphysis, epiphysis)
  - size
  - lytic/lucent vs. sclerotic
  - involvement (cortex, medulla, soft tissue)

Red Flags
- Persistent skeletal pain
- Localized tenderness
- Spontaneous fracture
- Enlarging mass/soft tissue swelling

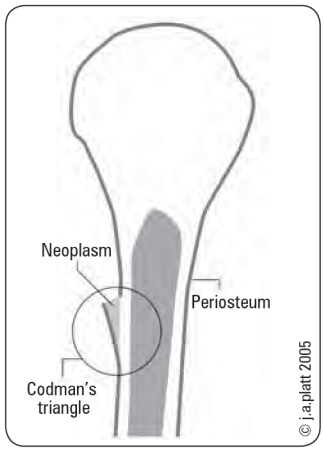


Figure 56. Codman's triangle – a radiographic finding in malignancy, where the partially ossified periosteum is lifted off the cortex by neoplastic tissue

  - matrix (radiolucent, radiodense or calcified)
  - periosteal reaction
  - margin (geographic vs. permeative)
  - any pathological fracture
  - soft tissue swelling
- malignancy is suggested by rapid growth, warmth, tenderness, lack of sharp definition
- staging should include
  - blood work including liver enzymes
  - CT chest
  - bone scan
  - bone biopsy
    - should be referred to specialized centre prior to biopsy
    - classified into benign, benign aggressive, and malignant
  - MRI of affected bone

Benign Active Bone Tumours

BONE-FORMING TUMOURS

Osteoid Osteoma
- bone tumour arising from osteoblasts
- peak incidence in 2nd and 3rd decades, M:F = 2:1 (young males)
- proximal femur and tibia diaphysis most common locations
- not known to metastasize
- radiographic findings: small, round radiolucent nidus (<1.5 cm) surrounded by dense sclerotic bone ("bull's-eye")
- symptoms: produces severe intermittent pain from prostaglandin secretion and COX1/2 expression, mostly at night (diurnal prostaglandin production), thus is characteristically relieved by NSAIDs
- treatment: NSAIDs for night pain; surgical resection of nidus

FIBROUS LESIONS

Fibrous Cortical Defect
- or non-ossifying fibroma; fibrous bone lesion
- most common benign bone tumour in children, typically asymptomatic and an incidental finding
- occur in as many as 35% of children, peak incidence between 2-25 yr old, higher prevalence in males
- femur and proximal tibia most common locations, 50% of patients have multiple defects usually bilateral, symmetrical
- radiographic findings: diagnostic, metaphyseal eccentric 'bubbly' lytic lesion near physis; thin smooth/lobulated well-defined sclerotic margin
- treatment: most lesions resolve spontaneously

Osteochondroma
- cartilage capped bony tumour
- 2nd and 3rd decades, M:F = 1.8:1
- most common of all benign bone tumours – 45%
- 2 types: sessile (broad based and increased risk of malignant degeneration) vs. pedunculated (narrow stalk)
- metaphysis of long bone near tendon attachment sites (usually distal femur, proximal tibia, or proximal humerus)
  - radiographic findings: cartilage-capped bony spur on surface of bone ("mushroom" on x-ray)
  - may be multiple (hereditary, autosomal dominant form) – higher risk of malignant change
- generally very slow growing and asymptomatic unless impinging on neurovascular structure ('painless mass')
  - growth usually ceases when skeletal maturity is reached
- malignant degeneration occurs in 1-2% (becomes painful or rapidly grows)
- treatment: typically observation; surgical excision if symptomatic

Enchondroma
- hyaline cartilage tumour; majority asymptomatic, presenting as incidental finding or pathological fracture
- 2nd and 3rd decades
- 60% occur in the small tubular bones of the hand and foot; others in femur (20%), humerus, ribs

Figure 57. T1 MRI of femoral enchondroma

- benign cartilagenous growth, an abnormality of chondroblasts, develops in medullary cavity
  - single/multiple enlarged rarefied areas in tubular bones
  - lytic lesion with sharp margination and irregular central calcification (stippled/punctate/popcorn appearance)
- malignant degeneration to chondrosarcoma occurs in 1-2% (pain in absence of pathologic fracture is an important clue)
- not known to metastasize
- treatment: observation with serial x-rays; surgical curettage if symptomatic or lesion grows

CYSTIC LESIONS

Unicameral/Solitary Bone Cyst

- most common cystic lesion; serous fluid filled lesion
- children and young adults, peak incidence during first 2 decades, M:F = 2:1
- proximal humerus and femur most common
- symptoms: asymptomatic, or local pain; complete pathological fracture (50% presentations) or incidental detection
- radiographic findings: lytic translucent area on metaphyseal side of growth plate, cortex thinned/expanded; well defined lesion
- treatment: aspiration followed by steroid injection; curettage ± bone graft indicated if re-fracture likely

Figure 58. X-ray of aneurysmal bone cyst. Note the aggressive destruction of bone

Benign Aggressive Bone Tumours

Giant Cell Tumours/Aneurysmal Bone Cyst/Osteoblastoma

- affects patients of skeletal maturity, peak 3rd decade
- osteoblastoma: found in the distal femur, proximal tibia, distal radius, sacrum, tarsal bones, spine
- giant cell tumour: pulmonary metastases in 3%
- aneurysmal bone cysts: either solid with fibrous/granular tissue, or blood-filled
- radiographic findings
  - giant cell tumour: eccentric lytic lesions, in epiphyses adjacent to subchondral bone; may break through cortex; T2 MRI enhances fluid within lesion (hyper-intense signal)
  - aneurysmal bone cyst: expanded with honeycomb shape
  - osteoblastoma: often nonspecific; calcified central nidus (>2 cm) with radiolucent halo and sclerosis
- symptoms: local tenderness and swelling, pain may be progressive (giant cell tumours), ± symptoms of nerve root compression (osteoblastoma)
- 15% recur within 2 yr of surgery

Treatment

- intralesional curettage + bone graft or cement
- wide local excision of expendable bones

Malignant Bone Tumours

Table 25. Most Common Malignant Tumour Types for Age

Age	Tumour
<1	Neuroblastoma
1-10	Ewing's of tubular bones
10-30	Osteosarcoma, Ewing's of flat bones
30-40	Reticulum cell sarcoma, fibrosarcoma, periosteal osteosarcoma, malignant giant cell tumour, lymphoma
>40	Metastatic carcinoma, multiple myeloma, chondrosarcoma

Osteosarcoma

- malignant bone tumour
- most frequently diagnosed in 2nd decade of life (60%), 2nd most common primary malignancy in adults
- history of Paget's disease (elderly patients), previous radiation treatment
- predilection for sites of rapid growth: distal femur (45%), proximal tibia (20%), and proximal humerus (15%)
  - invasive, variable histology; frequent metastases without treatment (lung most common)
- painful symptoms: progressive pain, night pain, poorly defined swelling, decreased ROM
- radiographic findings
  - characteristic periosteal reaction: Codman's triangle (see Figure 56) or "sunburst" spicule formation (tumour extension into periosteum)
  - destructive lesion in metaphysis may cross epiphyseal plate

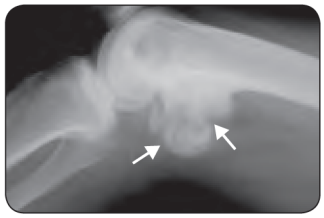


Figure 59. X-ray of osteosarcoma of distal femur

- management: complete resection (limb salvage, rarely amputation), neo-adjuvant chemo; bone scan – rule out skeletal metastases, CT chest – rule out pulmonary metastases
- prognosis: 70% (high-grade); 90% (low-grade)

Chondrosarcoma
- malignant chondrogenic tumour
- primary (2/3 cases)
  - previous normal bone, patient >40 yr; expands into cortex to give pain, pathological fracture, flecks of calcification
- secondary (1/3 cases)
  - malignant degeneration of pre-existing cartilage tumour such as enchondroma or osteochondroma
  - age range 25-45 yr and better prognosis than primary chondrosarcoma
- symptoms: progressive pain, uncommonly palpable mass
- radiographic findings: in medullary cavity, irregular "popcorn" calcification
- treatment: unresponsive to chemotherapy, treat with aggressive surgical resection + reconstruction; regular follow-up x-rays of resection site and chest
- prognosis: 10-yr survival 90% low-grade, 20-40% high-grade

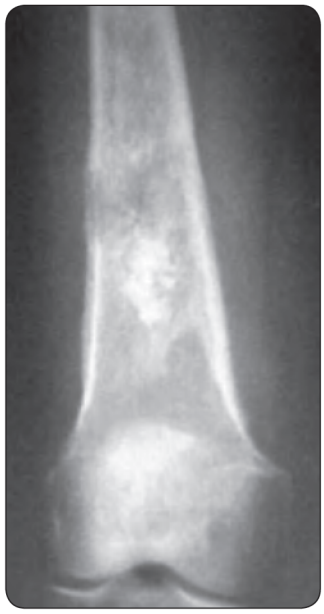


Figure 60. X-ray of femoral chondrosarcoma

Ewing's Sarcoma
- malignant small round cell sarcoma
- most occur between 5-25 yr old
- florid periosteal reaction in metaphyses of long bone with diaphyseal extension
- metastases frequent without treatment
- signs/symptoms: presents with pain, mild fever, erythema and swelling, anemia, increased WBC, ESR, LDH (mimics an infection)
- radiographic findings: moth-eaten appearance with periosteal lamellated pattern ("onion-skinning")
- treatment: resection, chemotherapy, radiation
- prognosis – 70%, worst prognostic factor is distant metastases

Multiple Myeloma
- proliferation of neoplastic plasma cells
- most common primary malignant tumour of bone in adults (~43%)
- 90% occur in people >40 yr old, M:F = 2:1, African-Americans (twice as common)
- signs/symptoms: localized bone pain (cardinal early symptom), compression/pathological fractures, renal failure, nephritis, high incidence of infections (e.g. pyelonephritis/pneumonia), systemic (weakness, weight loss, anorexia)
- labs: anemia, thrombocytopenia, increased ESR, hypercalcemia, increased Cr
- radiograpic findings: multiple, "punched-out" well-demarcated lesions, no surrounding sclerosis, marked bone expansion
- diagnosis
  - serum/urine immunoelectrophoresis (monoclonal gammopathy)
  - CT-guided biopsy of lytic lesions at multiple bony sites
- treatment: chemotherapy, bisphosphonates, radiation, surgery for symptomatic lesions or impending fractures – debulking, internal fixation
- prognosis: 5 yr survival 30%; 10 yr survival 11%
- see IHematology, II49

Signs of Hypercalcemia
"Bones, Stones, Moans, Groans, Psychiatric overtones"

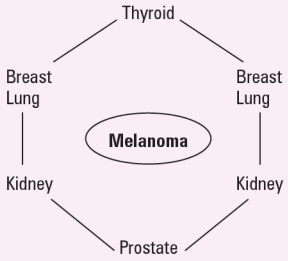
CNS: headache, confusion, irritability, blurred vision
GI: N/V, abdominal pain, constipation, weight loss
MSK: fatigue, weakness, unsteady gait, bone and joint pain
GU: nocturia, polydipsia, polyuria, UTIs

Bone Metastases
- most common cause of bone lesions in adults; typically age >40
- 2/3 from breast or prostate; also consider thyroid, lung, kidney
- usually osteolytic; prostate occasionally osteoblastic
- may present with mechanical pain and/or night pain, pathological fracture, hypercalcemia
- bone scan for MSK involvement, MRI for spinal involvement may be helpful
- treatment: pain control, bisphosphonates, stabilization of impending fractures if Mirel's Critera >8 (ORIF, IM rod, bone cement)

Table 26. Mirel's Criteria for Impending Fracture Risk and Prophylactic Internal Fixation

Variable	Number Assigned		
	1	2	3
Site	Upper arm	Lower extremity	Peritrochanteric
Pain	Mild	Moderate	Severe
Lesion	Blastic	Mixed	Lytic
Size	<1/3 bone diameter	1/3-2/3 diameter	>2/3 diameter

Most Common Tumours Metastatic to Bone



BLT with a Kosher Pickle
Breast
Lung
Thyroid
Kidney
Prostate

Common Medications

Table 27. Common Medications

Drug Name	Dosing Schedule	Indications	Comments
cefazolin (Ancef®)	1-2 g IV q8h	Prophylactically before orthopedic surgery	First generation cephalosporin; do not use with penicillin allergy
heparin	5000 IU SC q12h	To prevent venous thombosis and pulmonary emboli	Monitor platelets, follow PTT which should rise 1.5-2x
LMWH **dalteparin (Fragmin®)** **enoxaparin (Lovenox®)** **fondaparinux (Arixtra®)**	 5000 IU SC OD 30-40 mg SC bid 2.5 mg SC OD	DVT prophylaxis especially in hip and knee surgery	Fixed dose, no monitoring, improved bioavailability, increased bleeding rates
oral anticoagulants **dabigatran (Pradaxa®)** **rivaroxaban (Xarelto®)** **apixaban**	110 mg PO x1 then 220 mg PO OD 10 mg PO OD 2.5 mg PO bid	DVT prophylaxis especially TKA and THA	Predictable, no monitoring, oral administration; no antidote
midazolam (Versed®)	0.02-0.04 mg/kg IV	Conscious sedation for short procedures	Medication used during fracture reduction – monitor for respiratory depression
fentanyl (Sublimaze®)	0.5-3 μg/kg IV	Conscious sedation for short procedures	Short acting anesthetic used in conjunction with midazolam (Versed®)
triamcinolone (Aristocort®) – an injectable steroid	0.5-1 mL of 25 mg/mL	Suspension (injected into inflamed joint or bursa); amount varies by joint size	Potent anti-inflammatory effect; increased pain for 24 h, rarely causes fat necrosis and skin depigmentation
naproxen (Aleve®, Naprosyn®)	250-500 mg bid	Pain due to inflammation, arthritis, soft tissue injury	NSAID, may cause gastric erosion and bleeding
misoprostol (Cytotec®)	200 μg qid	Prophylaxis of HO after THA	Use with indomethacin
indomethacin (Indocid®)	25 mg PO tid	Prophylaxis of HO after THA	Use with misoprostol
ibuprofen (Advil®, Motrin®)	200-400 mg tid	Pain (including post-operative), inflammation (including arthritis)	NSAID, may cause gastric erosion and bleeding
propofol (Diprivan®)	1-2 mg/kg IV maintenance 0.5 mg/kg	Conscious sedation for short procedures	Short acting anesthetic often used in conjunction with fentanyl (Sublimaze®)

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