



**Student Notes**

# ANATOMY

1st Edition

# GENERAL ANATOMY



# Preface

Agam is a group of budding medicos, who are currently doing their under graduation in various Medical Colleges across Tamil Nadu and Pondicherry. The group was initiated on 18<sup>th</sup> November 2017, in the vision of uniting medicos for various social and professional causes.

We feel delighted to present you Agam Anatomy notes prepared by Agam Divide and Rule 2020 Team to guide our fellow medicos to prepare for university examinations.

This is a reference work of 2017 batch medical students from various colleges. The team took effort to refer many books and make them into simple notes. We are not the authors of the following work. The images used in the documents are not copyrighted by us and is obtained from various sources.

Dear readers, we request you to use this material as a reference note, or revision note, or recall notes. Please do not learn the topics for the 1<sup>st</sup> time from this material, as this contain just the required points, for revision.

# Acknowledgement

On behalf of the team, Agam would like to thank all the doctors who taught us Anatomy. Agam would like to whole heartedly appreciate and thank everyone who contributed towards the making of this material. A special thanks to Srivardhany Bhaskar and M. Snaha, who took the responsibility of leading the team. The following are the name list of the team who worked together, to bring out the material in good form.

- Geethik
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## GENERAL ANATOMY

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## BLOOD SUPPLY OF LONG BONES

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⇒ Long bones are supplied by

1. Nutrient artery
2. Periosteal artery
3. Metaphyseal artery
4. Epiphyseal artery

### NUTRIENT ARTERY

- ⇒ Enters the middle of the shaft of long bone through a nutrient foramen.
- ⇒ Runs obliquely through the cortex and in the medullary cavity divides into
  1. Ascending branch.
  2. Descending branch.
- ⇒ Each branch then subdivides into a number of smaller parallel vessels which enters the metaphysis and form **hair-pin** loop.
- ⇒ These loops anastomose with Periosteal, Metaphyseal and Epiphyseal artery.
- ⇒ Nutrient artery supplies -
  1. Medullary Cavity containing bone marrow.
  2. Inner 2/3<sup>rd</sup> of outer shell of compact bone of diaphysis and metaphysis.
- ⇒ The **nutrient artery of tibia** is the **largest nutrient artery** of the body.

## PERIOSTEAL ARTERY

- ↪ They are numerous.
- ↪ Ramify beneath the periosteum.
- ↪ Enter the bone through Volkmann's canals to supply outer 1/3<sup>rd</sup> of the cortex.
- ↪ They are especially numerous beneath the muscular and ligament attachments.

## METAPHYSEAL (JUXTA-EPIPHYSEAL) ARTERY

- ↪ Derived from neighboring arteries.
- ↪ Enter metaphysis directly along the attachment of joint capsule.

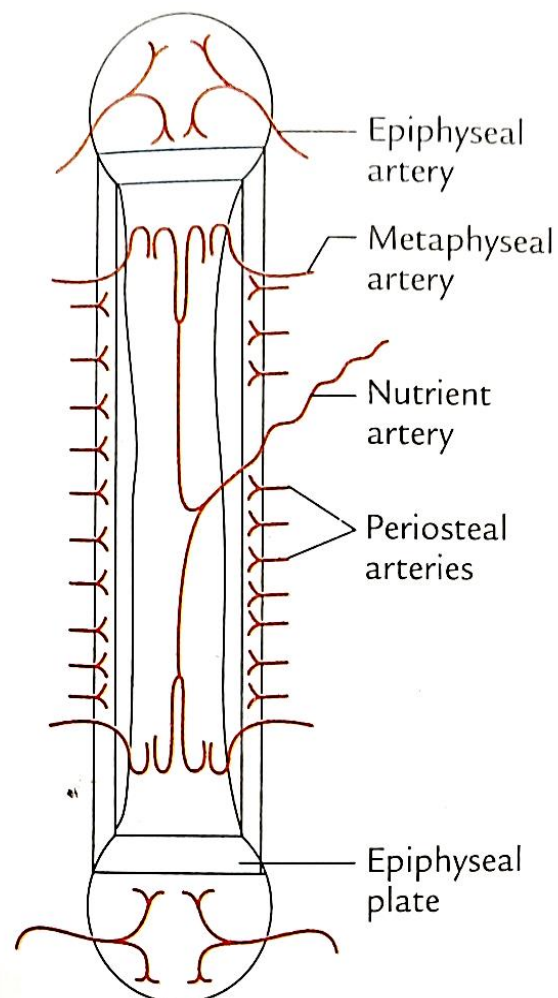


**FIG. 6.10** ■ Blood supply to a growing long bone.

## EPIPHYSEAL ARTERY

- ↳ Derived from arterial anastomosis around the joint (*circulus vasculosus*).
- ↳ Enter epiphysis either directly or after piercing the epiphyseal cartilage.

# OSSIFICATION

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↳ Its process of bone formation

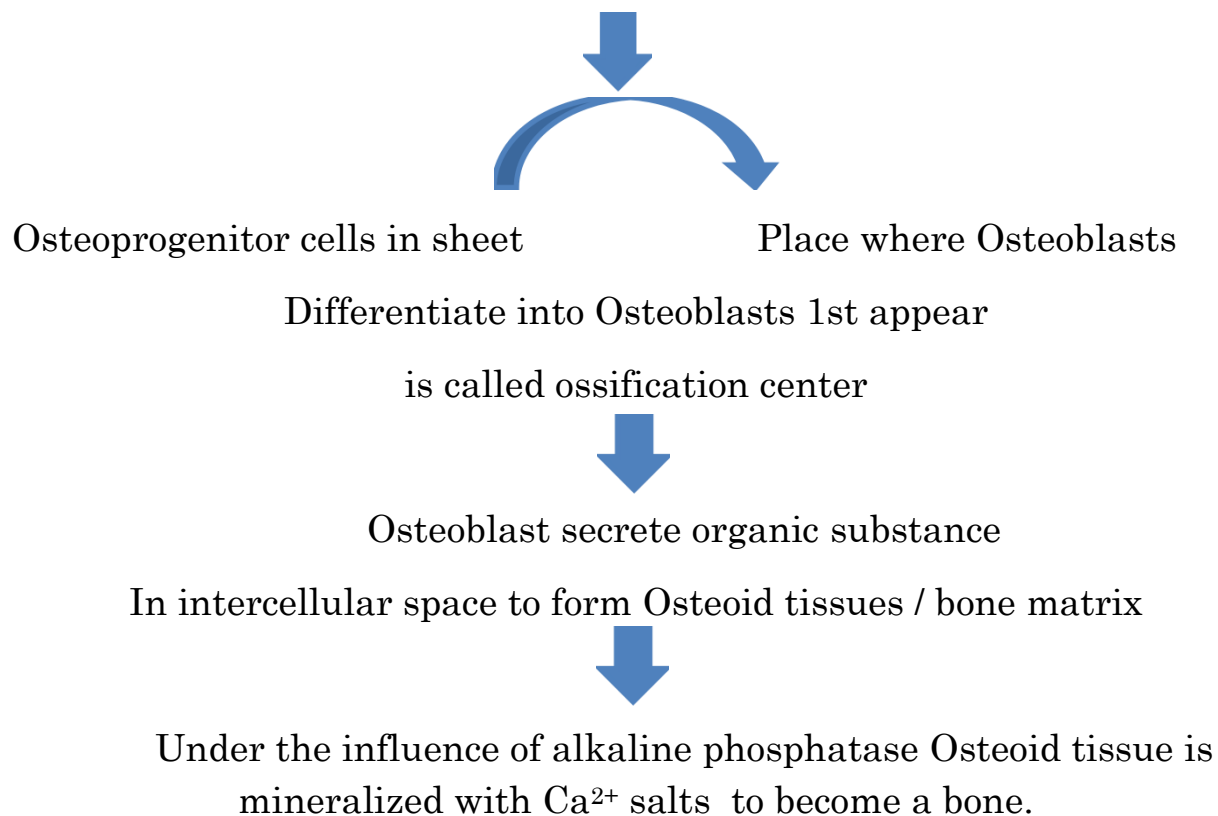
## TYPES OF OSSIFICATION

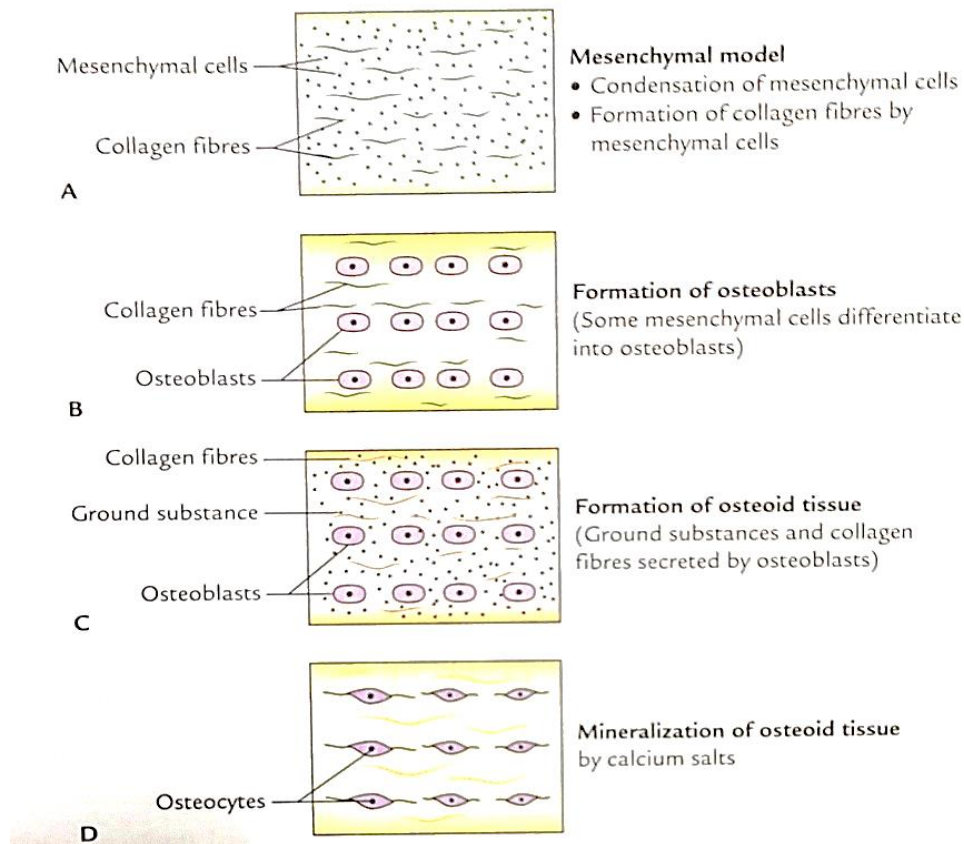
1. INTRAMEMBRANOUS OSSIFICATION – Forms Membranous bones and Membrano – Cartilaginous bones. (eg) flat bones of skull- frontal, parietal, occipital. And clavicle
2. ENDOCHONDRAL OSSIFICATION - Forms Cartilaginous bones and Membrano – Cartilaginous bones (eg) all long bones

## INTRAMEMBRANOUS OSSIFICATION

↳ It involves following steps

Mesenchymal Tissues condense to form membranous sheet model.





## ENDOCHONDRAL / CARTILAGINOUS OSSIFICATION

Cartilaginous cells enlarge and matrix surrounding them calcify under the influence of alkaline phosphatase secreted by them



Cartilage cells die and disappear leaving empty spaces called **primary areolae**



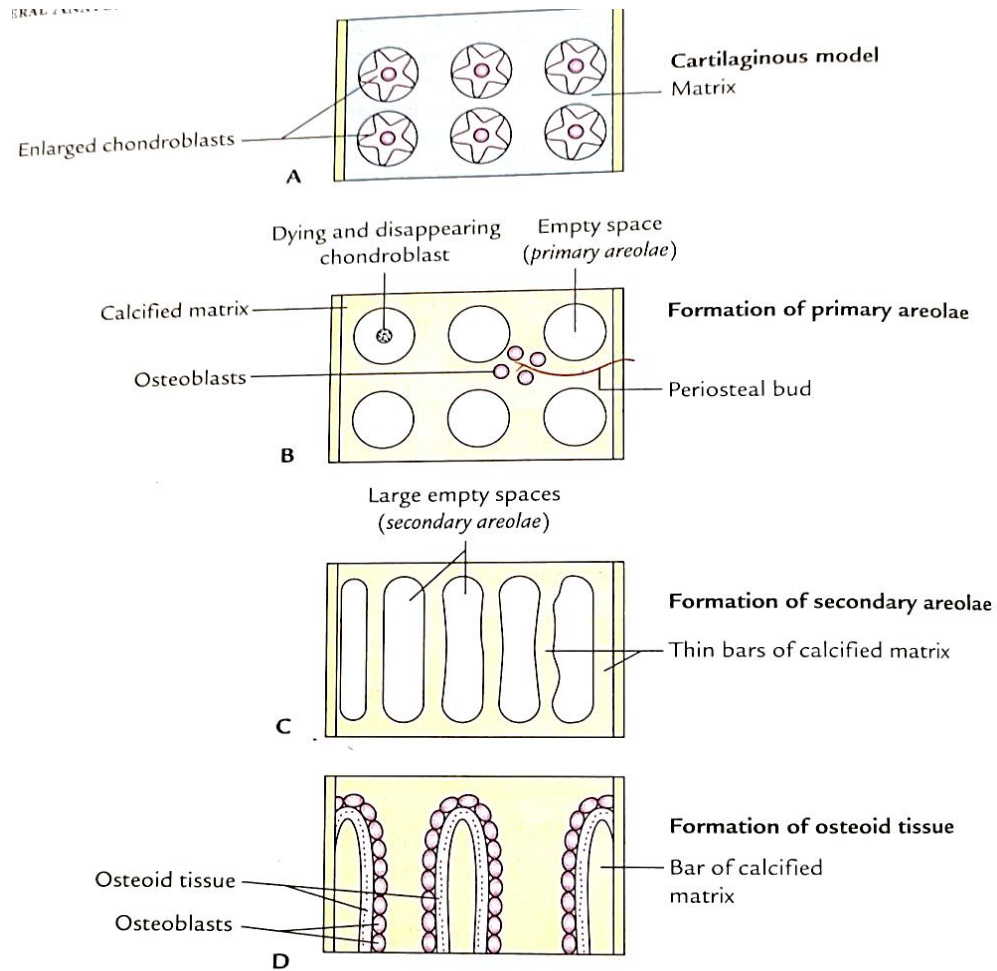
Cells of periosteum differentiate into osteoblasts, enter site of ossification along with blood vessels (periosteal bud)



Most calcified matrix is absorbed forming **secondary areolae**, leave behind thin bars of calcified matrix



Osteoid is laid down on the surface of calcified matrix and mineralization of it occurs



## OSSIFICATION OF LONG BONE:

Bone is laid down as Hyaline cartilage surrounded by perichondrium



**Primary centre of ossification** appears in center of shaft Spreads towards the end to form diaphysis



Periosteum laid down as **collar of bone**. Later, 2<sup>o</sup> Ossification center develop at the ends of cartilaginous model



Epiphyseal cartilage and articular cartilage remain cartilaginous.



Epiphyseal cartilage produce new cartilage thus Helping in growth.  
Thus its called **growth plate**.



After the growth is complete, proliferation ceases And epiphyseal cartilage ossifies into **Epiphyseal line**.

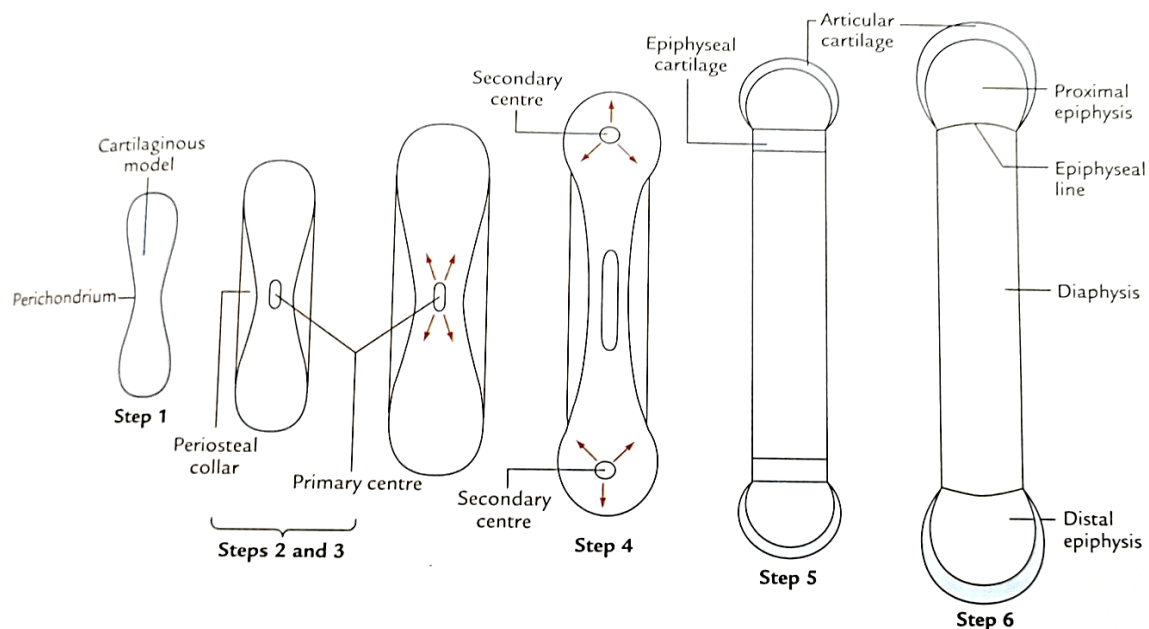


FIG. 6.14 ■ Ossification of a long bone.

## OSSIFICATION CENTERS

↳ These are sites where bone formation begins/sites where osteoblasts first appear.

1. **PRIMARY OSSIFICATION CENTER** – appear before birth (7<sup>th</sup>-12<sup>th</sup> weeks). Exceptions are tarsal and carpal bones except talus, calcaneum and cuboid. It forms the **diaphysis**.
2. **SECONDARY OSSIFICATION CENTER** – appears as a rule after birth. It forms **epiphysis**.

## CARTILAGE:

↳ It is a specialized connective tissue providing rigidity and elasticity.

1. **Temporary cartilage** – replaced by bone
2. **Permanent cartilage** – persist throughout life

## STRUCTURE:

↳ Includes the following

### Cells

1. Chondrogenic cells
2. Chondroblasts
3. Chondrocytes

### Fibres

1. Type I collagen fibres
2. Type II collagen fibres

### Ground substance

1. Proteoglycans
2. Glycoproteins
3. Water

## **GROWTH OF CARTILAGE:**

### **1. APPositional Growth**

- ↳ Chondroblasts from perichondrium form new cartilaginous cells and deposit beneath its surface
- ↳ This growth increases the width of the cartilage

### **2. INTERSTITIAL Growth**

- ↳ Due to proliferation of chondrocytes in centre of cartilaginous model the amount of intercellular matrix increases.
- ↳ Causes increase in length.

## **CHARACTERISTIC FEATURES OF CARTILAGE:**

- ↳ Its avascular and receive nutrition from ground substance
- ↳ No lymphatics
- ↳ No nerves
- ↳ Surrounded by perichondrium
- ↳ When cartilage calcify chondrocytes die because they are deprived of nutrition

## TYPES OF CARTILAGE:

| FEATURES               | HYALINE<br>CARTLAGE                            | ELASTIC<br>CARTLAGE                             | FIBROCARTLAGE                                                |
|------------------------|------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------|
| Color                  | Glossy bluish,<br>transparent                  | Yellowish                                       | White, opaque                                                |
| Perichondrium          | Present                                        | present                                         | Present                                                      |
| Chondrocytes           | Present in<br>large numbers,<br>inside lacunae | Large, packed<br>more closely<br>inside lacunae | Few scattered or<br>arranged in rows                         |
| Matrix                 | Collagen fibers<br>delicate and<br>not visible | Rich in elastic<br>fibers                       | Thick bundle of<br>collagen fibers run<br>parallel in matrix |
| Tendency to<br>calcify | Common                                         | Less common                                     | absent                                                       |

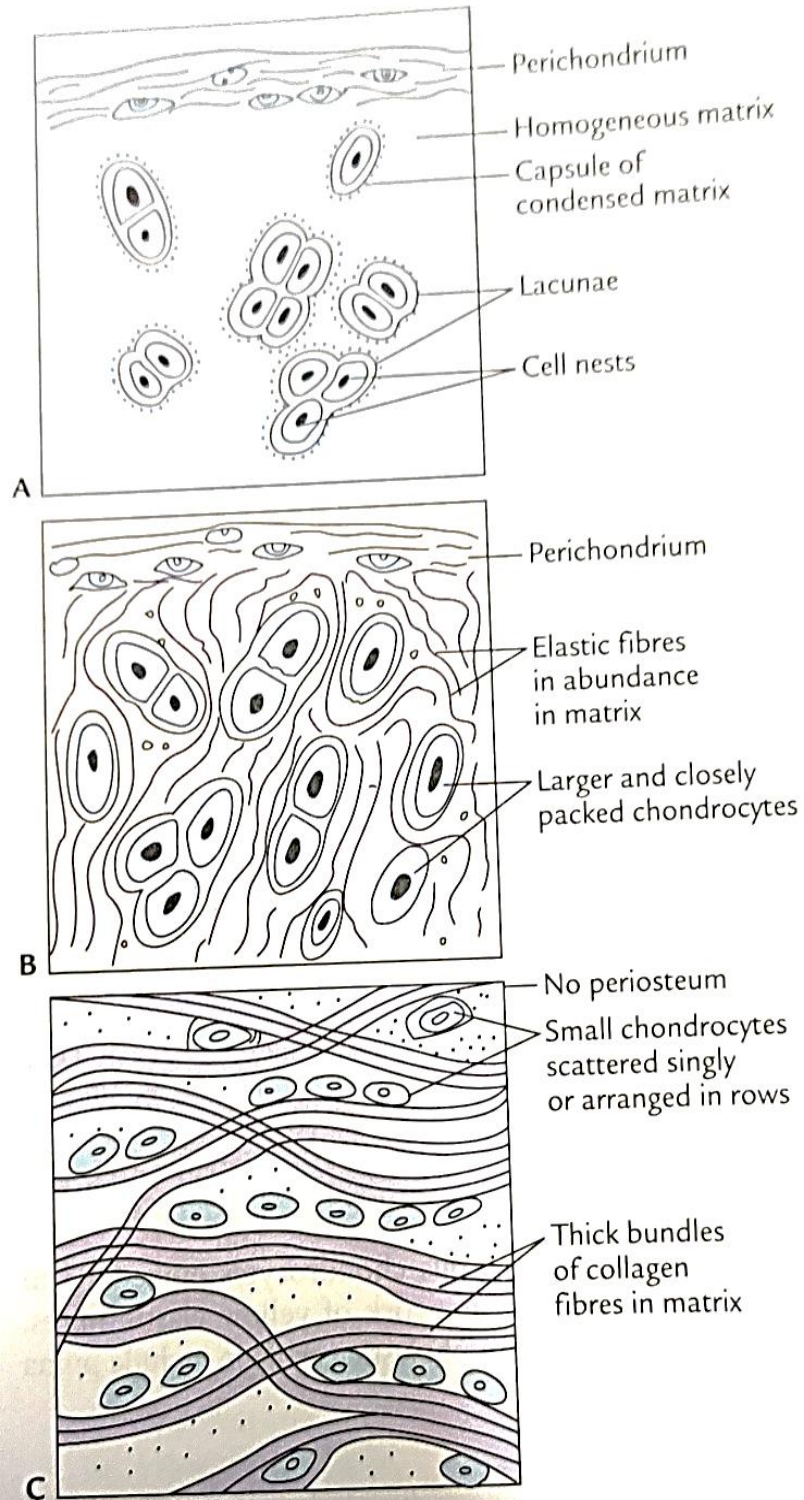


**FIG. 6.20** ■ Types of cartilage: (A) hyaline; (B) elastic and (C) fibrocartilage.

# CLASSIFICATION OF JOINTS:

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## FUNCTIONAL CLASSIFICATION: (Based on mobility)

1. **IMMOVABLE (SYNARTHROSES)** – no mobility. (eg) cranial sutures, 1°cartilaginous joints.
2. **SLIGHTLY MOVABLE (AMPHIARTHROSES)** - some degree of movement. (eg) syndesmoses, 2°cartilaginous joints
3. **FREELY MOVABLE (DIARTHROSES)** – max mobility. (eg) synovial joints.

## STRUCTURAL CLASSIFICATION: (make it a flow chart)

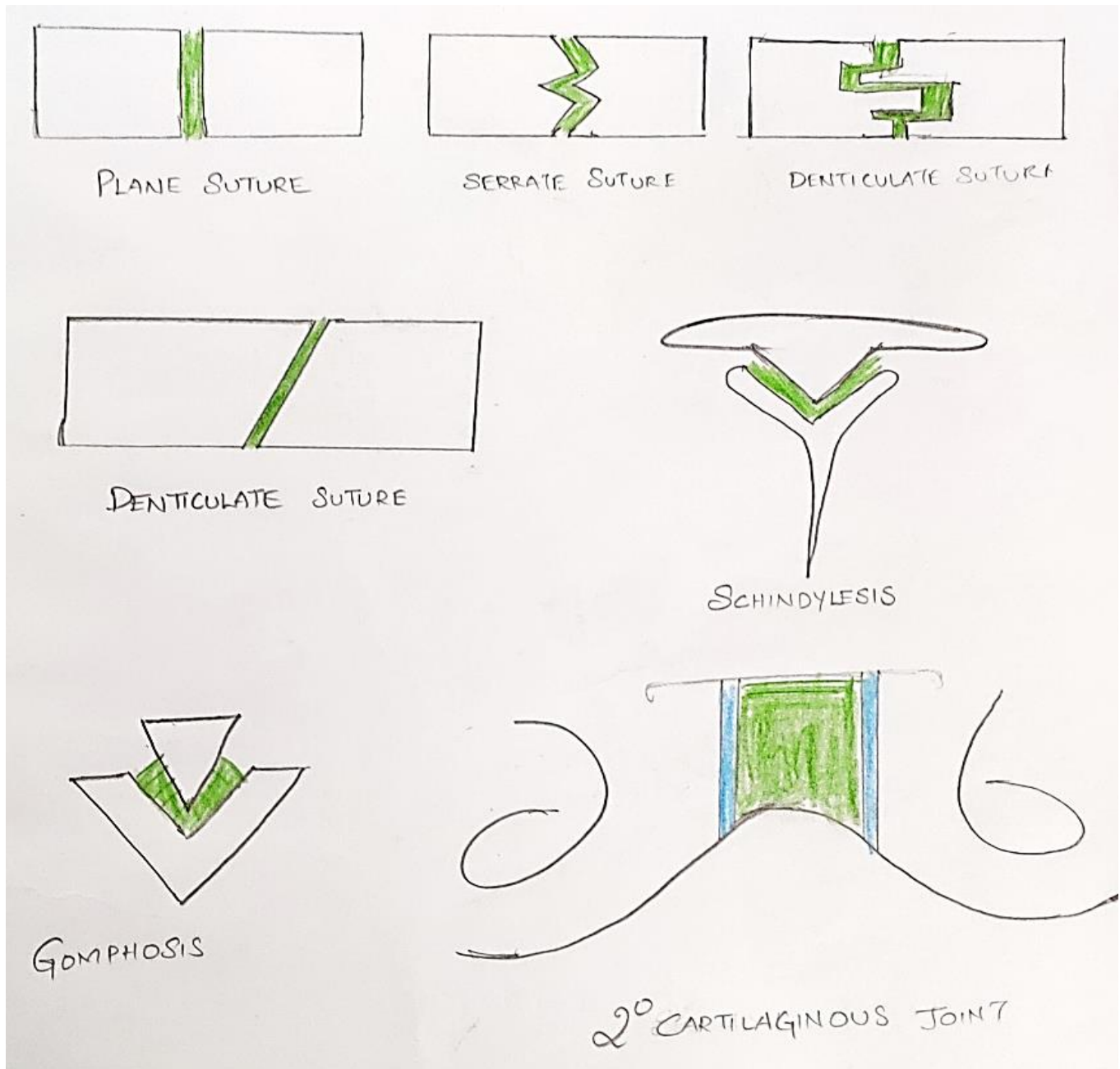
↳ Based on type of connective tissue and presence and absence of joint cavity

1. Fibrous
2. Cartilaginous
3. Synovial

**FIBROUS JOINT**- Bones are united by fibrous connective tissue. They are of 3 types

1. **SUTURES**- connected by sutural ligaments. There are five types
  - ↳ PLANE suture (eg) median palatine suture
  - ↳ SERRATE suture (eg) sagittal suture
  - ↳ DENTICULATE suture (eg) lambdoid suture
  - ↳ SQUAMOUS suture (eg) suture between temporal and parietal bone
  - ↳ SCHINDYLESIS (eg) between rostrum of sphenoid and cleft between alae of vomer

2. SYNDESMOSES – joints between two **adjacent** bones by greater amount of connective tissue. (eg) interosseous radio-ulnar joint
3. GOMPHOSES - fixation of teeth in the alveolar sockets of mandible.



## CARTILAGINOUS JOINTS

⇒ Bones are joined by either hyaline or fibrous cartilage

| 1° CARTILAGINOUS JOINTS                                                    | 2° CARTILAGINOUS JOINTS                                                              |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| ⇒ Bones are joined hyaline cartilage                                       | ⇒ Bones are joined fibrous cartilage                                                 |
| ⇒ Immovable                                                                | ⇒ Slightly movable                                                                   |
| ⇒ Temporary joint                                                          | ⇒ Permanent joint                                                                    |
| ⇒ Rarely occurs in midline                                                 | ⇒ Always occurs in midline                                                           |
| ⇒ (Eg) joint between epiphysis and diaphysis<br>⇒ First costosternal joint | ⇒ (Eg) symphysis pubis, intervertebral discs, manubriosternal joint, symphysis menti |

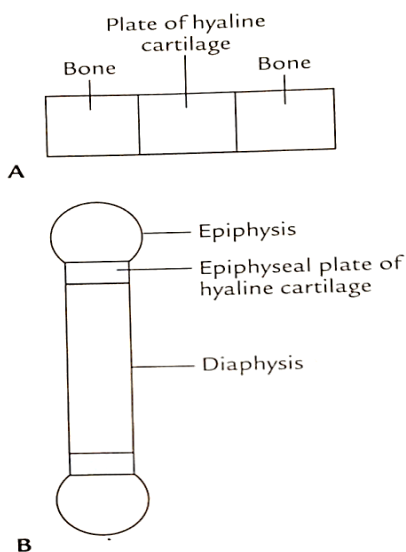


**FIG. 7.6** ■ Primary cartilaginous joint (synchondrosis): (A) schematic diagram and (B) primary cartilaginous joint between epiphysis and diaphysis representing synchondrosis.

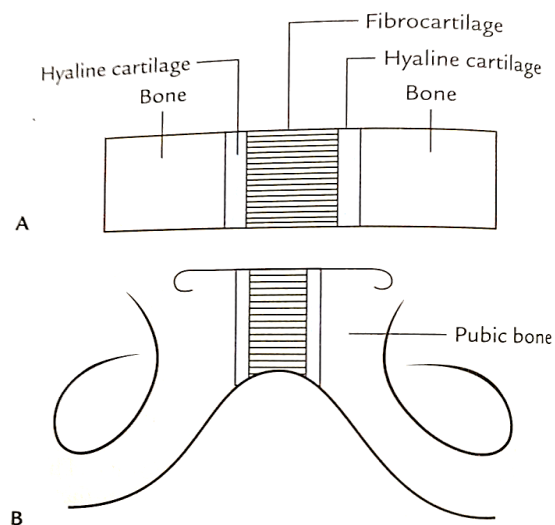


**FIG. 7.7** ■ Secondary cartilaginous joint (symphysis): (A) schematic diagram and (B) pubic symphysis representing symphysis.

## **SYNOVIAL JOINT:**

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- ↪ Joint possess a cavity enclosed by fibrous cavity. This cavity is filled by synovial fluid.

### **THE CHARACTERISTICS FEATURES OF SYNOVIAL JOINTS ARE:**

1. Articular surface is covered by hyaline cartilage.
2. Joint cavity enclosed by articular capsule which consist of outer fibrous and inner synovial membrane.
3. Cavity is lined everywhere except over articular cartilage.
4. Cavity is filled by synovial cavity which is secreted by synovial membrane. Provides lubrication of joint.

### **COMPONENTS OF SYNOVIAL JOINTS:**

1. Fibrous capsule
2. Ligaments
3. Synovial membranes
4. Articular cartilage
5. Articular disc
6. Bursae
7. Fat-pads (haversian glands)

### **CLASSIFICATION OF SYNOVIAL JOINTS:**

#### **ACCORDING TO SHAPE OF ARTICULAR SURFACE**

1. Plane joints – (eg) intercarpal, intertarsal
2. Hinge / Ginglymus joints – (eg) elbow, knee, ankle
3. Pivot/trochoid joints – (eg) superior radio-ulnar, median atlanto-axial
4. Condylar joints – (eg) temporomandibular
5. Ellipsoidal joints – (eg) radio-carpel, atlanto-occipital
6. Saddle/sellar joints – (eg) 1<sup>st</sup> carpometacarpal, sternoclavicular
7. Ball and socket/spheroidal joints – (eg) hip joint, shoulder joint

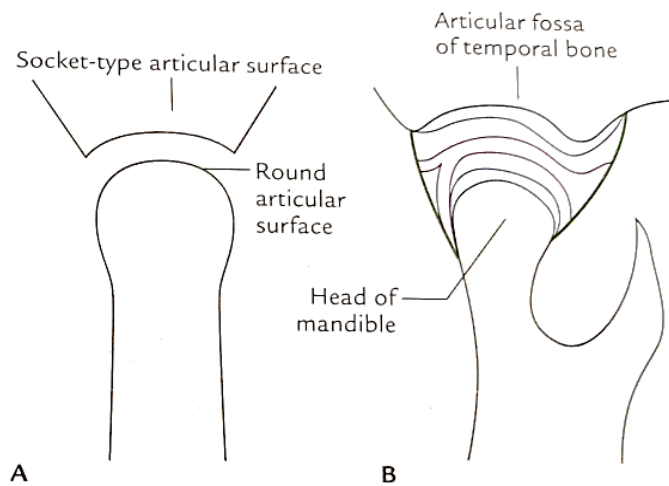
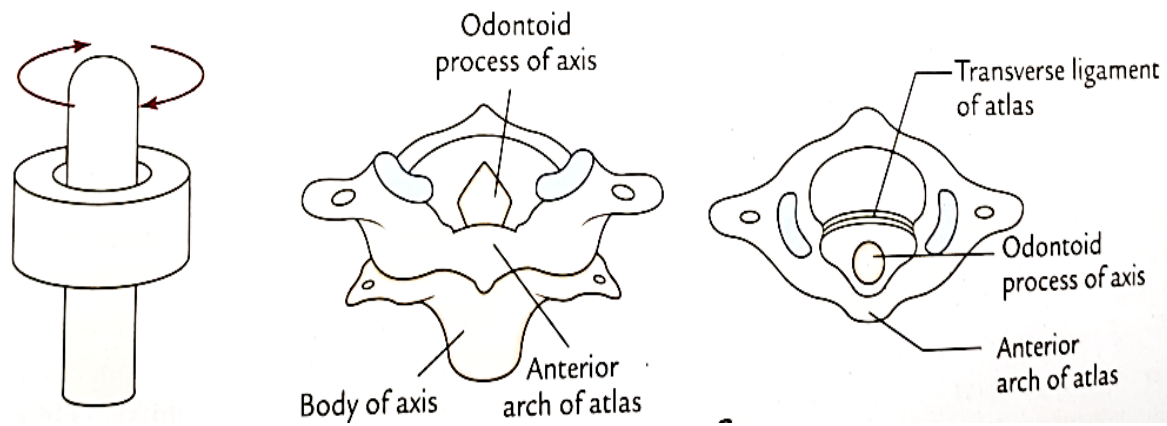


**FIG. 7.12** ■ Condylar joint: (A) diagrammatic representation of the joint and (B) temporo-mandibular joint representing a condylar joint.

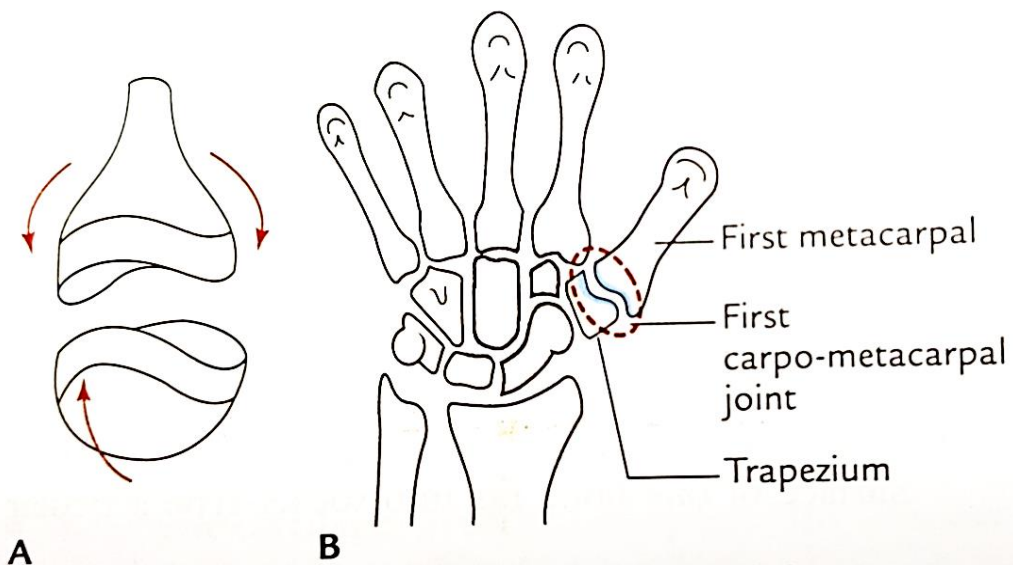


**FIG. 7.14** ■ Saddle joint: (A) diagrammatic representation and (B) first carpo-metacarpal joint representing saddle joint.

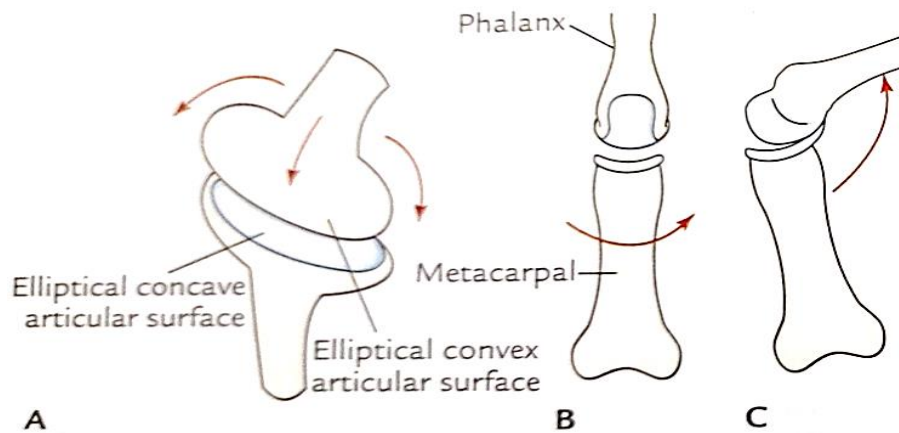


**FIG. 7.13** ■ Ellipsoid joint: (A) diagrammatic representation of the joint and (B and C) metacarpo-phalangeal joint representing ellipsoid joint.

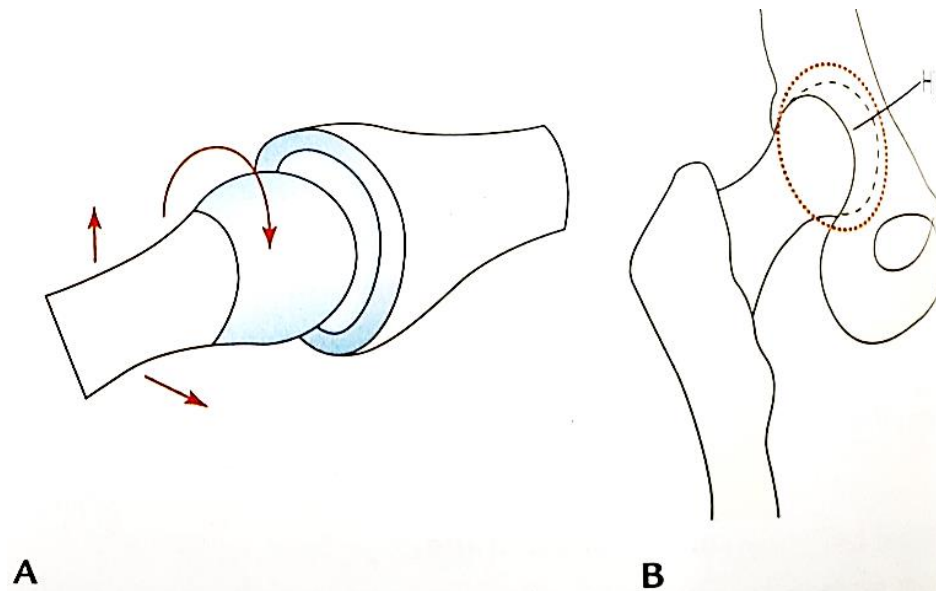


**FIG. 7.15** ■ Ball and socket joint: (A) diagrammatic representation of the joint showing directions of possible movement and (B) hip joint representing ball and socket joint.

## ACCORDING TO PLANE OF MOVEMENTS

1. UNIAXIAL JOINTS – (eg) hinge and pivot
2. BIAXIAL JOINTS – (eg) condylar, ellipsoidal, saddle
3. MULTIAXIAL JOINTS – (eg) ball and socket

## ACCORDING TO NUMBER OF ARTICULATING BONES

1. SIMPLE JOINTS – 2 bones (eg) interphalangeal joint
2. COMPOUND JOINTS – more than 2 bones (eg) ankle elbow
3. COMPLEX JOINTS – when joint cavity is divided into 2 (eg) knee joint

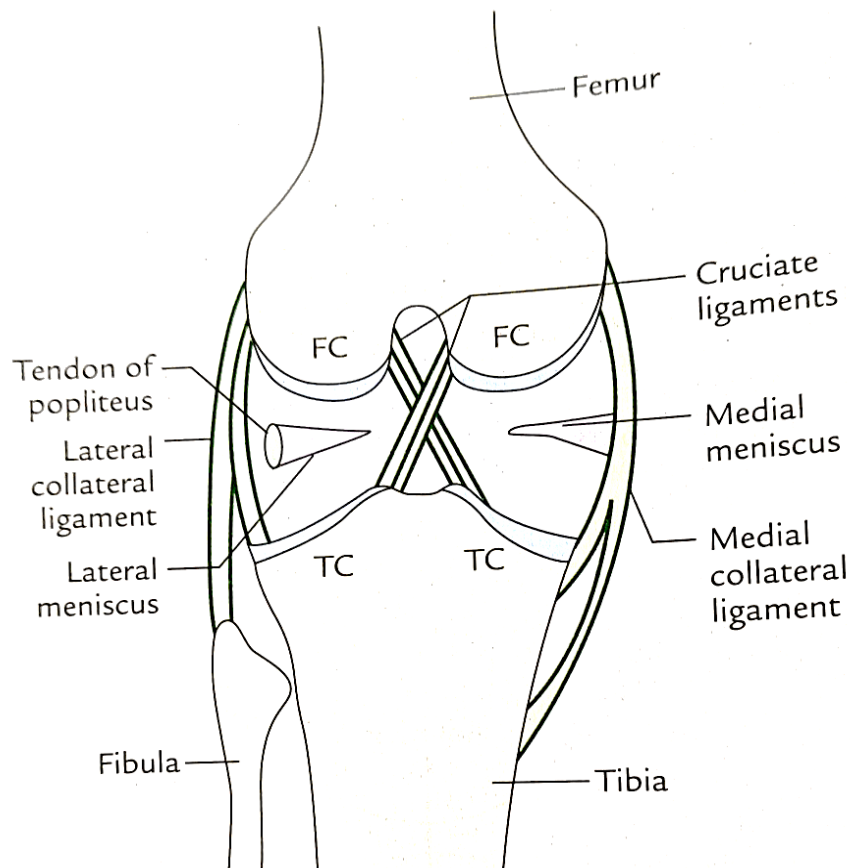


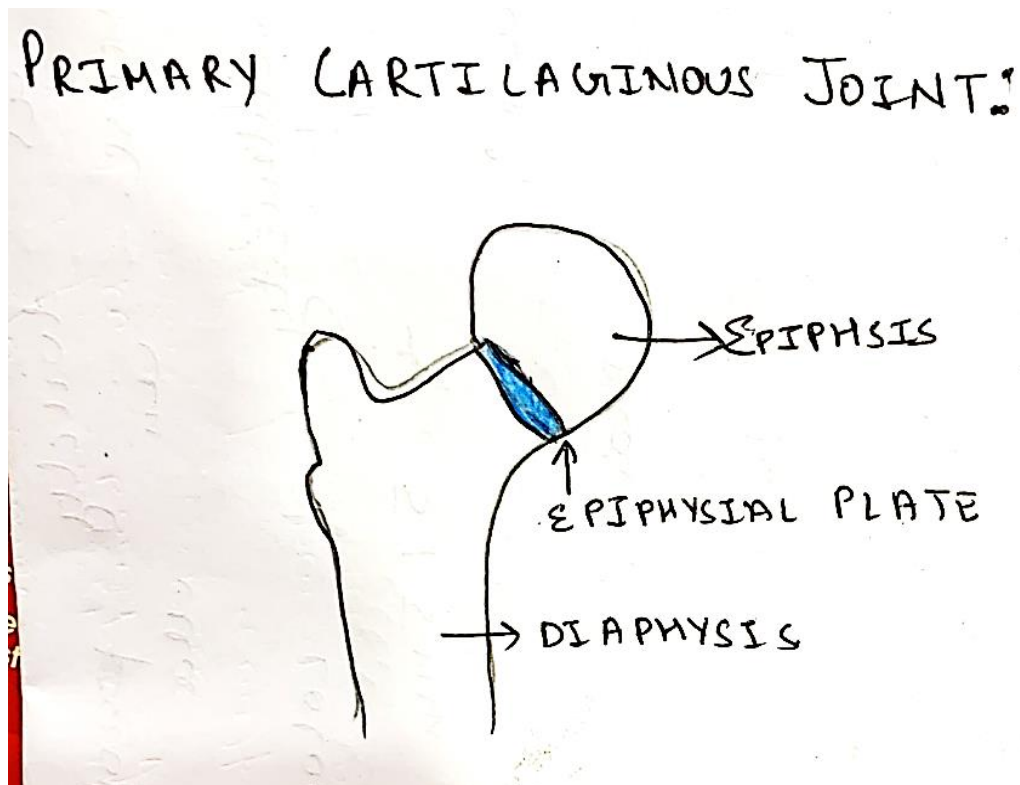
**FIG. 7.19** ■ Knee joint – an example of a complex joint (FC, femoral condyle; TC, tibial condyle.)

## CARTILAGINOUS JOINT

↳ In this the bone are joined by cartilage. It allows more movement than fibrous joint but less than synovial joint. There are of two types:

### PRIMARY CARTILAGINOUS JOINTS OR SYNCHONDROSIS:

1. These are hyaline cartilage joints.eg- first sternocostal joint.
2. The bones are united by a plate of hyaline cartilage so that the joint is immovable and strong.
3. A temporary form is called epiphyseal growth plate- These joints are temporary in nature after certain age the cartilaginous plate is replaced by a bone(synostosis)- this happens because of the action of estrogen in male and female.



### EXAMPLES:

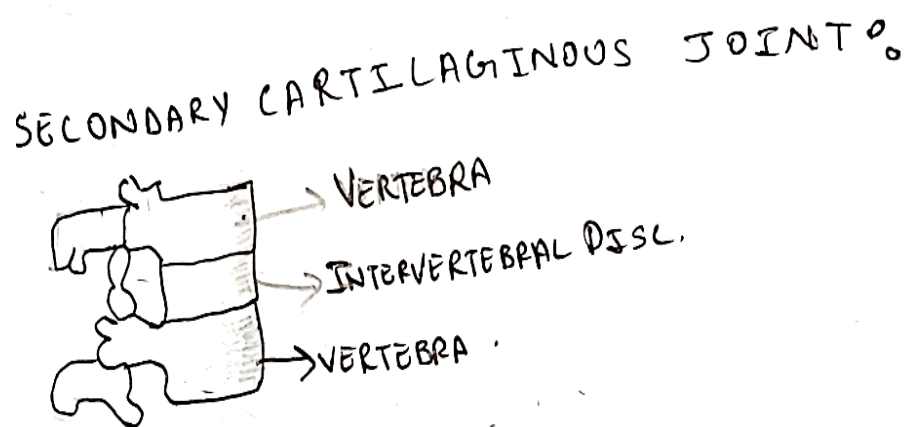
1. Spheno-occipital joint
2. First chondrosternal joint
3. Costochondral joints

### SECONDARY CARTILAGINOUS JOINT ( symphysis)

1. The articular surface are covered by a thin layer of hyaline cartilage and united by a disc of fibrocartilage.
2. These joints are permanent and persist throughout the life. The secondary cartilaginous joints occur in the median plane of the body and it may represent an intermediate stage in the evolution of synovial joints.

### EXAMPLE:

1. Symphysis pubis
2. Manubriosternal joint
3. Intervertebral joints between the vertebralbodies.



## EPIPHYSIS AND THEIR TYPES:

⇒ The ends and tips of a bone which ossify from secondary centres are called epiphyses.

1. PRESSURE EPIPHYSIS is articular and takes part in transmission of the weight. Examples: head of femur; lower end of radius, etc.
2. TRACTION EPIPHYSIS is nonarticular and does not take part in the transmission of the weight. It always provides attachment to one or more tendons which exert a traction on the epiphysis. Examples: trochanters of femur and tubercles of humerus
3. ATAVISTIC EPIPHYSIS is phylogenetically an independent bone which in man becomes fused to another bone. Examples: coracoid process of scapula and os trigonum or lateral tubercle of talus.
4. ABERRANT EPIPHYSIS is not always present. Examples: epiphysis at the head of the first metacarpal and at the base of other metacarpal bones.

# FIBROUS JOINT

↳ In fibrous joints the bones are joined by fibrous tissue. These joints are either immovable or permit a slight degree of movement.

↳ These can be grouped in the following three types.

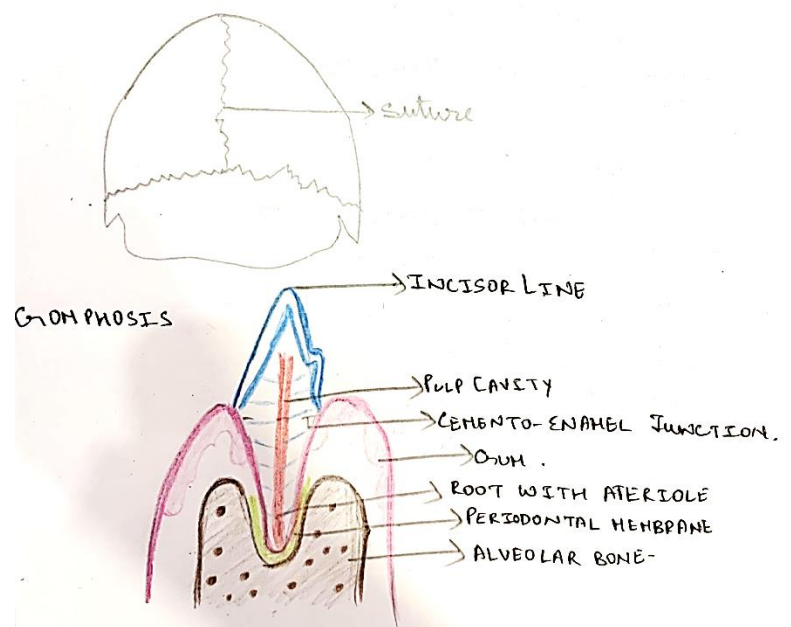
1. SUTURES: These are peculiar to skull, and are immovable. According to the shape of bony margins, the sutures can be:

- a) PLANE, e.g. internasal suture
- b) SERRATE, e.g. interparietal suture
- c) SQUAMOUS, e.g. temporo-parietal suture
- d) DENTICULATE, e.g. lambdoid suture
- e) SCHINDYLESIS TYPE , e.g. between rostrum of sphenoid and upper border of vomer.

2. SYNDESMOSIS: The bones are connected by the interosseous ligament. Example: inferior tibiofibular joint .

3. GOMPHOSIS (peg and socket joint). Example: root of the tooth in its bony socket.

3 YNARTHROSIS : FIBROUS JOINT.



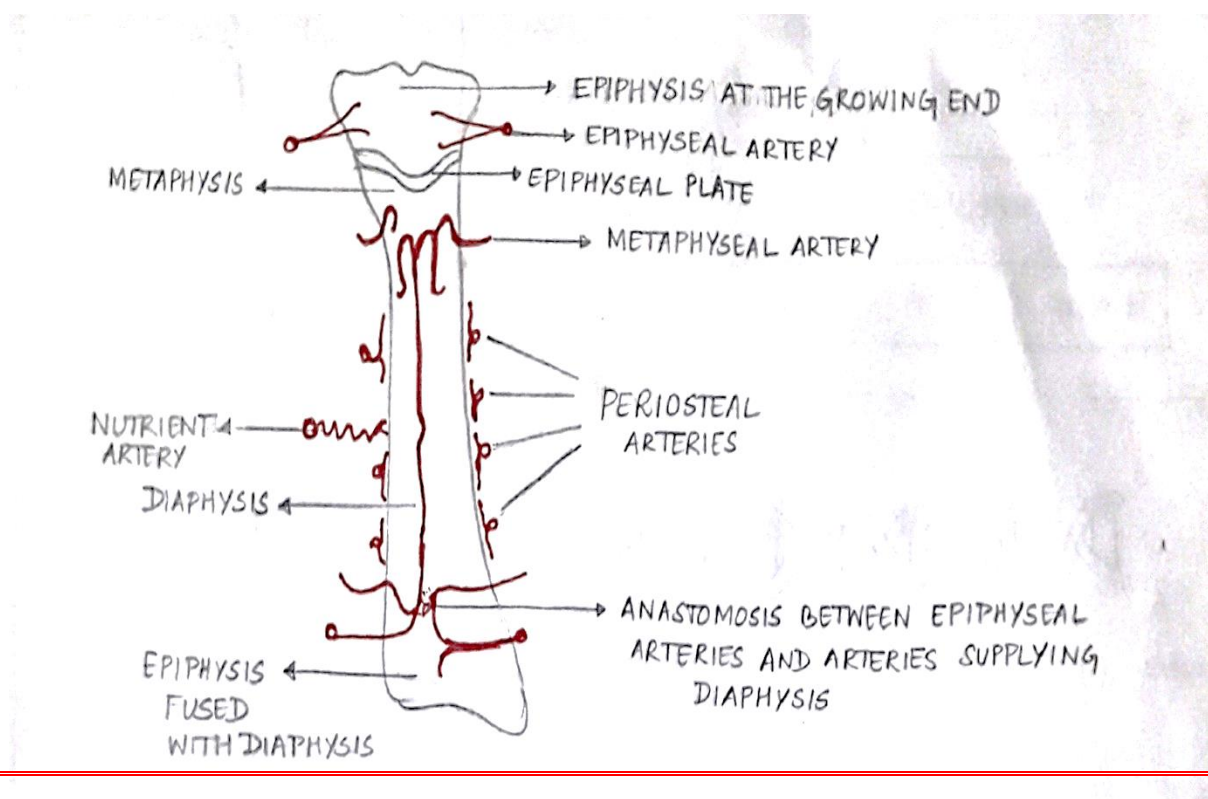
## PRONATION AND SUPINATION:

1. SUPINE POSITION: When a person is lying on her/his back, arms by the side, palms facing upwards and feet put together, the position is supine position
2. PRONE POSITION: Person lying on his/her face, chest and abdomen is said to be in prone position
3. SUPINATION: When the palm is facing forwards or upwards, as in putting food in the mouth.
4. PRONATION: When the palm faces backwards or downwards, as in picking food with fingers from the plate.

## NUTRIENT ARTERY

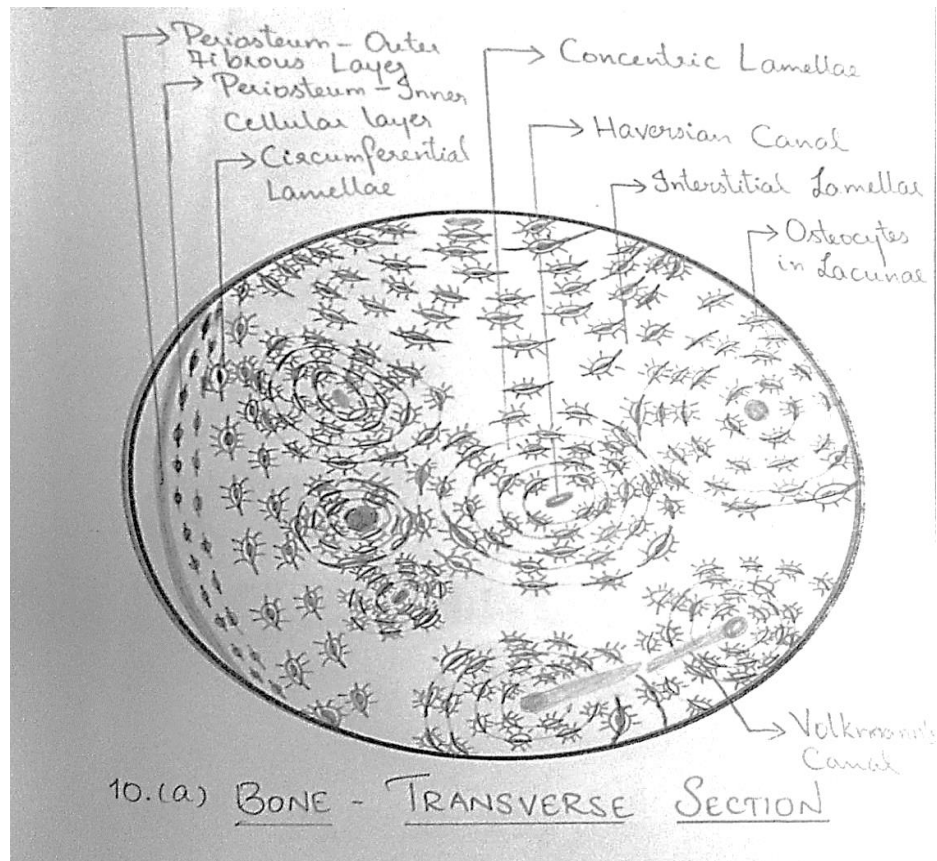
- ↪ The nutrient artery (arteria nutricia) or medullary, usually accompanied by one or two veins, enters the bone through the nutrient foramen, runs obliquely through the cortex, sends branches upward and downward to the bone marrow, which ramify in the endosteum—the vascular membrane lining the medullary cavity—and give twigs to the adjoining canals.
- ↪ Nutrient arteries are the most apparent blood vessels of the bones.
- ↪ All bones possess larger or smaller foramina for the entrance of the nourishing blood-vessels.
- ↪ These are known as the nutrient foramina, and are particularly large in the shafts of the larger long bones, where they lead into a nutrient canal, which extends into the medullary cavity (bone marrow cavity).
- ↪ Blood supply to the marrow is mainly provided by nutrient arteries that penetrate cortical bone, particularly at the mid-shaft of long bones.
- ↪ These arteries extend along the longitudinal axis of the bone and send off radial branches throughout the marrow.

- ⇒ Nutrient artery enters into the diaphysis of long bones through an oblique canal.
- ⇒ Direction of canal is determined by relative amount of growth that has occurred at proximal and distal ends of the bone.
- ⇒ Nutrient canals slope away from the knee in femur, tibia, and fibula and towards elbow in radius, ulna, and humerus.
- ⇒ Does not branch within the cortex.
- ⇒ Nutrient artery divides after reaching the medullary cavity, sending arteriole branches in proximal and distal directions and join with the metaphyseal arteries.
- ⇒ Vessels radiate from these medullary arteries to the cortex, and drain to venules on the periosteal surface of the bone.
- ⇒ Direction of blood flow is from endosteum to periosteum.
- ⇒ Intramedullary pressure is higher than periosteal surface allowing of egress of interstitial fluid in cortex.
- ⇒ Some of these branches enter cortex to supply haversian canals of inner two thirds of the cortex.
- ⇒ Other branches of nutrient artery continue in more or less parallel alignment to metaphysis.
- ⇒ In the child, these vessels end on metaphyseal side of epiphyseal plate, where they participate in endochondral ossification.



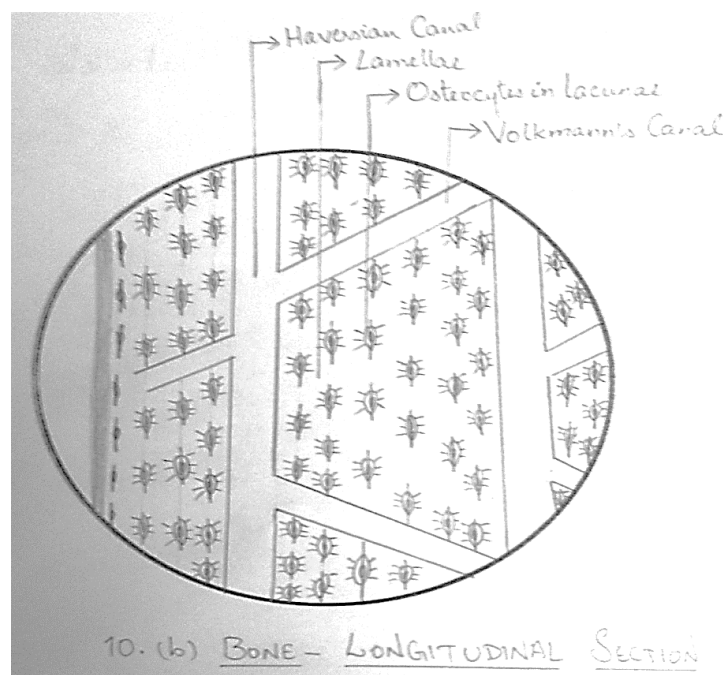
- ⇒ In growing bone can result in necrosis of large portion of marrow & of inner two thirds of cortex.
- ⇒ This cortical death does not occur in adult bone because combined epiphyseal-metaphyseal collateral circulation is developed enough to maintain these areas.
- ⇒ Loss of circulation in terminal vessels of nutrient artery of growing bone will interfere with endochondral ossification.

# HISTOLOGY OF BONE



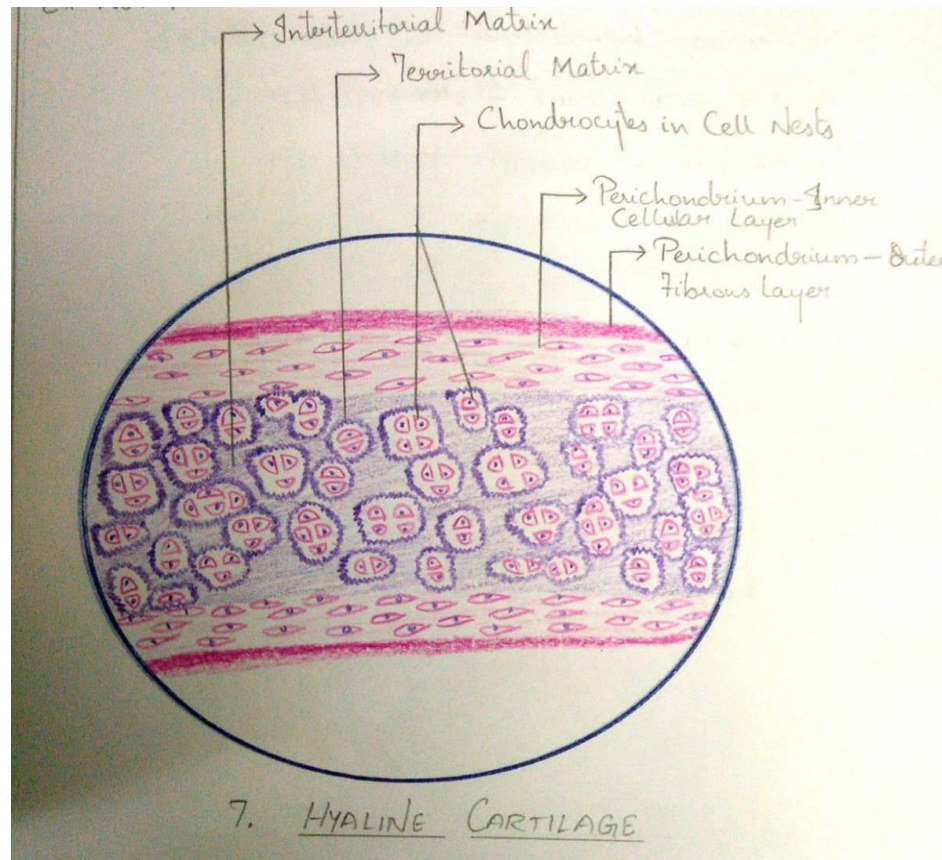
- ↪ Transverse section of Haversian system with concentric lamellae around Haversian canal.
- ↪ Lacunae containing osteocytes seen.
- ↪ Circumferential and interstitial lamellae seen.
- ↪ Periosteum present.
- ↪ Haversian system is considered as functional anatomical unit of bone.
- ↪ Haversian system or Osteon is made up of central Haversian canal.
- ↪ Around the canal osteoid matrix is laid in layers called lamellae.
- ↪ Between the lamellae and osteocytes are placed within lacunae, which are interconnected by canaliculi.
- ↪ Lamellae around the canal are called concentric lamellae.

- ⇒ At periphery running around the bone are circumferential lamellae which are located beneath the periosteum or endosteum.
- ⇒ Lamellae between the Haversian system are called interstitial lamellae.
- ⇒ Periosteum is a 2 layered structure:
  - 1) Outer fibrous layer
  - 2) Inner cellular layer
- ⇒ Fibrous layer contains collagen fibers.
- ⇒ Inner cellular layer with osteoprogenitor cells helps in appositional growth/ secondary healing.
- ⇒ 3 types of cells are seen:
  1. **OSTEOBLASTS** are bone-forming cells
  2. **OSTEOCLASTS** are seen at the sites of bone resorption.
  3. **OSTEOCYTES** are older inactive cells, buried between layers of osteoid.
- ⇒ Matrix is made up of ground substance, fibers and inorganic substance mainly calcium and phosphorous.



- ⇒ Longitudinal section of Haversian system with central Haversian canals.
- ⇒ Volkmann's canal – interconnecting the Haversian canals
- ⇒ Lacunae containing osteocytes seen.
- ⇒ Haversian system is considered as functional anatomical unit of bone.
- ⇒ Haversian system or Osteon is made up of central Haversian canal.
- ⇒ Around the canal osteoid matrix is laid in layers called lamellae.
- ⇒ Between the lamellae and osteocytes are placed within lacunae, which are interconnected by canaliculi.
- ⇒ Haversian Canals are interconnected by oblique canals called Volkmann's canals.
- ⇒ At periphery running around the bone are circumferential lamellae which are located beneath the periosteum or endosteum.
- ⇒ **PERIOSTEUM** is a 2 layered structure:
  - i. Outer fibrous layer
  - ii. Inner cellular layer

## HISTOLOGY OF HYALINE CARTILAGE

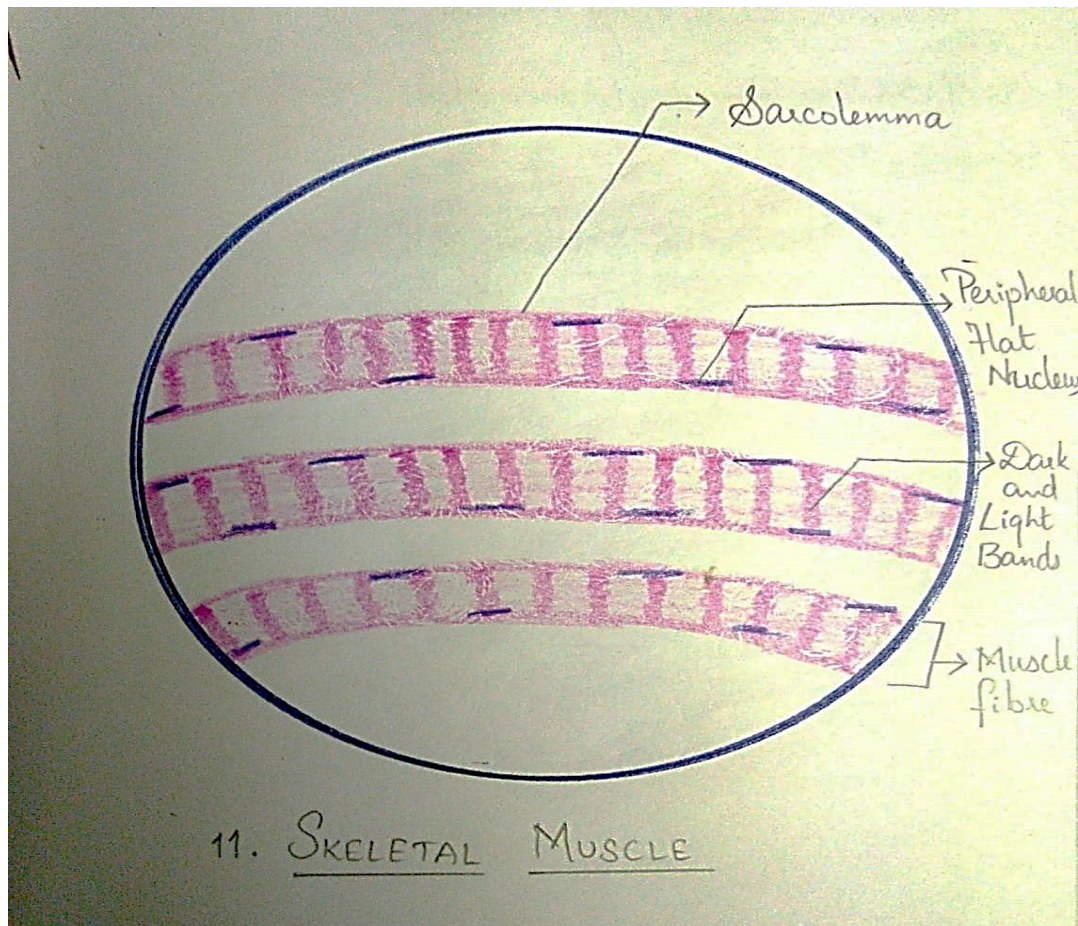


- ↪ Typical chondrocytes in cell nests of 2-4 cells.
- ↪ Homogenous basophilic matrix
- ↪ Perichondrium present.
- ↪ Hyaline cartilage has typical ground glass appearance with homogenous bluish matrix.
- ↪ Chondrocytes lie within lacunae.
- ↪ They are arranged in groups of 2-6 cells called cell nest.
- ↪ Apposing surface of chondrocytes are flattened.
- ↪ Matrix is basophilic due to presence of large amount of proteoglycans
- ↪ Matrix is homogenous because the refractive index of collagen fibers and ground substance is same.

- ⇒ Matrix around the cell nest looks denser and dark staining and is also called the territorial matrix. It is the newly formed matrix secreted by the chondrocytes.
- ⇒ In between the nests is the inter-territorial matrix which is pale staining.
- ⇒ Hyaline cartilage is surrounded by perichondrium which is a two-layered structure – inner cellular and outer fibrous layer.
  1. Fibrous layer made of collagen fibres.
  2. Cellular layer is made of chondrogenic cells responsible for appositional growth of cartilage.
- ⇒ **EXAMPLE:** Articular cartilage, foetal skeleton, costal cartilage, epiphyseal plate.

# HISTOLOGY OF SKELETAL MUSCLE

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- ↪ Unbranched long cylindrical fibres.
- ↪ Multiple peripherally placed flattening nuclei.
- ↪ Dark and light cross striations seen.
- ↪ Each cell is long cylindrical without branching.
- ↪ Fibres run parallel to each other.
- ↪ **Skeletal muscles** have transverse striations which are seen as light(I) and dark (A) bands.
- ↪ Hence, they are called **striated muscles**.
- ↪ Striations are not easily seen under low magnification.

- ⇒ Dark and light bands are due to regular arrangements of actin and myosin filaments.
- ⇒ Center of 'I' band is called **Z line**.
- ⇒ Center of 'A' band is light **H zone**.
- ⇒ **Dark M line** is seen in the center of H zone.
- ⇒ The part of myofibril between two adjacent Z lines is called sarcomere which is the functional unit of the muscle.
- ⇒ 'A' band remains constant during muscle contraction, I and H bands become short.
- ⇒ Skeletal muscles are **voluntary muscles**, innervated by somatic motor nerves.
- ⇒ Connective tissue covering of each muscle fiber is endomysium.
- ⇒ Bundles of such fibers (fascicles) are covered by perimysium.
- ⇒ Entire muscle covered by epimysium.

## SYNOVIAL JOINTS

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⇒ Synovial joints are most evolved, and , therefore, most mobile type of joints.

### ⇒ CHARACTERISTICS:

⇒ Articular surfaces are covered with hyaline cartilage, like clavicle and mandible.

⇒ **Articular cartilage** is avascular and non-nervous and elastic.

⇒ Surface of cartilage shows **fine undulations** filled with synovial fluid.

⇒ Between the articular surfaces there is a joint cavity filled with **synovial fluid**.

⇒ The cavity may be partially or completely subdivided by an articular disc or meniscus.

⇒ The joint is surrounded by an articular capsule made up of a fibrous capsule **lined by synovial membrane**.

⇒ It has **rich nerve supply**.

⇒ Fibrous capsule is often reinforced by

a) Capsular or true ligaments

b) Accessory ligaments

⇒ Synovial membrane lines whole of interior of joint except for articular surfaces.

⇒ Membranes **secrete synovial fluid**.

⇒ The fluid **lubricates the joint** and nourishes the articular cartilage.

⇒ **Viscosity of fluid** is due to hyaluronic acid secreted by synovial membrane cells.

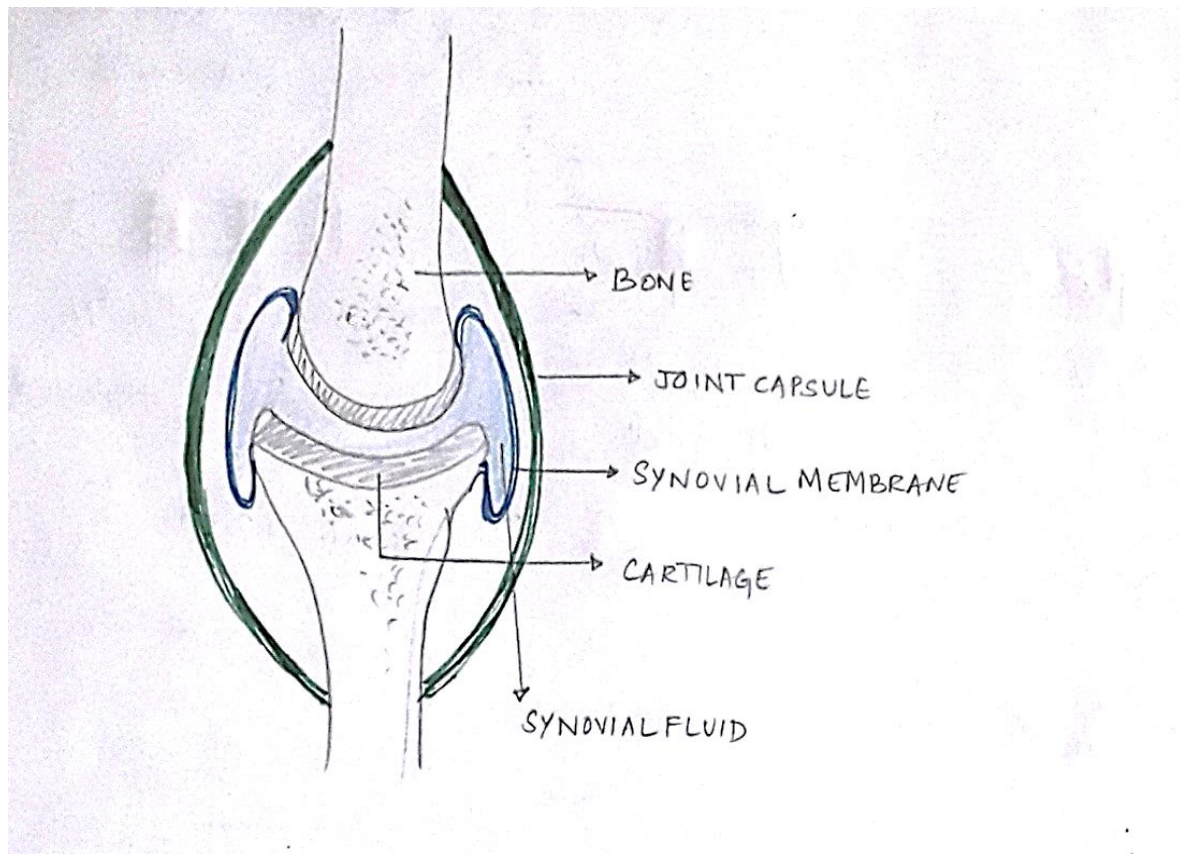
⇒ Varying degrees of movements are always permitted by synovial joints.

|                                       |                                                                                             |
|---------------------------------------|---------------------------------------------------------------------------------------------|
| A. Plane or gliding type              | Gliding movement                                                                            |
| B. Uniaxial joints                    |                                                                                             |
| 1. Hinge joint                        | Flexion and extension                                                                       |
| 2. Pivot joint                        | Rotation only                                                                               |
| C. Biaxial joints                     |                                                                                             |
| 1. Condylar joint                     | Flexion, extension, and limited rotation.                                                   |
| 2. Ellipsoid joint                    | Flexion, extension, abduction, adduction and circumduction.                                 |
| D. Multiaxial joints                  |                                                                                             |
| 1. Saddle joint                       | Flexion, extension, abduction, adduction, and conjoint rotation                             |
| 2. Ball-and-socket (spheroidal) joint | Flexion and extension, abduction and adduction, circumduction, medial and lateral rotation. |

## PLANE SYNOVIAL JOINTS

- Articular surfaces are more or less flat (plane). They permit gliding movements (translations) in various directions.
- **Examples:**
  1. Intercarpal joints
  2. Intertarsal joints
  3. Joints between articular processes of vertebrae
  4. Cricothyroid joint

5. Cricothyroid joint
6. Superior tibiofibular
7. Interchondral joint (5-9 ribs)
8. Costovertebral
9. Costotransverse
10. Acromioclavicular with intra-articular disc
11. Carpometacarpal (except first)
12. Tarsometatarsal
13. Intermetacarpal
14. Intermetatarsal
15. Chondrosternal (except first)
16. Sacroiliac



## HINGE JOINTS

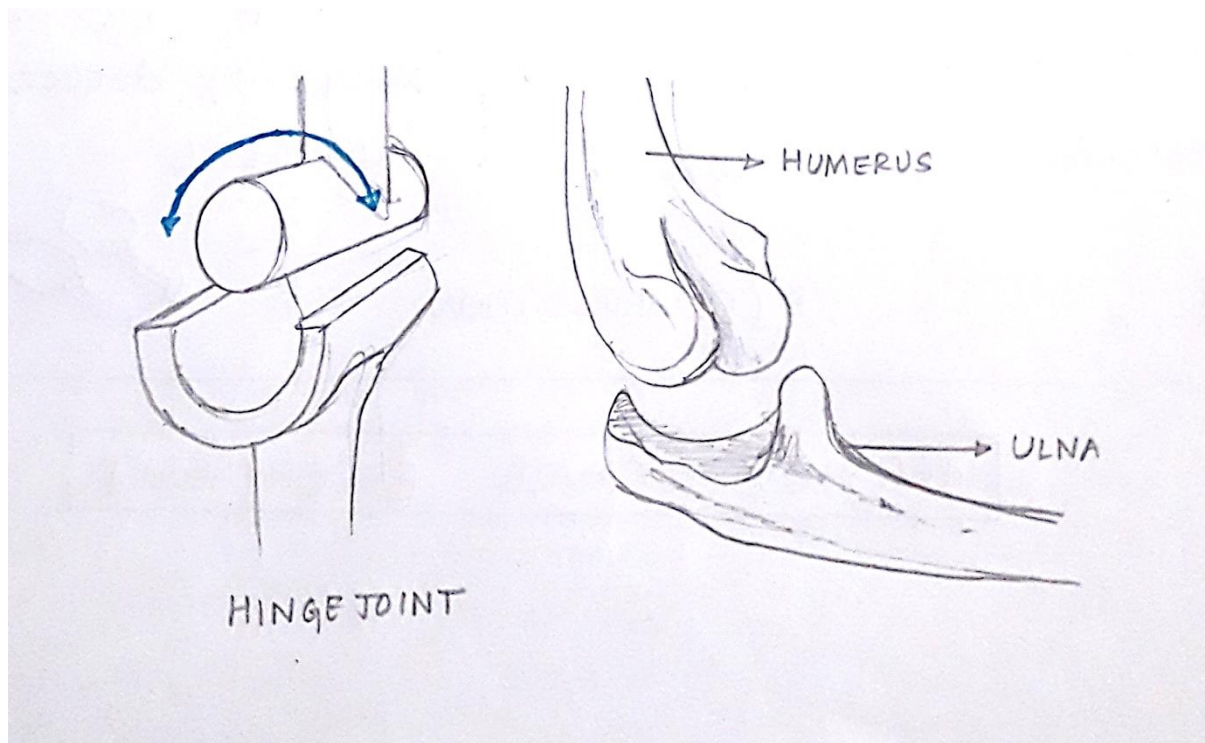
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⇒ AKA Ginglymi

⇒ Articular surfaces are pulley shaped. There are strong collateral ligaments. Movements are present in one plane around a transverse.

⇒ **EXAMPLES:**

1. Elbow joint
2. Ankle joint
3. Interphalangeal joints



( Diagram showing the elbow joint – humeroulnar component – Hinge joint)

## PIVOT JOINTS

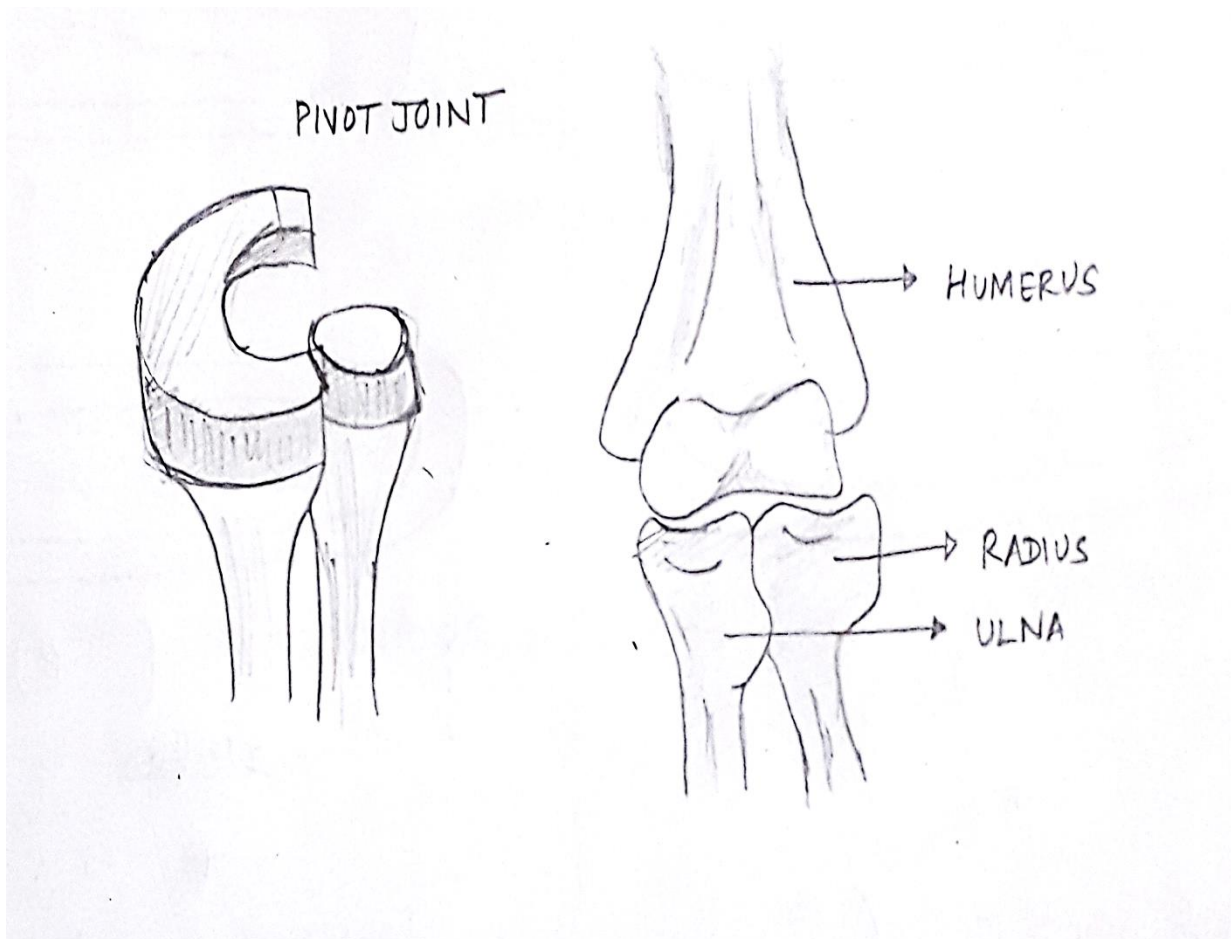
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⇒ AKA Trochoid joints.

⇒ Articular surfaces comprise a central bony pivot (peg) surrounded by an osteo-ligamentous ring. Movements are permitted in one plane around a vertical axis.

⇒ **EXAMPLES:**

1. Superior and inferior radioulnar joints
2. Median atlantoaxial joint



( Diagram showing the articular surfaces of superior radioulnar joint – pivot joint)

## CONDYLAR JOINTS

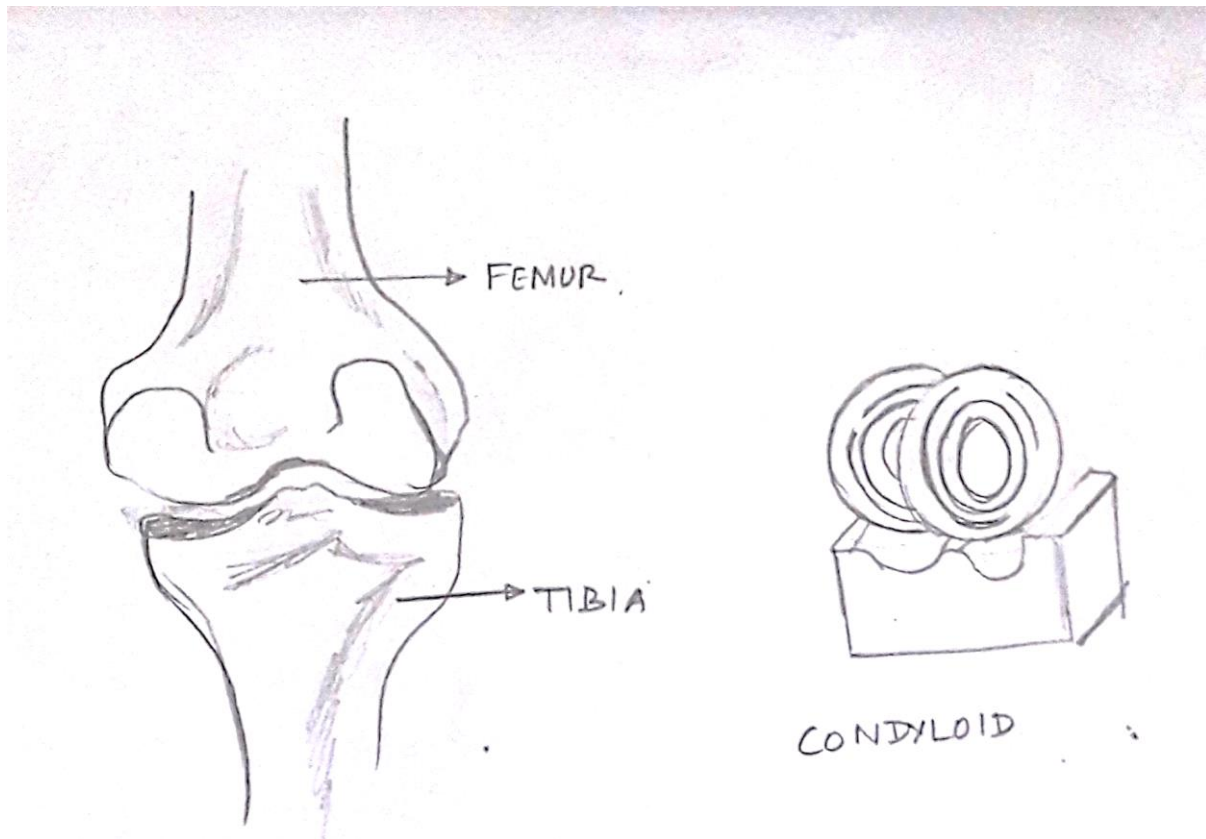
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⇒ AKA Bicondylar joints.

⇒ Articular surfaces include two distinct condyles (convex male surfaces) fitting into reciprocally concave female surfaces (which are also, sometimes, known as condyles, such as in tibia). These joints permit movements mainly in one plane around a transverse axis, but partly in another plane (rotation) around a vertical axis.

⇒ EXAMPLES:

1. Knee joint
2. Right and left jaw joints or temporomandibular joint.



( Diagram showing articular surfaces of the knee joint- synovial joint of condylar variety)

## ELLIPSOID JOINTS

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- ⇒ Articular surfaces include an oval, convex, male surface fitting into an elliptical, concave female surface.
- ⇒ Free movements are permitted around both the axes; flexion and extension over the transverse axis, and abduction and adduction over the anteroposterior axis.
- ⇒ Combination of movements produces circumduction. Typical rotation around a third (vertical) axis does not occur.
- ⇒ Examples:
  1. Atlanto-occipital joints.
  2. Wrist joint
  3. Metacarpophalangeal joints

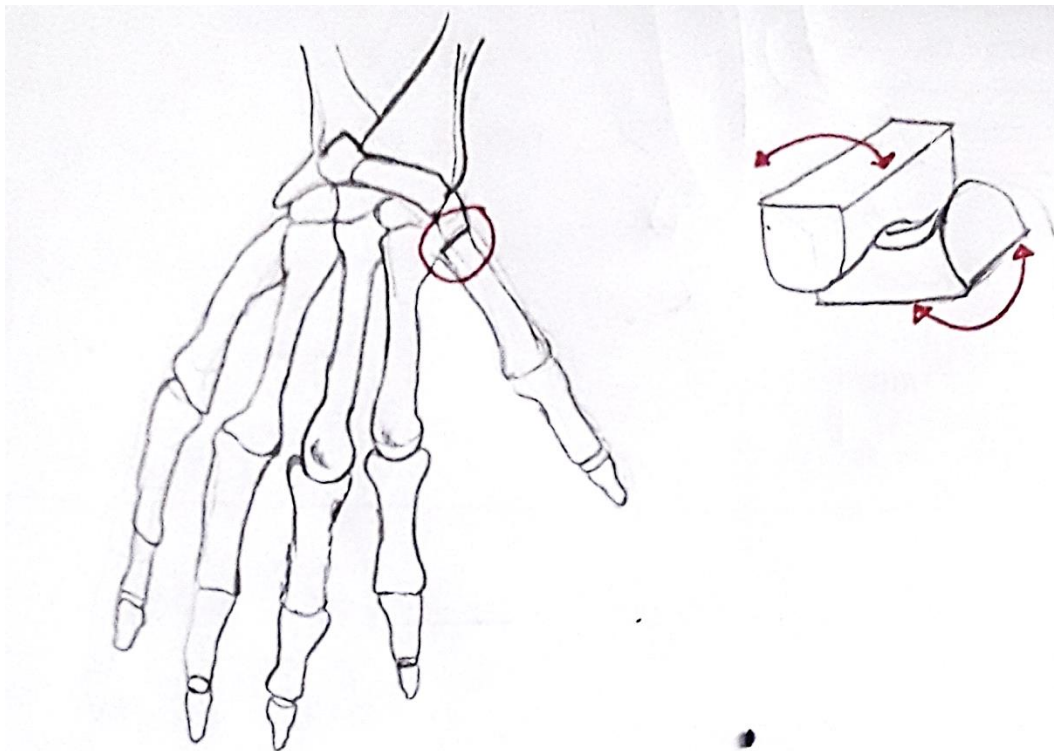
## SADDLE JOINTS

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⇒ Articular surfaces are reciprocally concavo-convex. Movements are similar to those permitted by an ellipsoid joint, with addition of some rotation (conjunct rotation) around a third axis which, however, cannot occur independently.

⇒ Examples:

1. First carpometacarpal joint
2. Sternoclavicular joint
3. Calcaneocuboid joint
4. Incudomalleolar joint
5. Between femur and patella

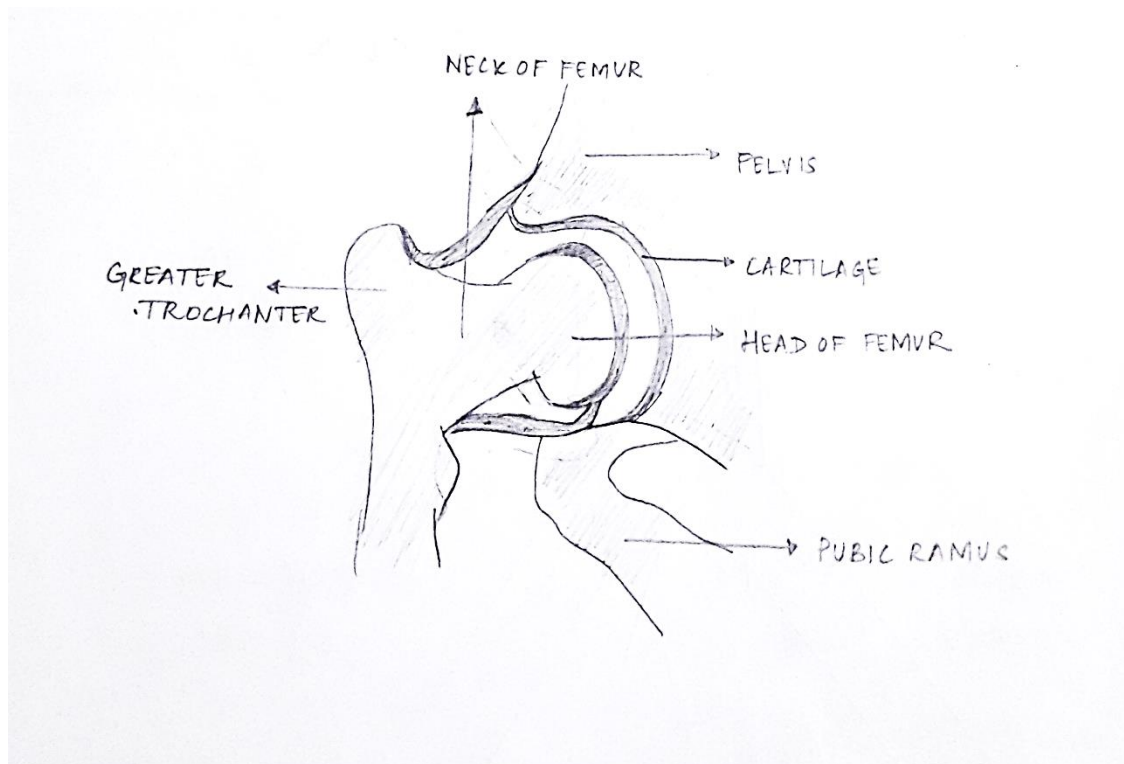


( Diagram showing the movements of first carpometacarpal joint –  
Saddle joint)

## BALL AND SOCKET JOINTS

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- ⇒ AKA Spheroidal joints.
- ⇒ Articular surfaces include a globular head (male surface) fitting into a cup shaped socket (female surface).
- ⇒ Movements occur around an indefinite number of axes which have one common centre.
- ⇒ Flexion, extension, abduction, adduction, medial rotation, lateral rotation, and circumduction, all occur quite freely.
- ⇒ EXAMPLES:
  1. Shoulder joint
  2. Hip joint
  3. Talocalcaneonavicular joint
  4. Incudostapedial joint



( Diagram showing the articular surfaces of hip joint -Ball and socket variety)

## CLOSE PACKED POSITIONS OF JOINTS

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| JOINT                   | CLOSE PACKED POSITION          |
|-------------------------|--------------------------------|
| Temporomandibular       | Clenched teeth                 |
| Spine                   | Extension                      |
| Shoulder                | Abduction and lateral rotation |
| Elbow                   | Extension                      |
| Wrist                   | Extension and radial deviation |
| Trapeziometacarpal      | Opposition (thumb)             |
| Metacarpophalangeal     | Flexion (finger)               |
| Interphalangeal         | Extension                      |
| Hip                     | Extension and medial rotation  |
| Knee                    | Extension and locking          |
| Ankle                   | Dorsiflexion                   |
| Subtalar and mid-tarsal | Inversion                      |
| Metatarsophalangeal     | Extension                      |
| interphalangeal         | Extension                      |

# **LUBRICATION MECHANISMS**

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## **SYNOVIAL FLUID**

- ↳ Secreted by synovial membrane, is sticky and viscous due to hyaluronic acid (a mucopolysaccharide).
- ↳ It serves the main function of lubrication of the joint.
- ↳ It also nourishes the articular cartilage.

## **HYALINE CARTILAGE**

- ↳ Covering the articular surfaces possess inherent slipperiness, like that of the ice.

## **INTRA-ARTICULAR FIBROCARTILAGES**, Articular Discs or Menisci, Complete or Incomplete

- ↳ Help in spreading the synovial fluid throughout the joint cavity, but particularly between the articular surfaces, e.g. temporomandibular joint.
- ↳ The disc divides the joint into two cavities for diverse movements in 2 cavities.
- ↳ The disc strengthens the joint.

## **HAVERSIAN GLAND**

- ↳ Occupy extra spaces in the joint cavity between the incongruous bony surfaces.
- ↳ All of them are covered with synovial membrane.
- ↳ Function as swabs to spread the synovial fluid.

## BURSA

- ↪ It is a bag like space lined by synovial membrane containing synovial fluid.
- ↪ The digital synovial sheath is a synovial fluid filled bag or sheath in relation to tendons, joints and bones to prevent friction.
- ↪ The tendons are supplied by blood through vincula brevia and vincula longa.
- ↪ The inflammation of bursa is called bursitis.
- ↪ Bursa reduces friction and permits limited free movements.

## TYPES OF BURSAE:

1. SUBCUTANEOUS BURSAE: These are present between bony prominences and skin, e.g. prepatellar bursa and subcutaneous intrapatellar bursa.
2. ARTICULAR BURSA: This functions as a joint, e.g. bursa between dens of axis and transverse ligament of atlas vertebra.
3. SUBTENDINOUS BURSA: These are present between bone and tendon, e.g. supraspinatous bursa; between bone and ligament, e.g. bursa deep to tibial collateral ligament; or bursa between 2 and 3 tendons, e.g. anserine bursa.

## BLOOD SUPPLY

- ↪ The articular and epiphysial branches given off by the neighbouring arteries form a **periarticular arterial plexus**.
- ↪ Numerous vessels from this plexus pierce the fibrous capsule and form a **rich vascular plexus** in the deeper parts of synovial membrane.
- ↪ The blood vessels of the synovial membrane terminate around the articular margins in a fringe of looped anastomoses termed the **circulus vasculosus** (circulus articularis vasculosus).

- ↪ It supplies capsule, synovial membrane and the epiphysis.
- ↪ The articular cartilage is **avascular**.
- ↪ After epiphysial fusion, communications between circulus vasculosus and the end arteries of metaphysis are established, thus **minimizing the chances of osteomyelitis** in the metaphysis.

## CLINICAL ANATOMY

- ↪ Intervertebral disc forms secondary cartilaginous joint between the bodies of the vertebrae. If the nucleus pulposus part of the disc protrudes backwards, it may press on the spinal nerve leaving out from the intervertebral foramina. The condition is known as herniation of the disc or disc prolapse. If disc prolapse occurs in lumbar vertebrae there is radiating pain in the lower limb, and the condition is called **SCIATICA**.
- ↪ The joints may get dislocated, i.e. the end of one of the bones gets out of its socket. In **SUBLUXATION**, the end of the bone partially leaves its socket.
- ↪ **RHEUMATIC FEVER** causes fleeting pain in the joints, accompanied by streptococcal pharyngitis. It is mostly temporary pain in the joints. The toxins of the bacteria may affect the mitral valve of the heart or the kidneys.
- ↪ **RHEUMATOID ARTHRITIS** is an inflammatory systemic disease resulting in thickened synovial membranes of small joints of the hands. Due to chronic inflammatory process there is erosion of bones leading to deformity of the fingers
- ↪ **OSTEOARTHRITIS** is a degenerative condition of the weight-bearing joints. The articular cartilage wears out, degenerates and there is formation of peripheral osteophytes. Rubbing of bones together during movements results in pain.

- ↳ Degenerative changes or **SPONDYLITIS** may occur in cervical spine, leading to narrow intervertebral foramen, causing pressure on spinal nerve.
- ↳ In some joints, the capsule encloses metaphysis. In such joints, infection from metaphysis would reach the joint cavity and cause septic arthritis.
- ↳ **NEUROPATHIC JOINT** is the result of complete denervation. All reflexes are eliminated and the joint is left unprotected liable to mechanical damage. Shows painless swelling, excessive mobility and bony destruction. Commonly caused by leprosy, tabes dorsalis and syringomyelia.