

# Musculoskeletal System: Structure and Function



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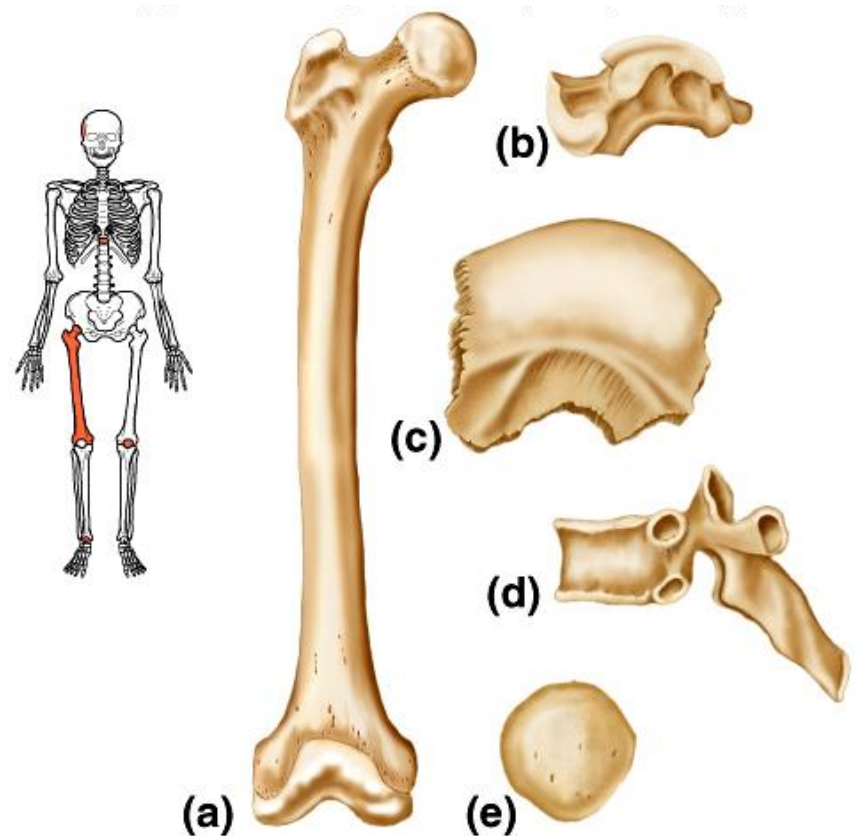


# Skeletal System

## Types of Bone

- Long Bones
- Short Bones
- Flat Bones
- Irregular Bones
- Sesamoid (Round) Bones

There are **206 bones** in the human skeleton (210 if we count the two sesamoid bones that lie under the head of the first metatarsal in each foot in most people).



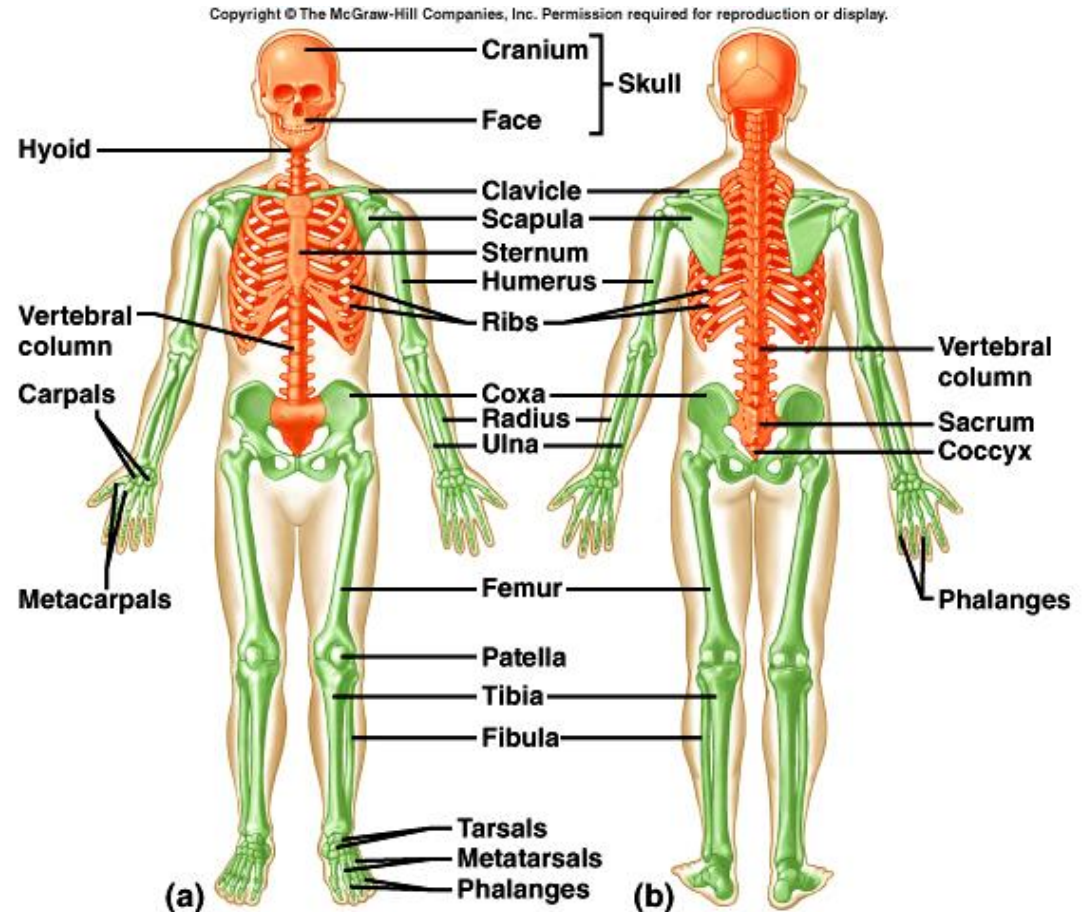
# Skeletal Organization

## Axial Skeleton

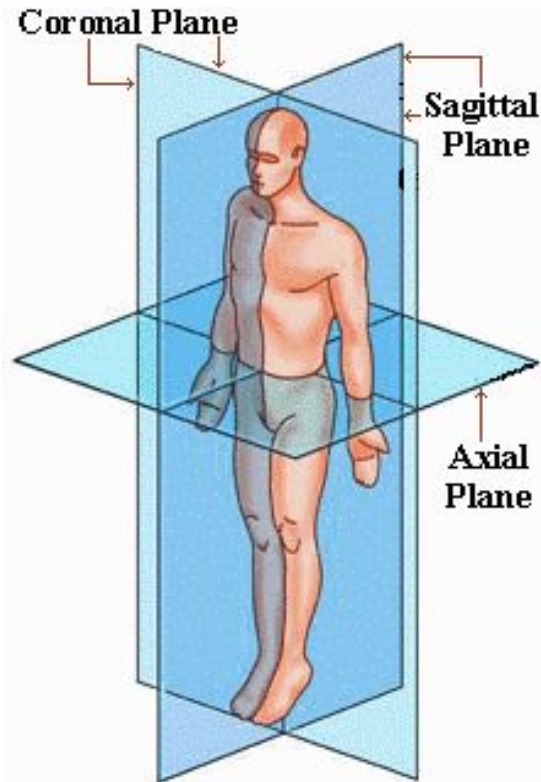
- skull
- thorax
- vertebral column

## Appendicular Skeleton

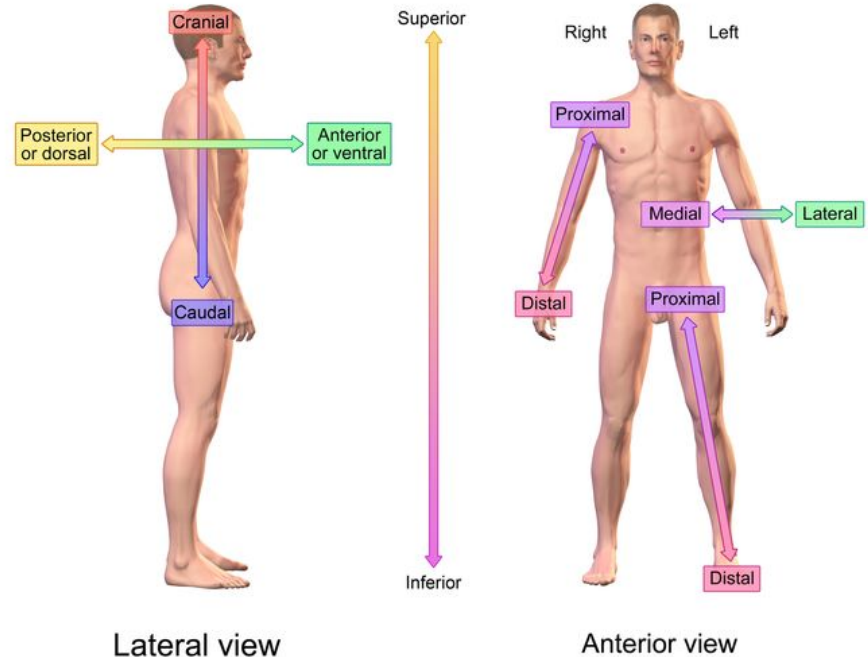
- upper limbs
- lower limbs
- pectoral girdle
- pelvic girdle



# Anatomical planes and directions



(a)



## Directional References

(b)

Sketch showing (a) anatomical planes of reference; (b) anatomical directions and movements of the hip joint.



# Anatomical Terms

- Anterior and posterior: describe structures at the front (anterior) and back (posterior) of the body; e.g. the toes are anterior to the heel.
- Superior and inferior: describe a position above (superior) or below (inferior) another part of the body; e.g. the pelvis is inferior to the abdomen.
- Proximal and distal: describe a position that is closer (proximal) or further (distal) from the trunk of the body; e.g. the shoulder is proximal to the arm, and the foot is distal to the knee.
- Medial and lateral: describe a position that is closer to (medial) or further from (lateral) the midline of the body; e.g. the nose is medial to the eyes, and the thumb is lateral to the other fingers.
- Ventral and Dorsal: describe structures derived from the front (ventral) and back (dorsal) of the embryo, before limb rotation.
- Cranial and caudal, which describe structures close to the top of the skull (cranial), and towards the bottom of the body (caudal).



# Anatomy of a Femur

**Femur – the longest and strongest bone**

## □ Epiphyses : the connectors

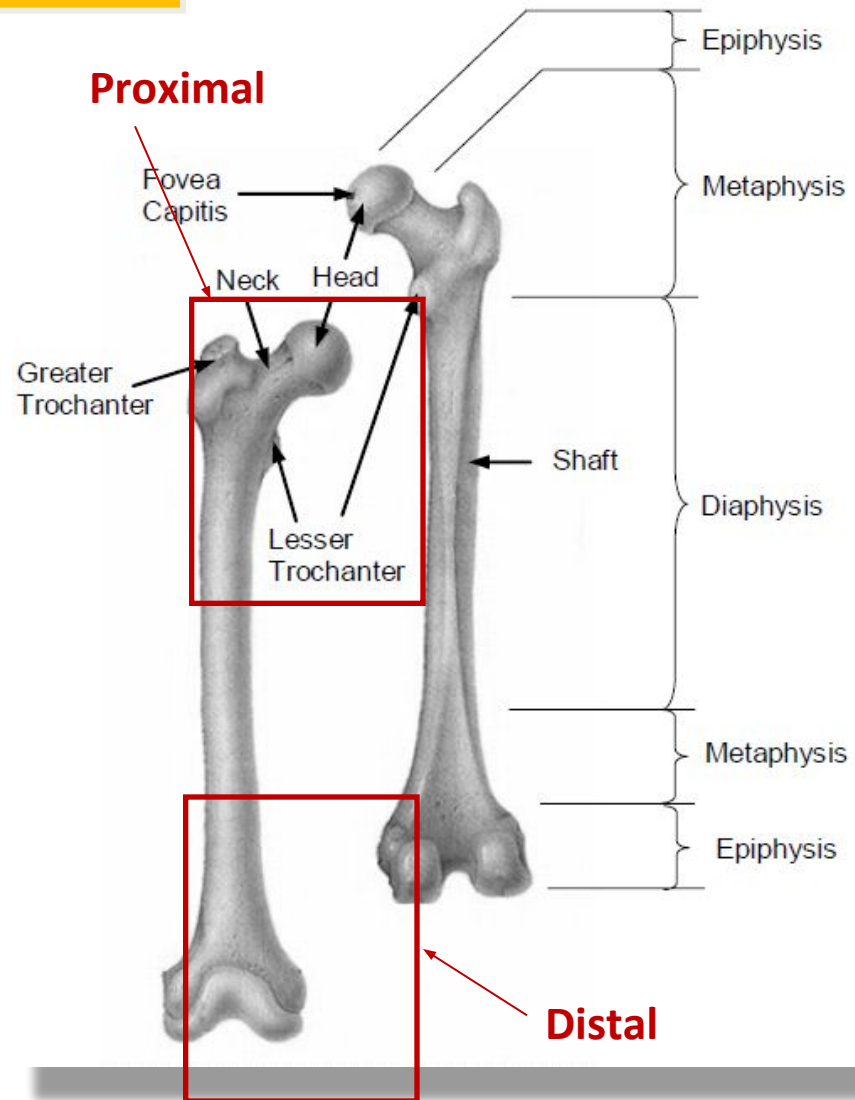
- Connect femur with other bones

## □ Diaphysis : the central shaft

- Composed of hard cortical bone
- Transfers load

## □ Metaphyses : conical eminences

- Composed of cancellous bone with thin layer of cortex
- Sites for muscle attachments





# Bone Function

## Support, Movement & Protection

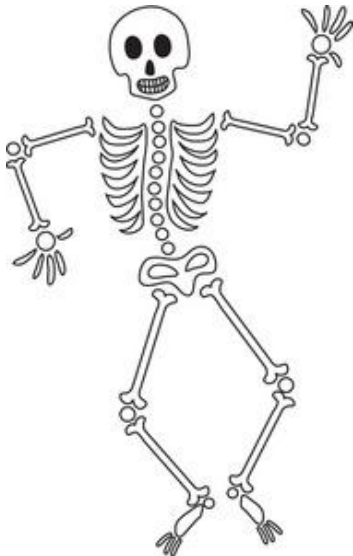
- supports body weight
- protects vital organs, e.g. brain, lungs, heart
- bones and muscles interact when limbs move – **enables mobility**

## Blood Cell Formation

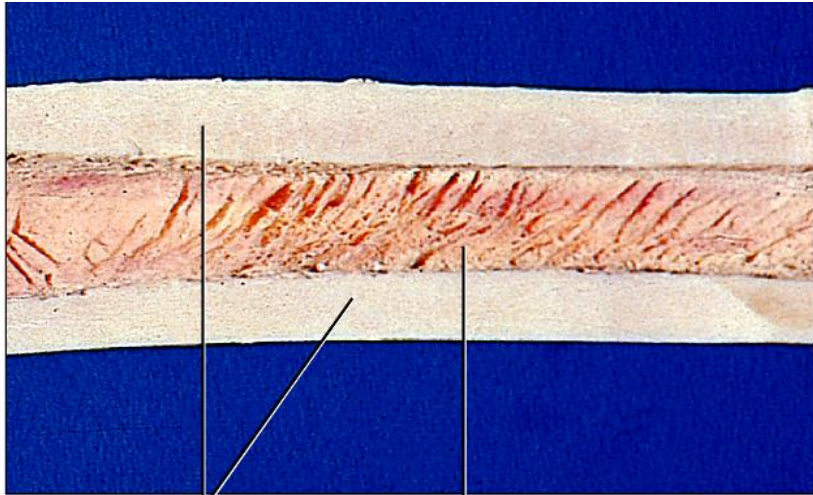
- hematopoiesis
- red marrow

## Mineral Storage

- calcium
- phosphate
- magnesium
- sodium
- potassium

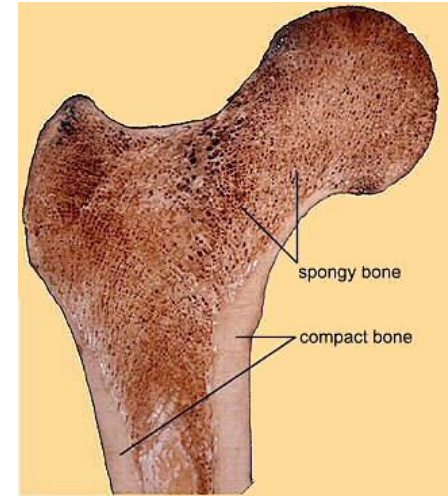


# Compact and Spongy Bone



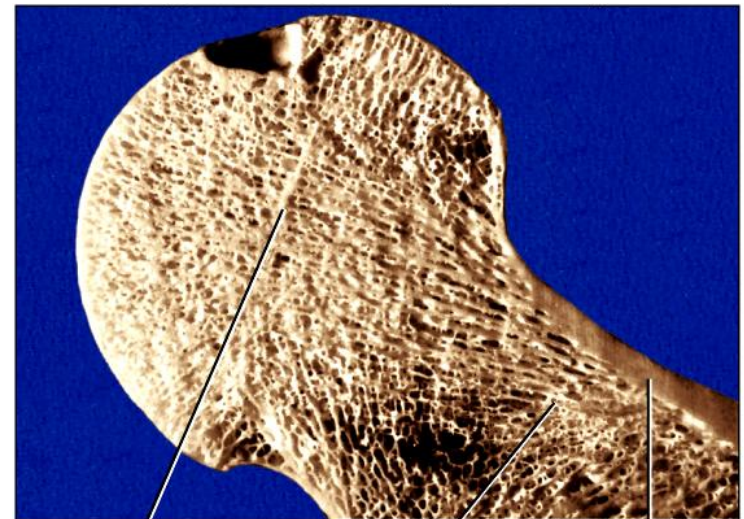
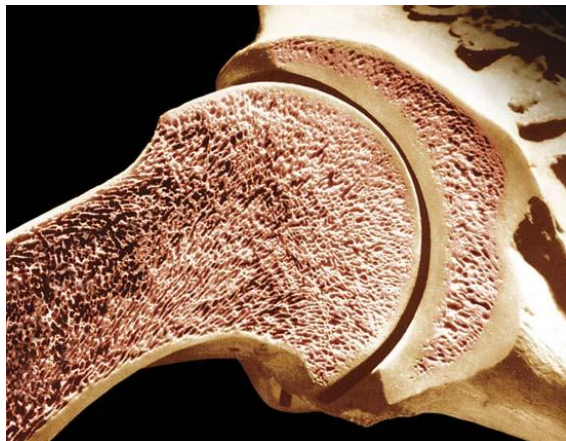
Compact bone

Yellow marrow in medullary cavity



spongy bone

compact bone



Remnant of epiphyseal plate

Spongy bone

Compact bone



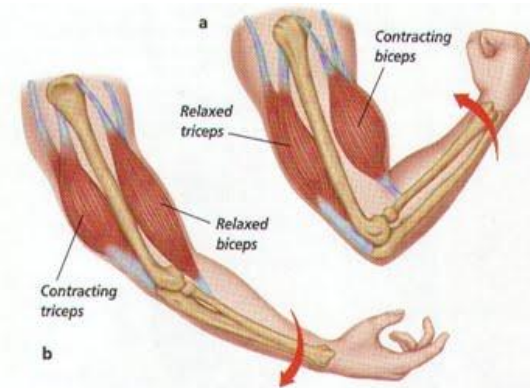
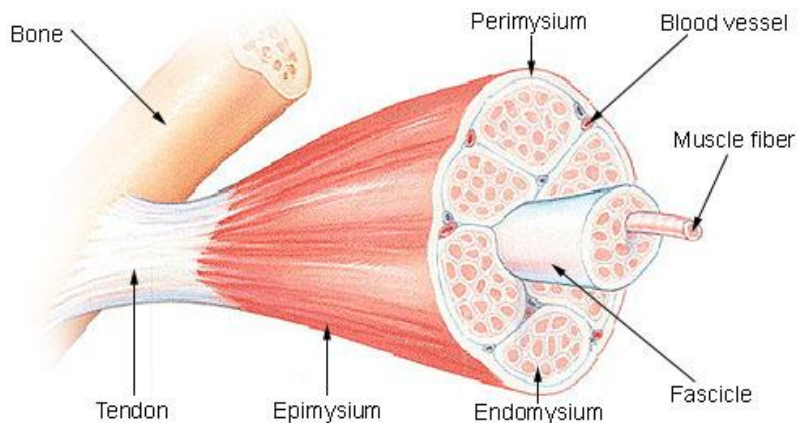
# Muscle

There are approximately 700 different muscles in the human body, three types:

- **Skeletal:** attached to bones and moves skeleton, voluntary muscle
- **Cardiac:** muscle of the heart, involuntary muscle (e.g., in walls of blood vessels, intestine, & other 'hollow' structures and organs)
- **Smooth or visceral:** muscle of the viscera



## Structure of a Skeletal Muscle



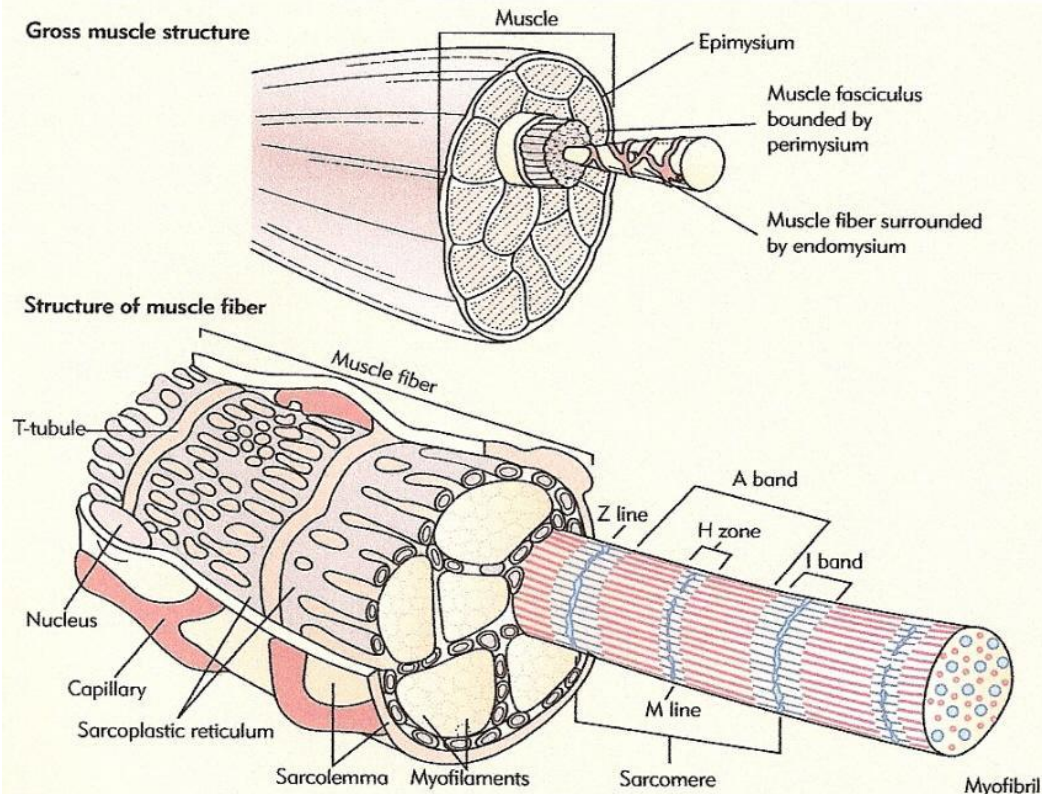
## Functions of muscle:

- motion
- maintenance of posture
- heat production



# Skeletal Muscles

Skeletal muscles consist of numerous subunits or bundles called fascicles (or fascicles). Fascicles are also surrounded by connective tissue (called the perimysium) and each fascicle is composed of numerous muscle fibers (or muscle cells).



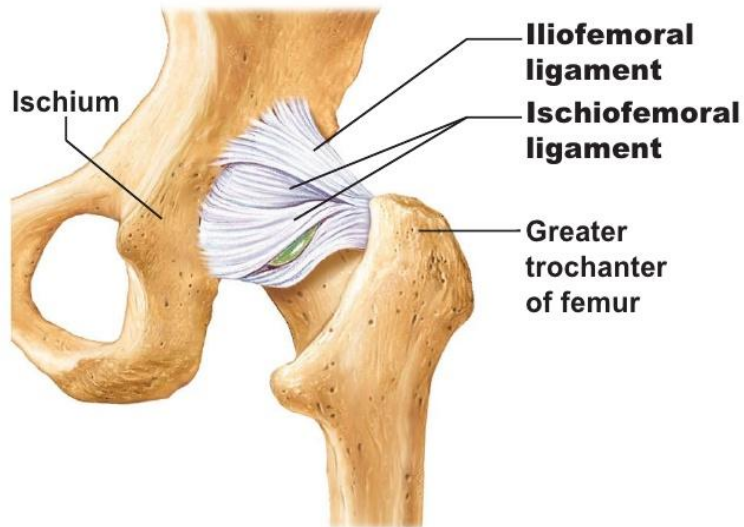
**Muscle cells**, ensheathed by endomysium, consist of many fibrils (or myofibrils), and these myofibrils are made up of long protein molecules called myofilaments. There are two types of myofilaments in myofibrils: thick myofilaments and thin myofilaments.

Skeletal muscles are usually attached to bone by **tendons** composed of connective tissue. This connective tissue also draws the entire muscle & is called epimysium.

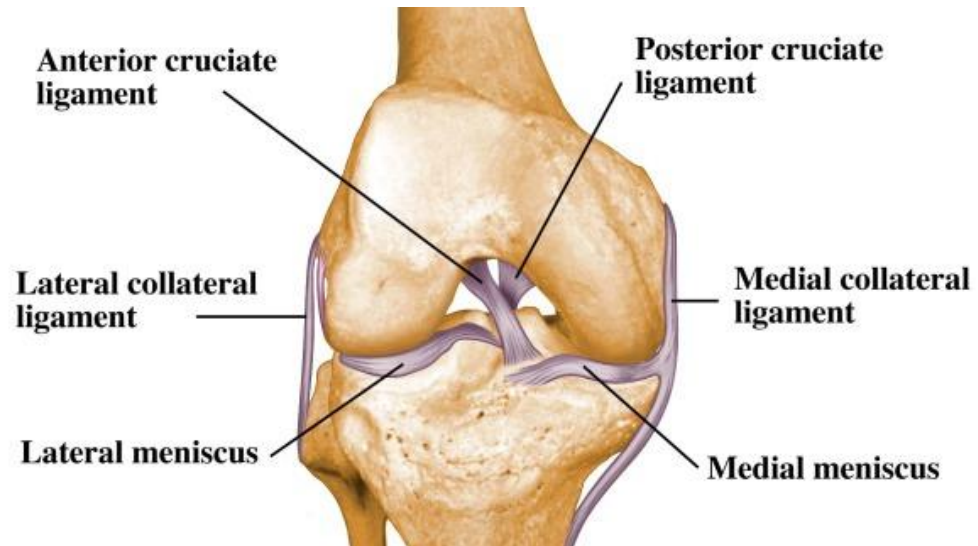


# Ligament

A **ligament** is the fibrous connective tissue that connects bones to other bones and is also known as articular **ligament**, articular larua, fibrous **ligament**, or true **ligament**.



**Hip Joint**

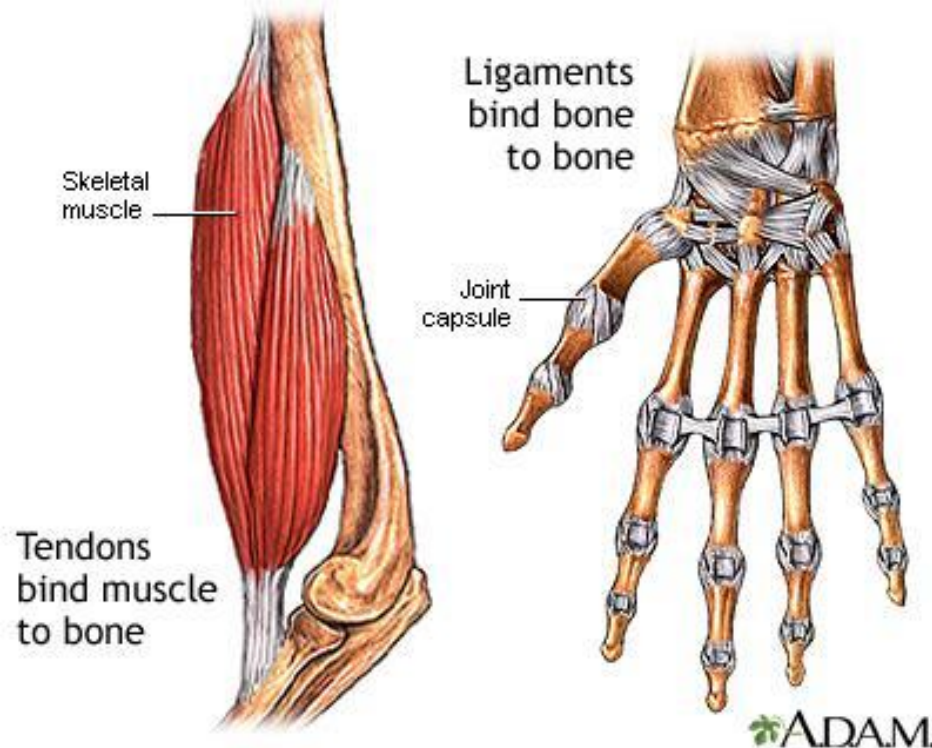


**Knee Joint**



# Tendon

A **tendon** (or sinew) is a tough band of fibrous connective tissue that usually connects muscle to bone and is capable of withstanding tension. Tendons may also attach muscles to structures such as the eyeball. A tendon serves to move the bone or structure.



**Tendons** are similar to ligaments and fasciae; all three are made of collagen.

A ligament is a fibrous connective tissue which attaches bone to bone, and usually serves to hold structures together and keep them stable.



# Rigid Body Model Elements

## Anatomic Element

## Model Element

**Bone**

**Rigid links**

**Joints**

**Standard Joints**

**Muscle + Tendon**

**Actuators**

(responsible for moving or controlling a mechanism or system)

**Ligament**

**Controllers**  
**Springs**

(monitors and physically alters the operating conditions of a given dynamical system)





# Joints



# Joints

**Articulations:** The site where 2 or more bones meet.

Joints are the weakest part of the skeleton.

## Classification

Functional: Amount of movement allowed

- 1). Synarthroses: Immovable joints
- 2). Amphiarthrosis: Slightly movable joint
- 3). Diarthroses: Fully movable joints



# Joints

## Classification

Structural: based on material binding the bone.

- 1) **Fibrous:** Bone ends united by collagenic fibers
  - a) Sutures
  - b) Syndesmoses
  - c) Gomphoses



# Joint

## Classification

### 2) Cartilaginous Joints

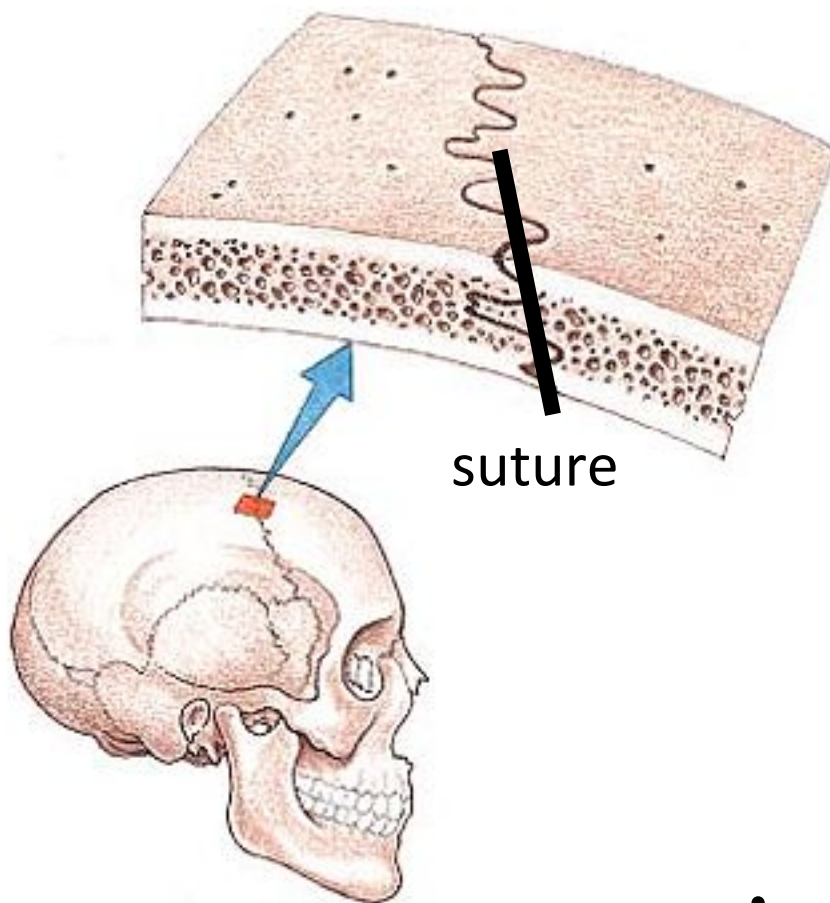
Bones are united by cartilage

- a) Synchondrosis
- b) Symphyses
- c) Synovial Joints



# Fibrous Joints

## Immovable Joints (synarthrosis)



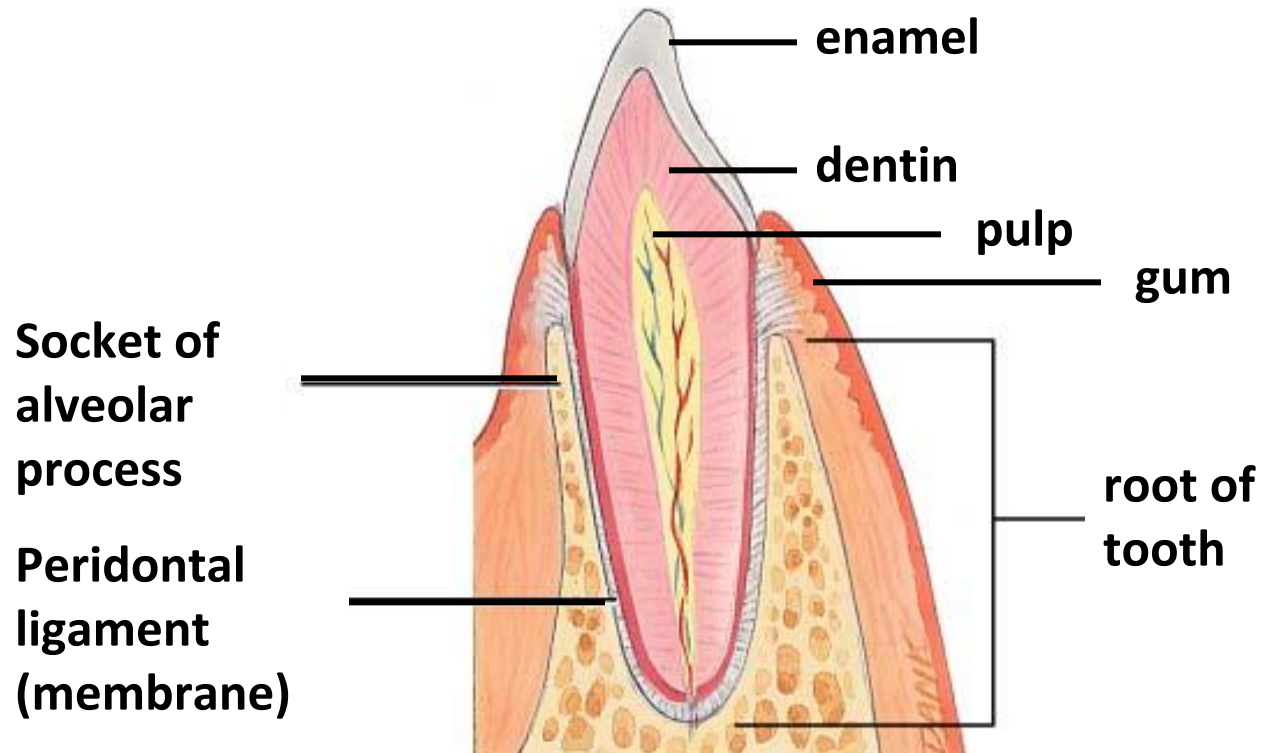
Interosseous membrane (syndesmosis)

- Bones united by ligament





# Gomphosis



- Ligaments hold tooth in bony socket
- Immovable joint

# Cartilagenous Joints

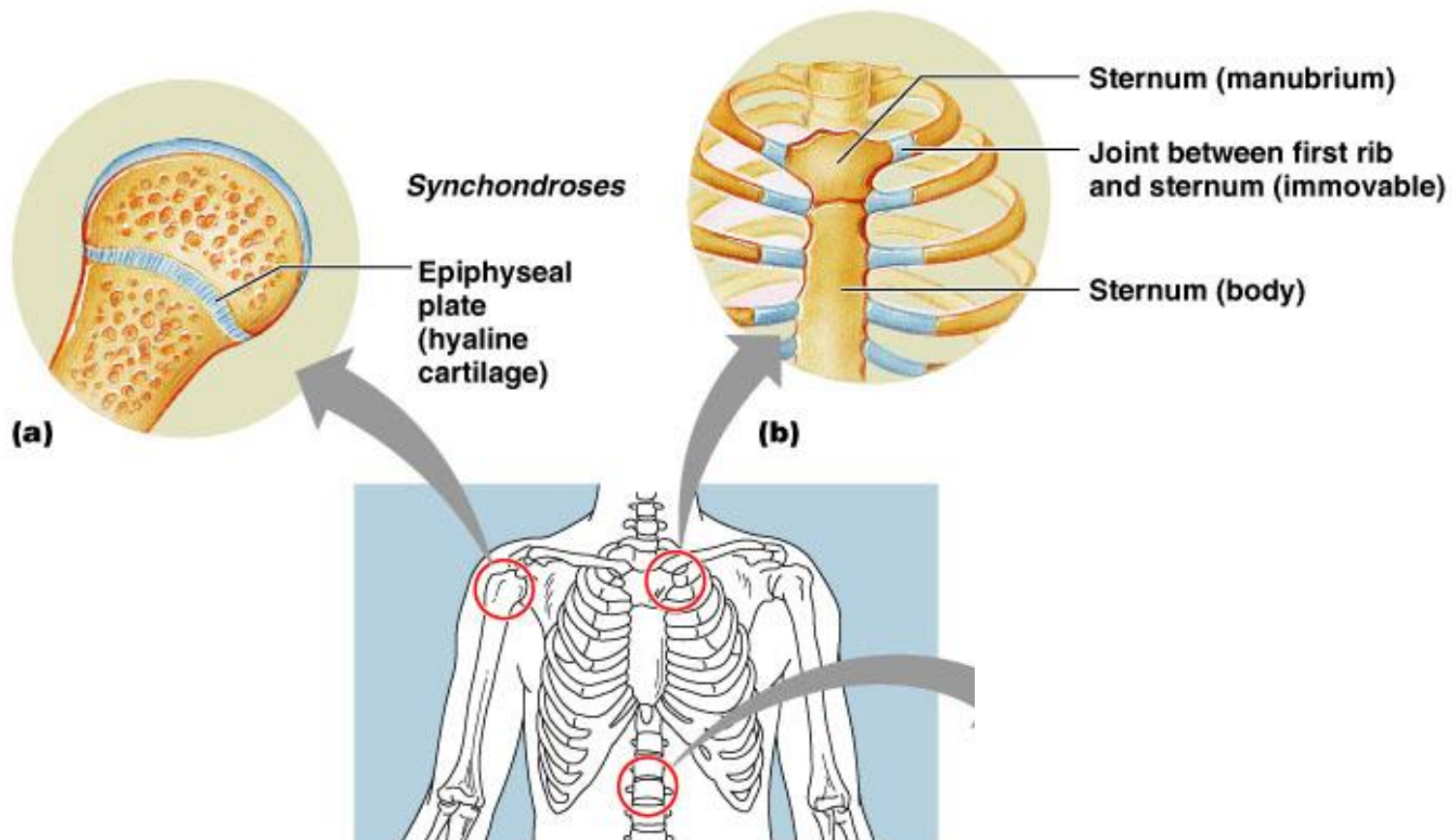
## Slightly Movable (ampharthrosis) and Immovable (synarthrosis) Joints

- Lacks a synovial cavity
- Bones connected by fibrocartilage or hyaline cartilage
- Two (2) types
  - synchondrosis
  - symphyses



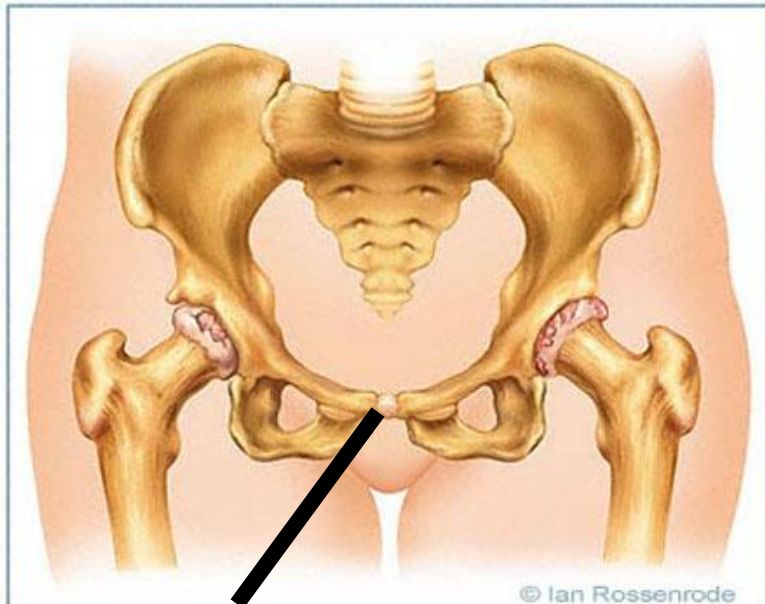
# Cartilagenous Joints

## Immovable Joint (**synchondrosis**)

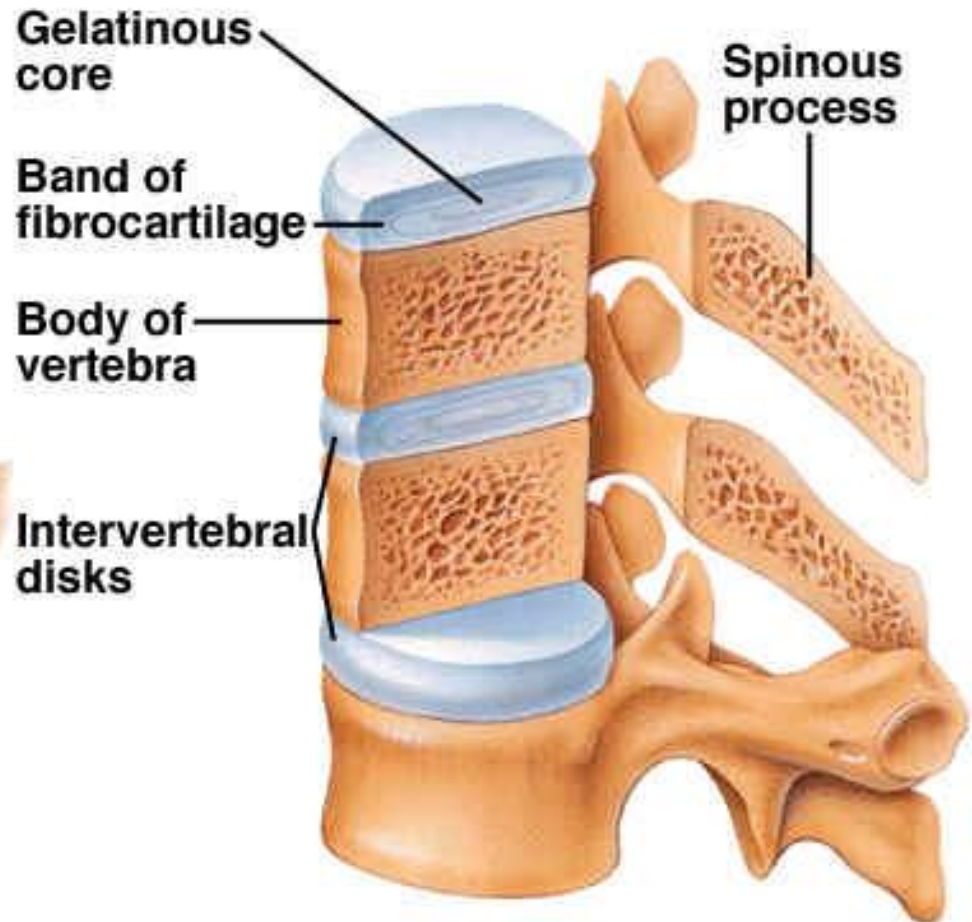


# Cartilagenous Joints

## Slightly Movable Joint (**ampharthrosis**)



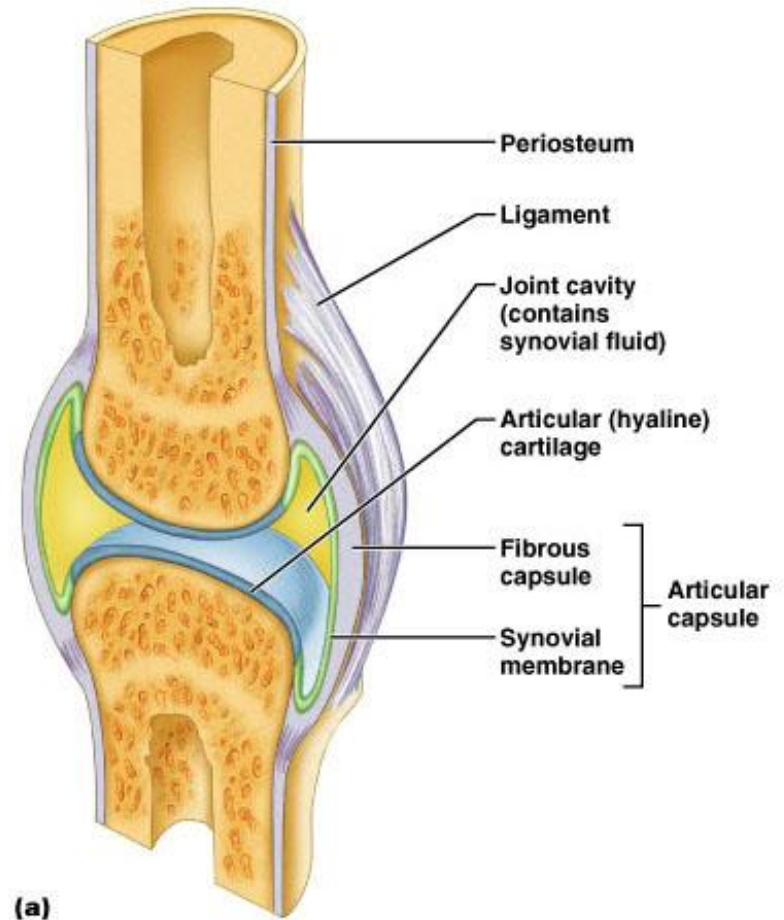
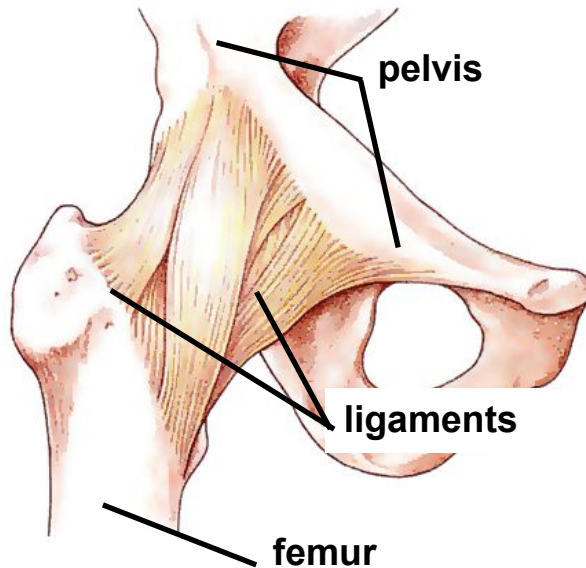
pubic symphysis



# Synovial Joints

## Freely moveable (diarthrosis)

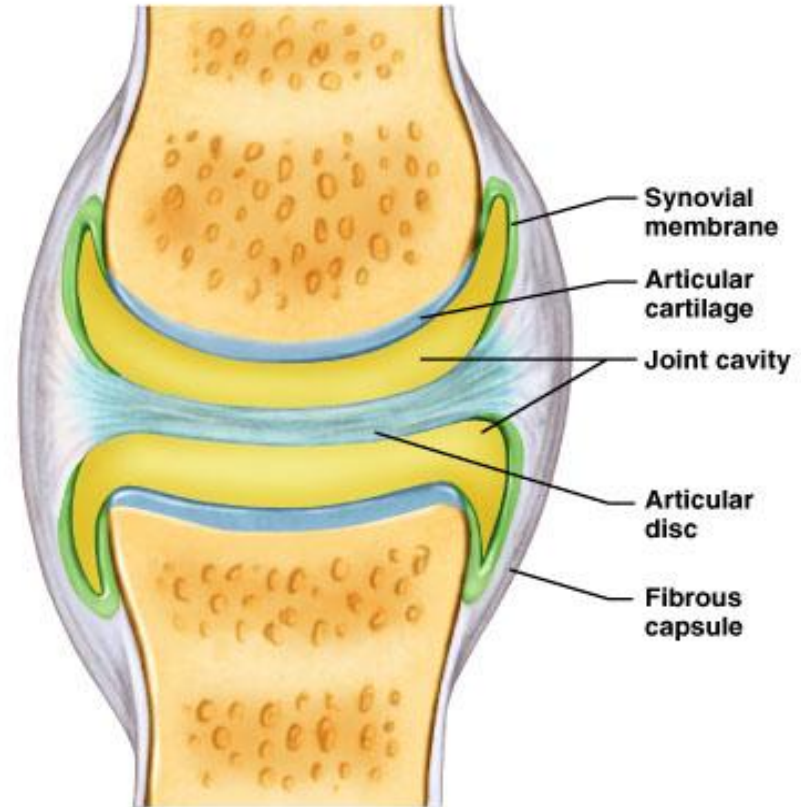
- Most movable type of joint
- All are diarthroses
- Each contains a fluid-filled joint cavity





# Synovial Joints with Articular Discs

- Some synovial joints contain an articular disc:
  - Occur in the temporomandibular joint and at the knee joint
  - Occur in joints whose articulating bones have somewhat different shapes

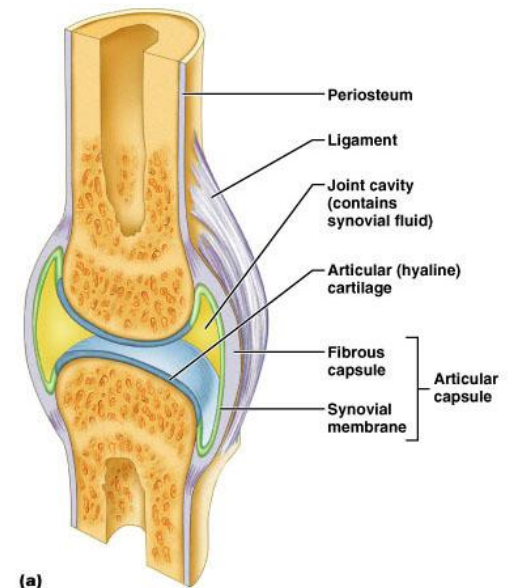
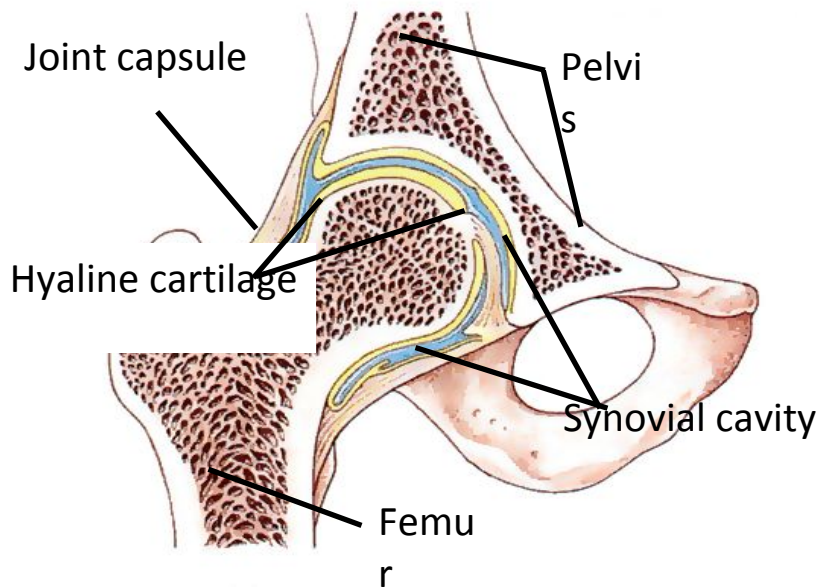


(c)



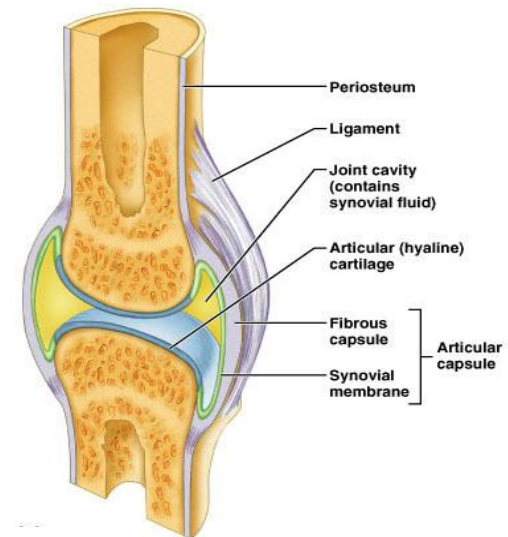
# General Structure of Synovial Joints

- **Articular cartilage**
  - Ends of opposing bones are covered with hyaline cartilage
  - Absorbs compression
- **Joint cavity (synovial cavity)**
  - Unique to synovial joints
  - Cavity is a potential space that holds a small amount of fluid



# General Structure of Synovial Joints

- **Articular capsule – joint cavity is enclosed in a two-layered capsule**
  - Fibrous capsule – dense irregular connective tissue – strengthens joint
  - Synovial membrane – loose connective tissue
    - Lines joint capsule and covers internal joint surfaces
    - Functions to make synovial fluid

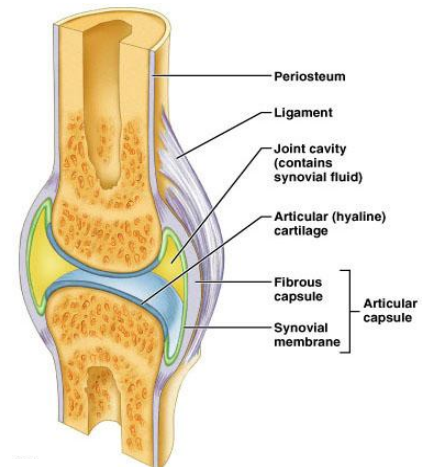


- **Synovial fluid**
  - A viscous fluid similar to raw egg white
    - A filtrate of blood
      - Arises from capillaries in synovial membrane
    - Contains glycoprotein molecules secreted by fibroblasts



# General Structure of Synovial Joints

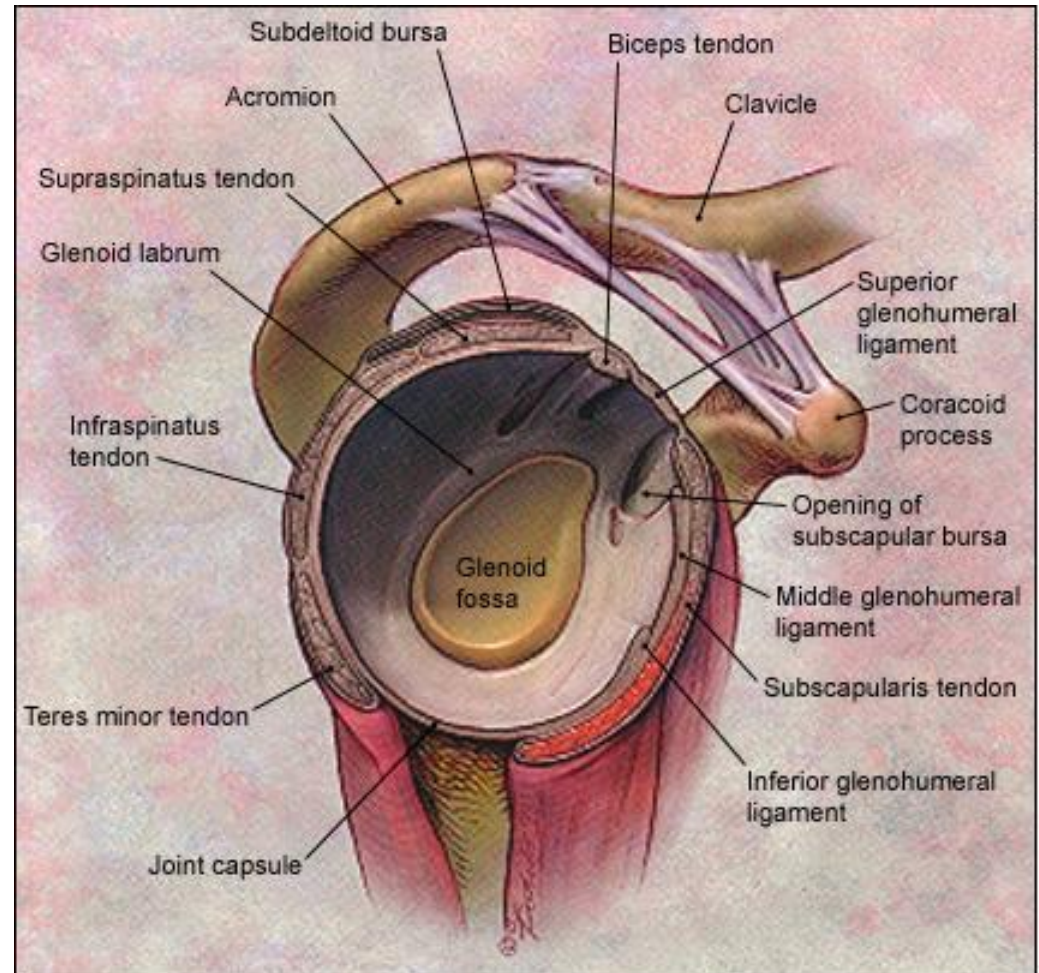
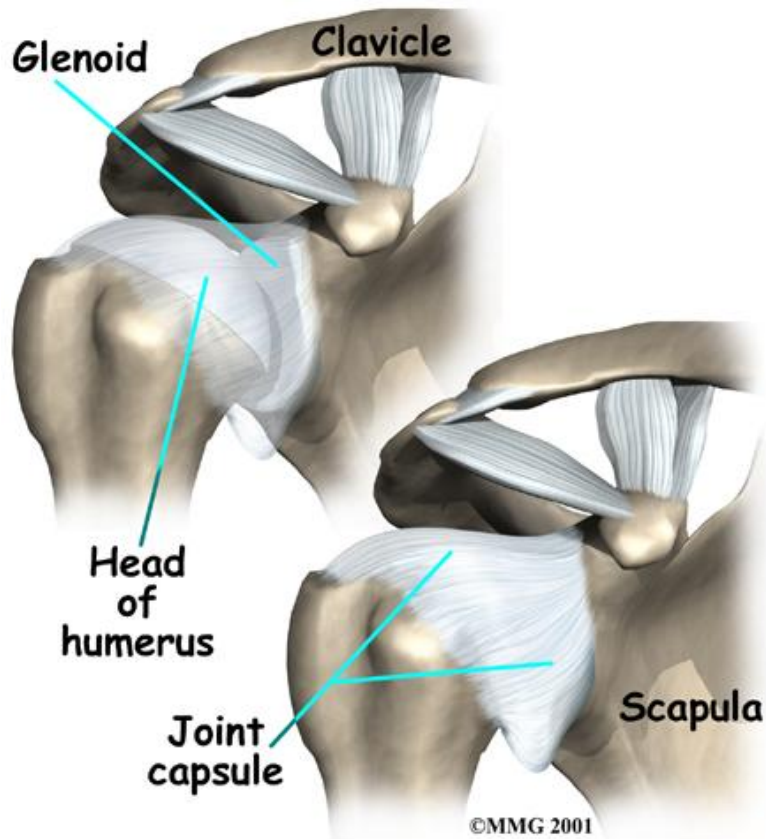
- **Reinforcing ligaments**
  - Often are thickened parts of the fibrous capsule
  - Sometimes are *extracapsular ligaments* – located outside the capsule
  - Sometimes are *intracapsular ligaments* – located internal to the capsule
- **Richly supplied with sensory nerves**
  - Detect pain
  - Most monitor how much the capsule is being stretche
- **Have a rich blood supply**
  - Most supply the synovial membrane
  - Extensive capillary beds produce basis of synovial fluid
  - Branches of several major nerves and blood vessels





# Synovial Joints

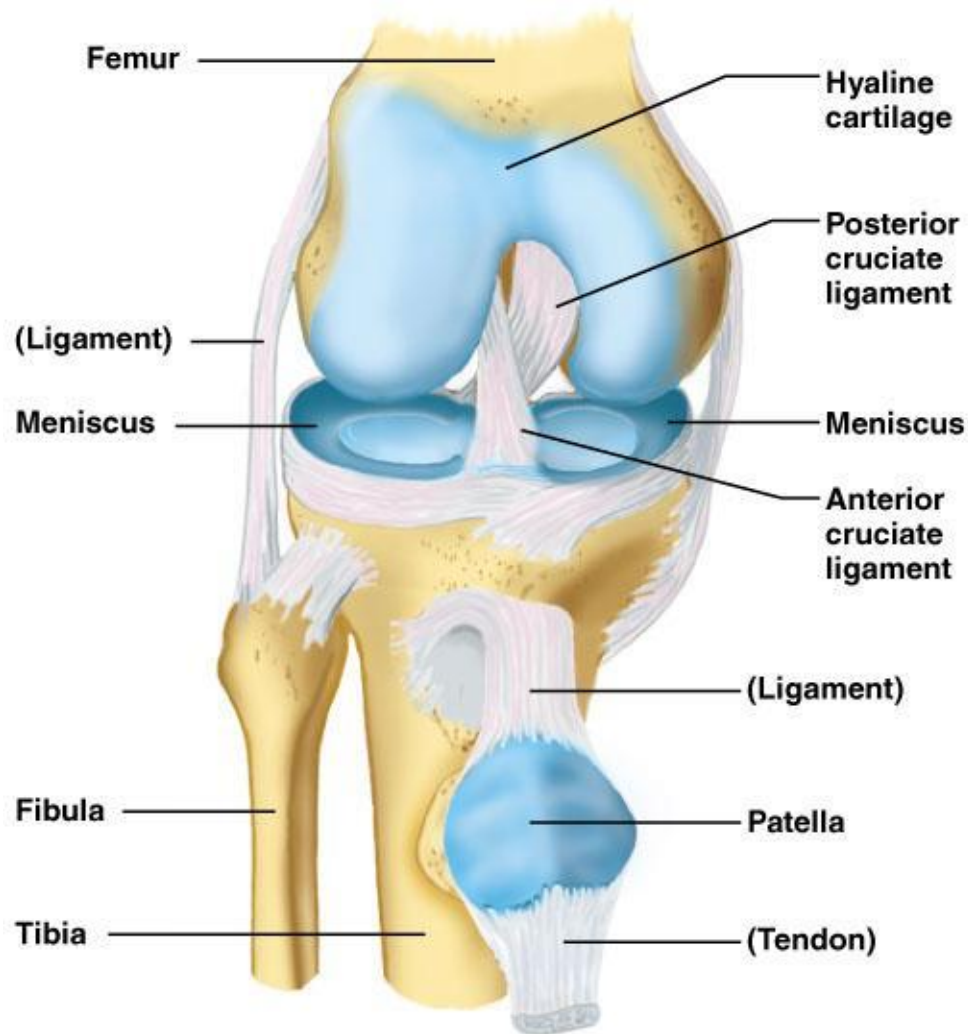
## Shoulder joint





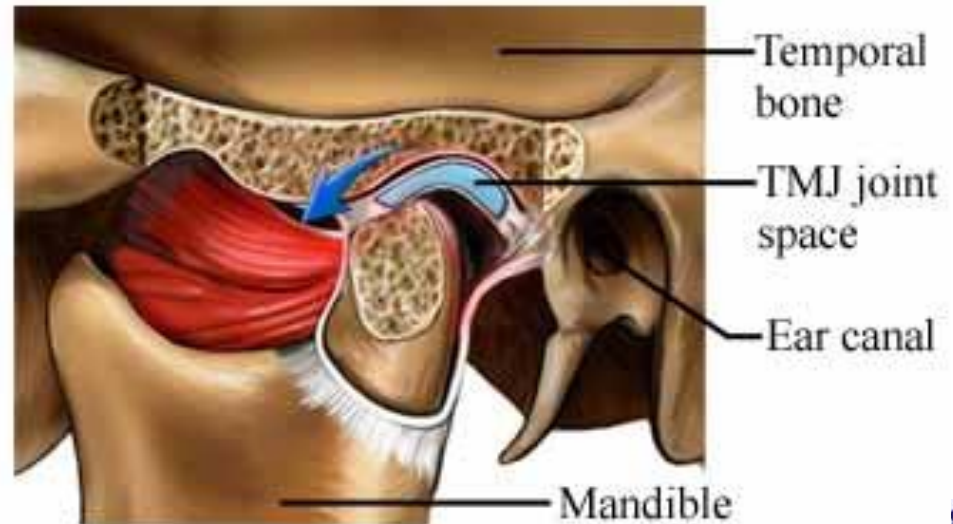
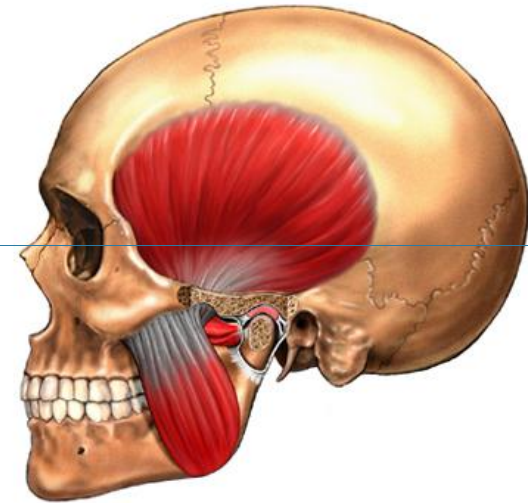
# Synovial Joints

## Knee joint



# Temporomandibular Joints

- Complex Joint
- Articular disc
- Gliding above disc
- Hinge below disc
- Movements:
  - depression
  - elevation
  - protraction
  - retraction

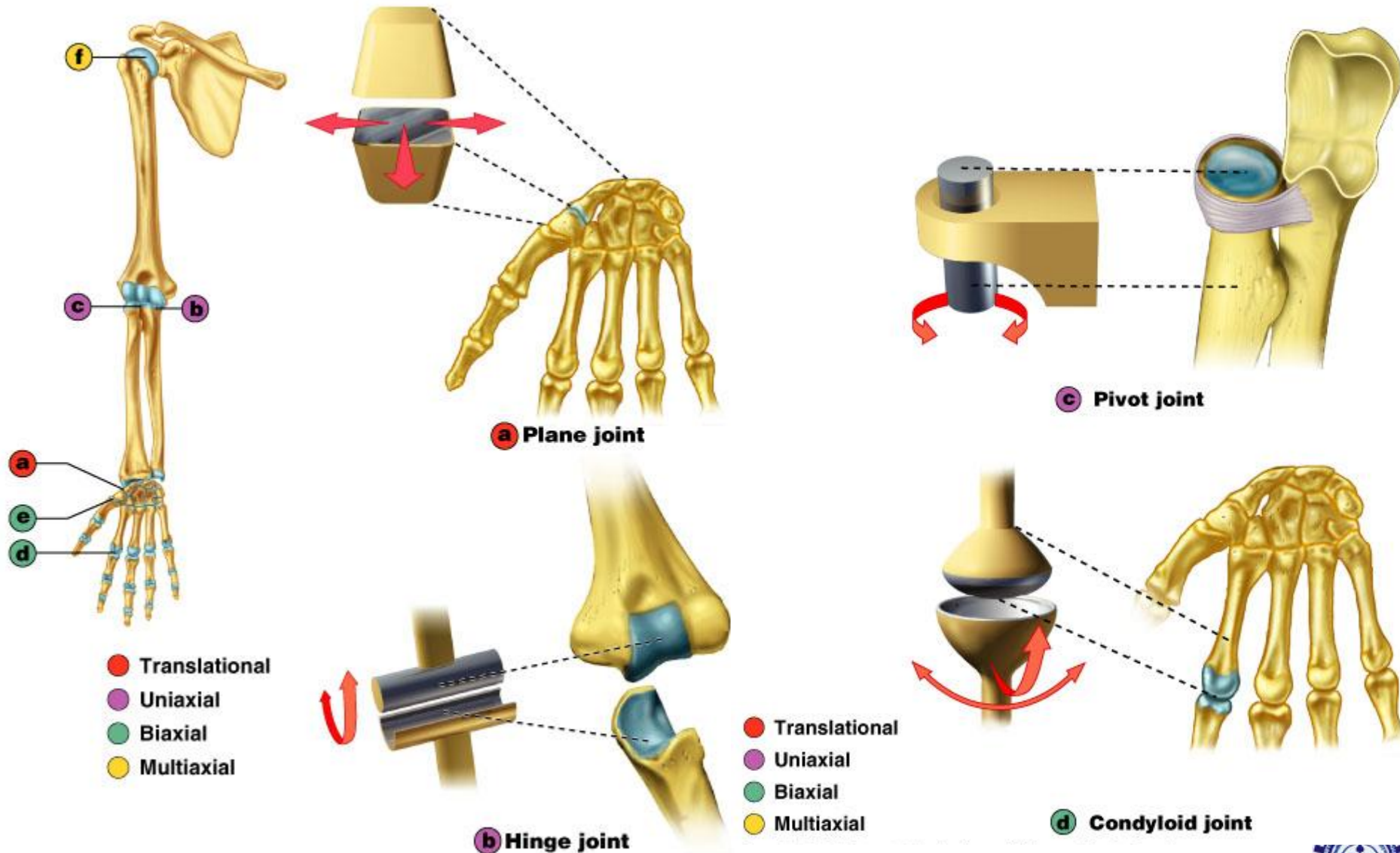


# Types of Synovial Joints

-  Planar Joint
-  Hinge Joint
-  Pivot Joint
-  Saddle Joint
-  Ball and Socket Joint
-  Condylloid or Ellipsoid Joint

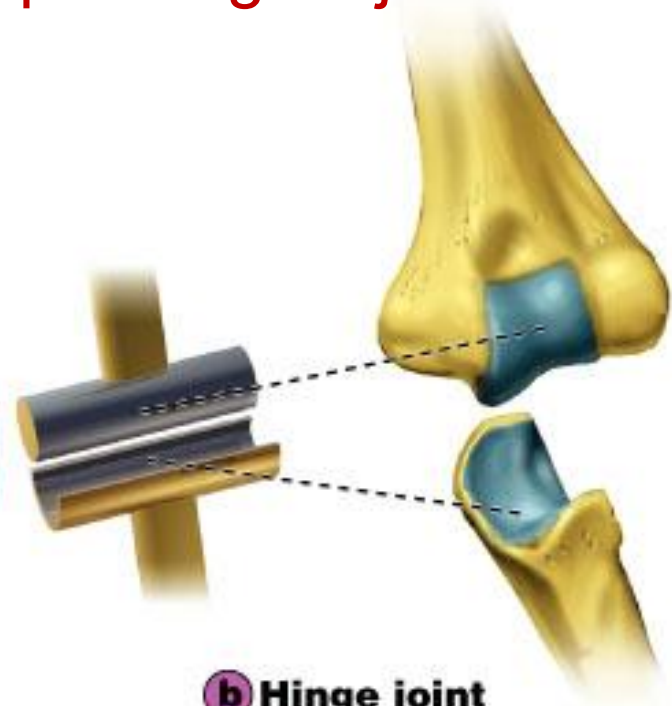


# Types of Synovial Joints



# Hinge Joint

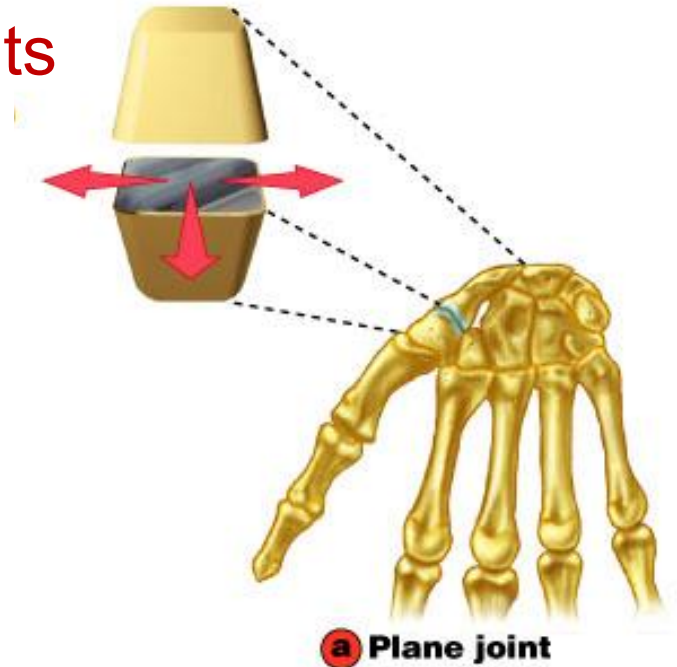
- Convex surface of bone fits in concave surface of 2<sup>nd</sup> bone
- Unilateral like a door hinge
- Examples:
  - Knee, elbow, ankle, interphalangeal joints
- Movements produced:
  - flexion
  - extension
  - hyperextension





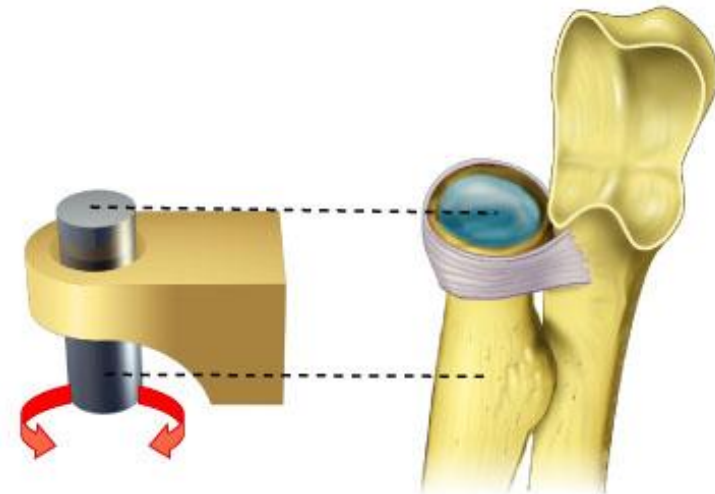
# Planar Joint

- Bone surfaces are slightly curved
- Side to side movement only
- Rotation prevented by ligaments
- Examples:
  - intercarpal to intertarsal joints
  - sternoclavicular joint
  - vertebrocostal joints



# Pivot Joint

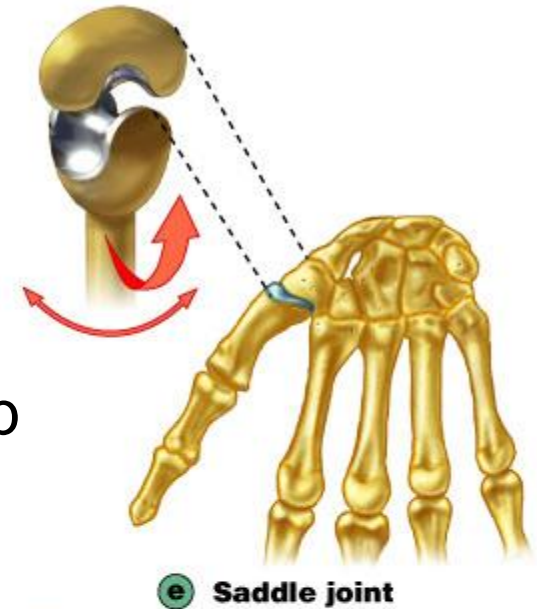
- Rounded surface of bone articulates with the ring formed by the 2<sup>nd</sup> bone and ligament
- Monoaxial since it only allows rotation around longitudinal axis
- Examples:
  - proximal radioulnar joint
  - supination
  - pronation
  - atlanto-axial joint
  - Turning head side to side “no”



© Pivot joint

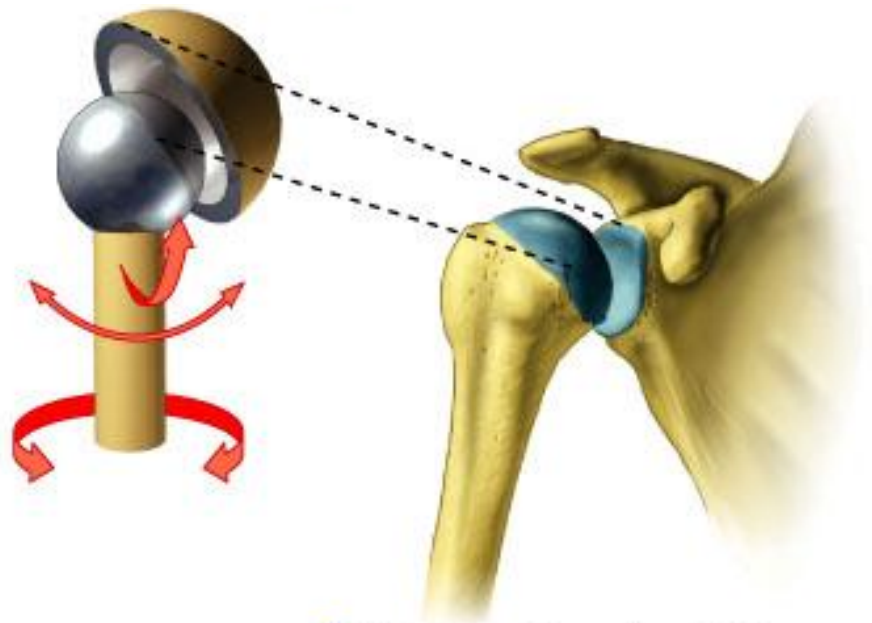
# Saddle Joint

- One bone saddle-shaped, other bone fits like a person riding on the saddle
- Biaxial
  - circumduction allows the tip of the thumb to travel in a circle
  - Opposition allows thumb to touch tip of other fingers
- Examples:
  - Trapezium of carpus and metacarple of thumb



# Ball-and-socket Joint

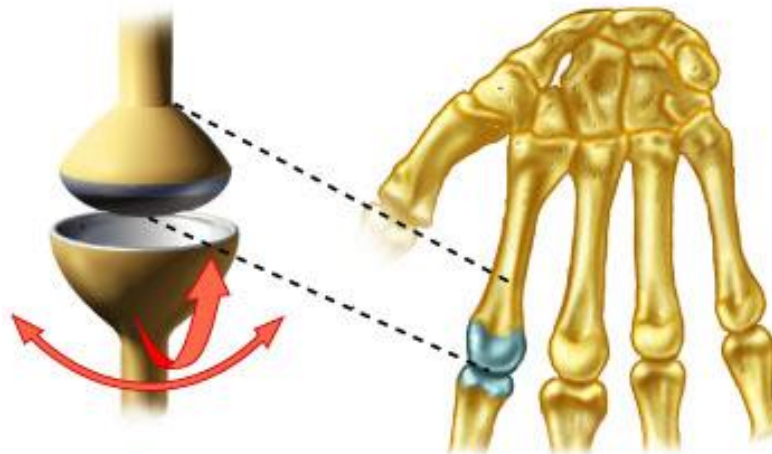
- Ball fitting into a cup-like depression
- Multiaxial
  - flexion/extension
  - abduction/adduction
  - rotation
- Examples:
  - shoulder joint
  - hip joint



**f Ball-and-socket joint**

# Condylloid Joint

- Oval-shaped depression fits into oval depression
- Biaxial = flex/extend or adduct/abduct is possible
- Examples:
  - Wrist and metacarpophelangeal joints for 2 to 5 digits



**d Condylloid joint**





# Factors Influencing Joint Stability

## A) The shape of articular surfaces

Shallow poor fitting articular surfaces hinder stability, whereas well fitting articular surfaces (i.e. hip joint) improve stability

## B) Ligaments

Ligaments unite bones and prevent excessive, undesirable motion

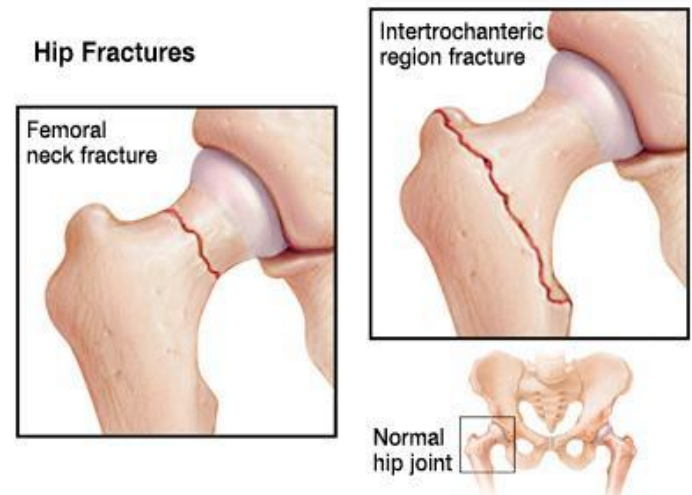
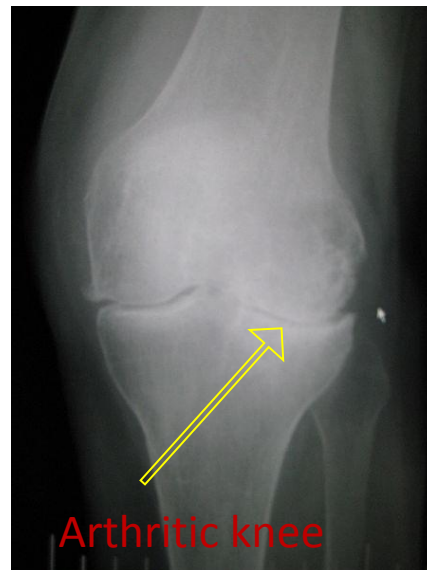
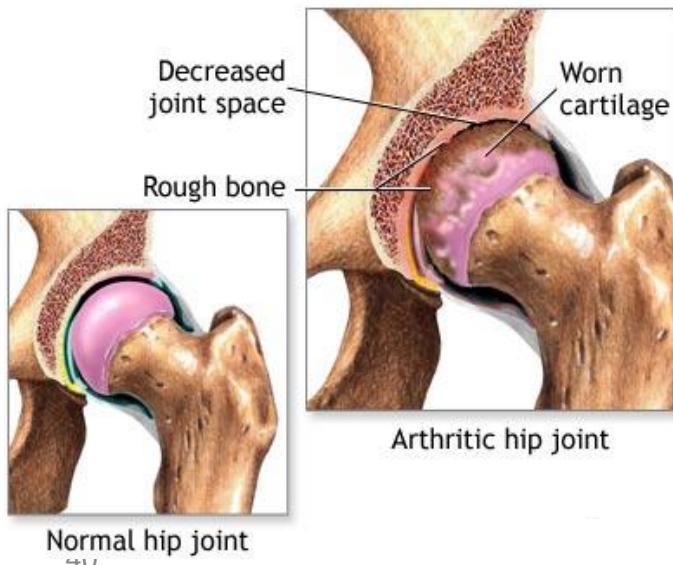
## C) Muscle Tendon

Muscle tendons are the most important stabilizing factor



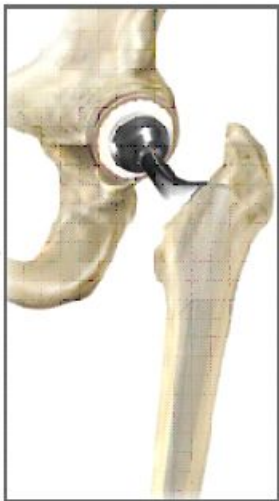
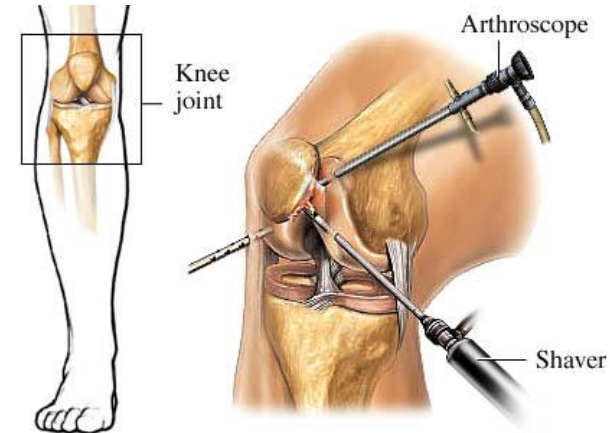
# Joint Disorders

- Pain and restricted movement and resulting in reduction in productivity and quality of life for people with damage to their major joints (hip, knee, shoulder, elbow)
  - Osteoarthritis 75% of joint replacements
  - Fracture 12%
  - Rheumatoid arthritis 4%
  - Other 7%



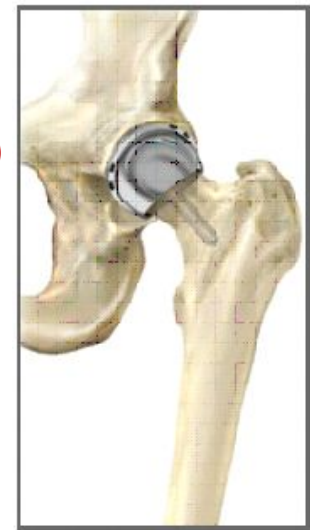
# Arthroscopy and Arthroplasty

- **Arthroscopy- examination of joint**
  - instrument size of pencil
  - removal of torn knee cartilage
  - small incisions only
- **Arthroplasty- replacement of joints**
  - total hip replaces acetabulum & head of femur
  - plastic socket & metal head
  - knee replacement common

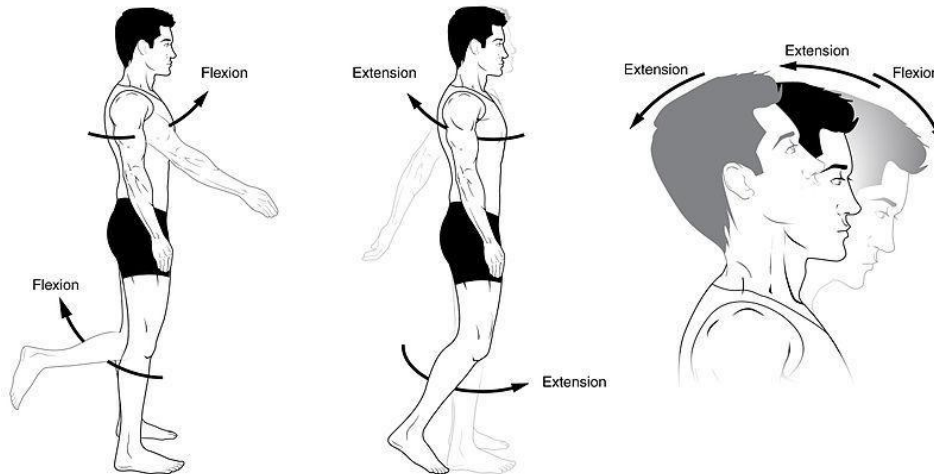


“Synergy” total hip replacement  
(Smith and Nephew)

ASR hip resurfacing (DePuy)



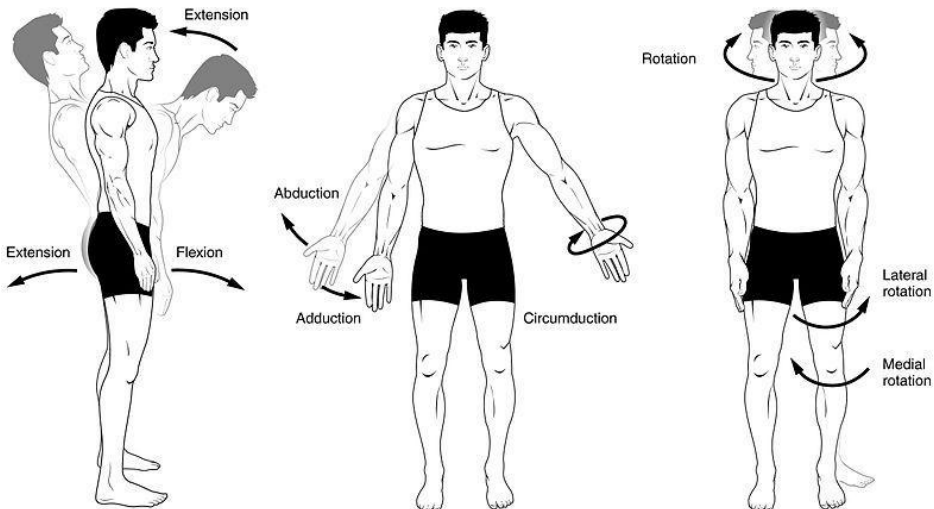
# Joint Movements



(a) and (b) Angular movements: flexion and extension at the shoulder and knees

(c) Angular movements: flexion and extension of the neck

- Flexion and Extension
- Abduction and Adduction
- *Internal rotation (or medial rotation)* and *External rotation (or lateral rotation)*
- Elevation and Depression

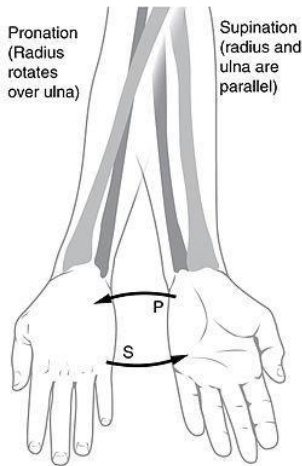


(d) Angular movements: flexion and extension of the vertebral column

(e) Angular movements: abduction, adduction, and circumduction of the upper limb at the shoulder

(f) Rotation of the head, neck, and lower limb

# Special movements of hands and feet



(g) Pronation (P) and supination (S)



(h) Dorsiflexion and plantar flexion



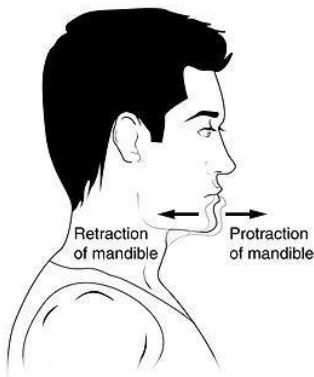
(i) Inversion and eversion

[Dorsiflexion](#) and [Plantarflexion](#) refers to flexion (dorsiflexion) or extension of the foot at the ankle.

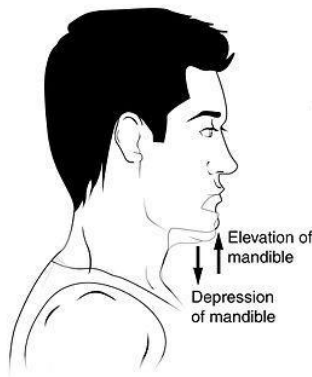
[Palmarflexion](#) and dorsiflexion refer to movement of the flexion (palmarflexion) or extension (dorsiflexion) of the hand at the wrist.

[Pronation](#) and [Supination](#) refer to rotation of the forearm or foot so that in the [anatomical position](#) the palm or sole is facing anteriorly (supination) or posteriorly (pronation) rotation of the forearm.

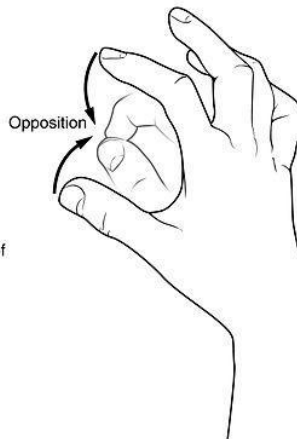
[Eversion](#) and [Inversion](#) refer to movements that tilt the sole of the foot away from (eversion) or towards (inversion) the midline of the body.



(j) Protraction and retraction



(k) Elevation and depression



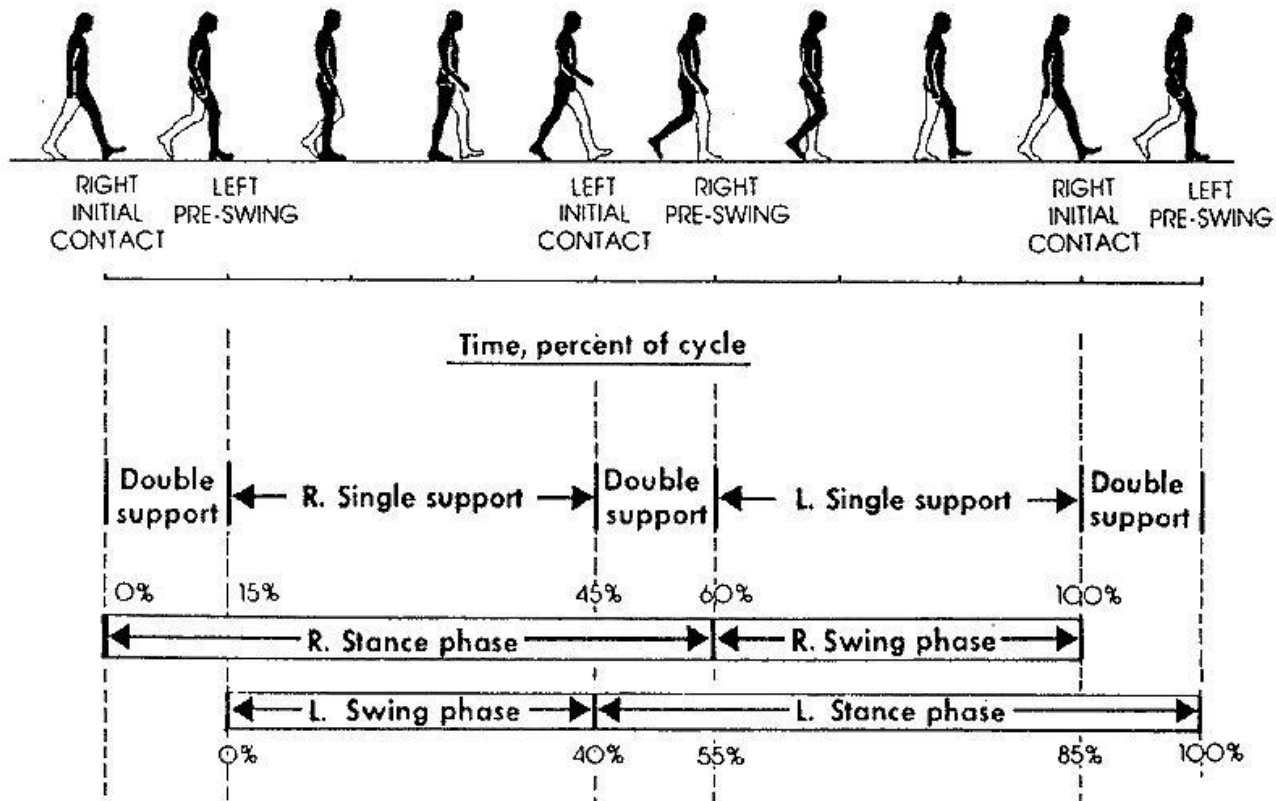
(l) Opposition





# Gait Cycle

A typical gait cycle showing different phases

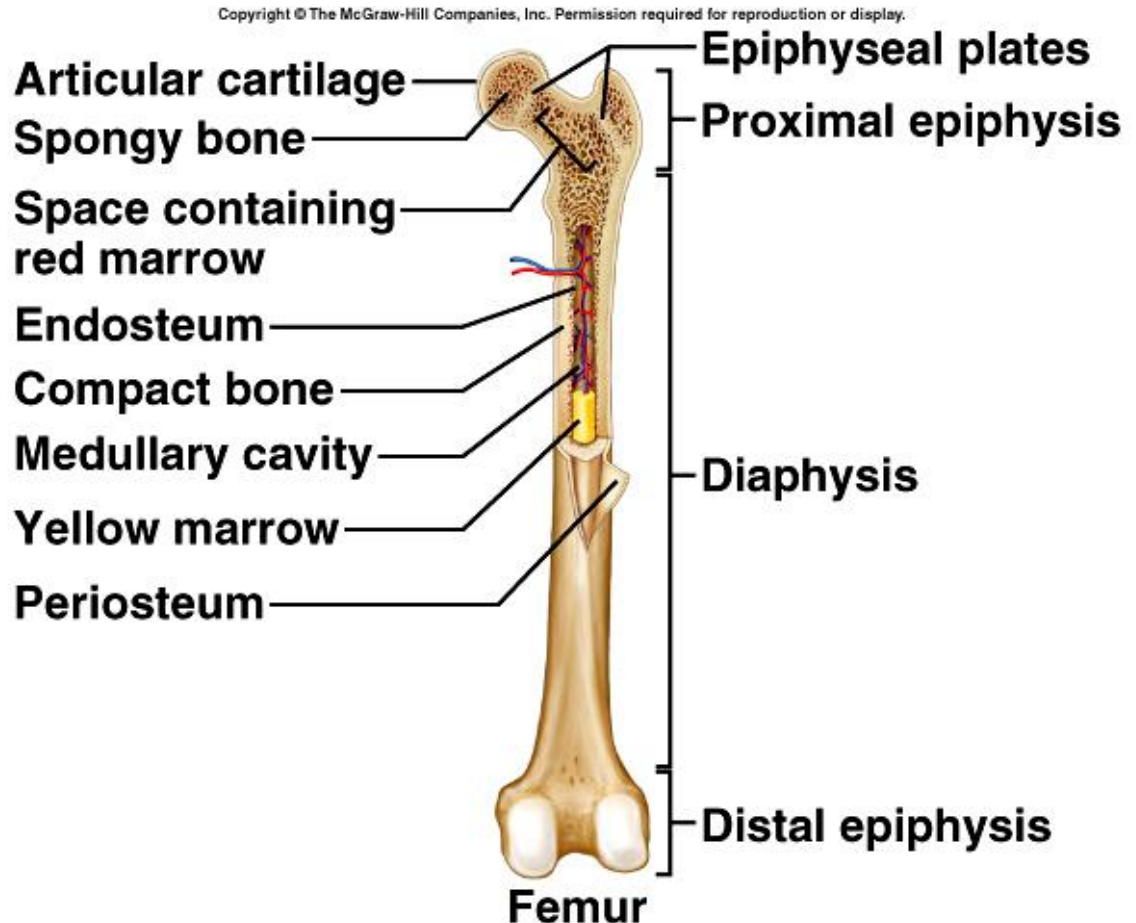


***~ Thank you for listening ~***



# Parts of a Long Bone

- epiphysis
  - distal
  - proximal
- diaphysis
- compact bone
- spongy bone
- articular cartilage
- periosteum
- endosteum
- medullary cavity
  - red
  - yellow



# Microscopic Structure of Bone

- osteon
- central canal
- perforating canal
- osteocyte
- lacuna
- bone matrix
- canaliculus

