SECTION

1

General Anatomy

- Skeleton
- Joints
- Muscles
- Cardiovascular System

Attention Please

All the texts in boxes are not to be written in the examination.

CHAPTER

1

Skeleton

SN-1 Long Bone

1. Features of long bone

A. It is placed vertically in the body or in the long axis of the body.

B. Its length is more than breadth.

C. It has

a. Shaft with two expanded ends,

b. Three surfaces and three borders (Fig. 1.1),

c. One diaphysis and more than two epiphyses, and

d. Medullary cavity.

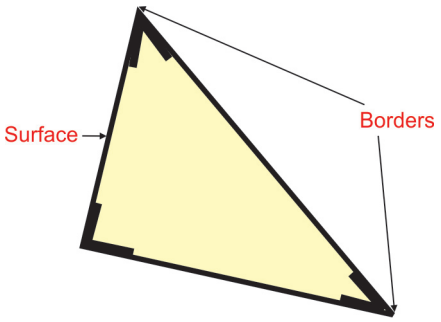


Fig. 1.1: Transverse section (TS) of long bone showing three borders and three surfaces

D. It

a. Serves as a lever for muscular actions.

b. Transmits weight, from axial to appendicular skeleton.

c. Develops in cartilage.

d. Forms joints with upper and lower ends and with interosseous border.

E. Surfaces of long bones are covered by periosteum except articular surfaces.

2. Sub-classification

A. Typical long bone: It has all the features of long bone.

a. Examples of typical long bones

I. Humerus (Fig. 1.2),
II. Radius,
III. Ulna,
IV. Femur (Fig. 1.3),
V. Tibia, and
VI. Fibula.

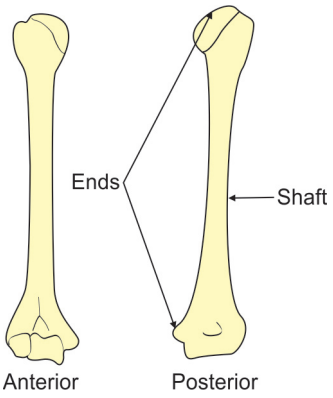


Fig. 1.2: Right humerus

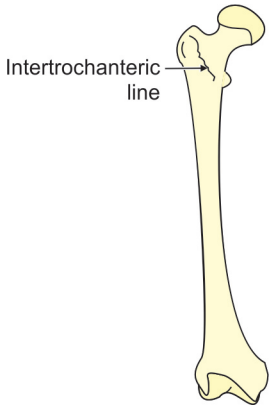


Fig.1.3: Long bone—right femur, anterior view

B. Modified long bone: Some of the characters of typical long bones are modified.

a. It does not have medullary cavity.
b. It ossifies in membrane or cartilage or both.
c. The clavicle transmits the weight from appendicular skeleton to axial skeleton. The body of vertebra transmits the weight from axial to appendicular skeleton.

Example

I. Clavicle (Fig. 1.4)
II. Body of vertebra (Fig. 1.5).

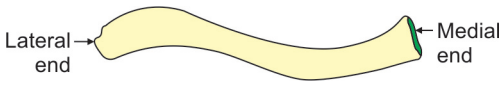


Fig. 1.4: Modified long bone—clavicle

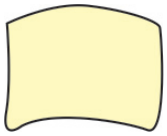


Fig. 1.5: Body of vertebra

C. Miniature long bone (Fig. 1.6) (mockery of long bone): It is smaller in all dimensions, namely length, breadth, weight and diameter and has only 1 epiphysis, e.g.

a. Metacarpals,
b. Metatarsals, and
c. Phalanges.

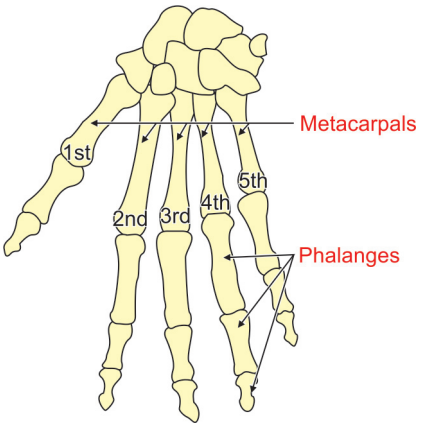


Fig. 1.6: Miniature long bones—metacarpals and phalanges

SAQ-1 Short Bones

Introduction: The bones which are not long called short bones (Fig. 1.7). They are cubical  in shape and present six surfaces.

1. **Features:** Out of six surfaces
   A. Four are articular, and
   B. Two are non-articular.
2. Articular surfaces give attachment to muscles and ligaments.
3. They are pierced by blood vessels.
4. **Examples**
   A. **Carpal** bones:  **S**he **l**ooks **t**oo **p**retty, **t**ry **t**o **c**atch **h**er

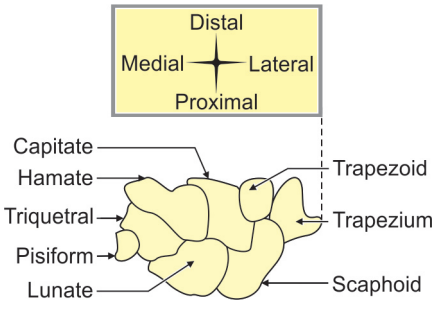


Fig. 1.7: Short bones of right wrist

Scaphoid  ,

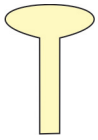
Lunate  ,

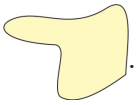
Triquetral  ,

Pisiform 

Trapezium 

Trapezoid 

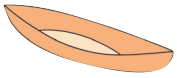
Capitate  and

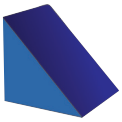
Hamate  .

B. **Tarsal** bones

a. Calcaneus,

b. Cuboid , 

c. Navicular  and

d. Cuneiform 

I. Medial cuneiform

II. Intermediate cuneiform

III. Lateral cuneiform

C. **Sesamoid**  bones

5. **Ossification**

A. They ossify in cartilage.

B. They ossify after birth except talus, calcaneus and cuboid which ossify in intra-uterine life.

SN-2 Pneumatic Bone

(*Pneuma* air)

Introduction: The pneumatic bone has outer and inner tables. It is lined by muco-periosteum and contains air.

1. **Site:** Bones lining respiratory passage, e.g.
   - A. **Paired:** Maxilla
   - B. **Unpaired**
     - a. Frontal,
     - b. Ethmoid,
     - c. Sphenoid.
2. **Features:** In the pneumatic bone, the spongy substance is replaced by the air-filled paranasal sinuses.
3. **Functions:** ARTI
   - A. It acts as **A**ir conditioning chamber.
     - a. It changes humidity and temperature of the inspired air.
     - b. It makes the air free from foreign particles.
   - B. It acts as **R**esonance (prolongation and intensification of sound) of the voice.
   - C. It improves **T**imbre (quality of musical sound) of the voice.
   - D. It provides **I**nsulation.
   - E. They reduce the weight of the bone by 200 to 300 g.
4. **Development**
   - A. They develop in membrane due to differential growth of 2 tables.
   - B. Inner table breaks up and penetrates into neighbouring mucosa and forms the pneumatic bone.

SN-3 Sesamoid Bone

Introduction: It is oval  shaped nodules, a few mm in diameter varying in shape and size which develops in tendons or/and joint capsule.

1. **Nomenclature:** Arabic term *Sesame*—seed-like  , *oid*—resemblance.
2. **Evolution:** Phylogenetically it is part of skeleton.
3. **Structure:** It is formed by fibrous tissue, cartilage or bone which develops in tendon. It exerts a considerable amount of pressure on bony structure (Fig. 1.8).
4. **Ossification:** It ossifies in 2nd decade except patella which ossifies in the 1st decade.

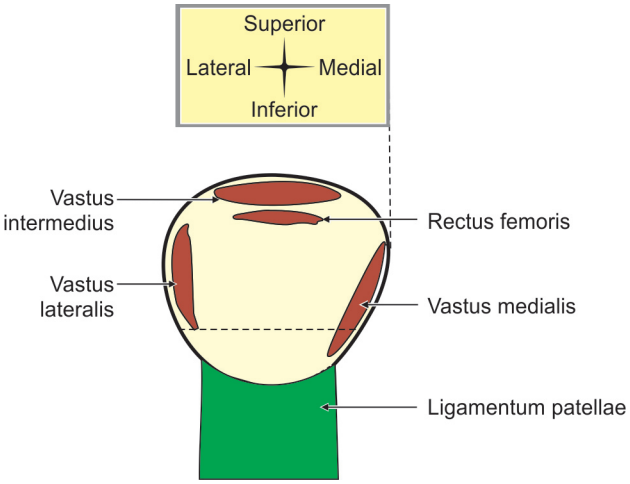


Fig. 1.8: Right patella showing the attachments of quadriceps femoris

5. **Characters:** **NO** **MP HP**

   A. It does not have:
   - **M**edullary cavity,
   - **P**rimary centre,
   - **H**aversian system, and
   - **P**eriosteum.

   B. It has articular or non-articular surface.

   C. The articular surface is covered by hyaline cartilage.

   D. It is lubricated by bursa or synovial fluid.

6. **Functions:** The exact function is not definitely known. However, the following functions are attributed.

SESAMOID

Serves as a mechanical advantage to the tendon.

Ensures (makes certain) the prevention of wear and tear of the tendon.

Stabilises the local circulation.

Alters the direction of pull of the muscle.

Maintains the local circulation.

Overcomes the pressure.

Insures (protects) the vessels and nerves.

Diminishes the friction.

Site: Following are the sesamoid bones (Table 1.1).

Table 1.1: Sesamoid bones related tendons

Tendon	Name of sesamoid bone
• Quadriceps femoris (related to articular surface of knee joint)	• Patella (biggest sesamoid bone)
• Flexor carpi ulnaris	• Pisiform
• Gastrocnemius (lateral head)	• Fabella (little bean)
• Adductor longus	• Riders bone
• Flexor pollicis longus	–
• Flexor pollicis brevis	–
• Adductor pollicis	–

7. **Applied anatomy**
   - ➢ Failure of ossification is mistaken for fracture of bone, e.g. patella.
   - ➢ Stress fracture occurs in ballet dancers and long-distance runners.

SN-4 Periosteum

(*Greek. Peri*—around, *osteon*—bone)

1. **Definition:** The surface of the shaft and part of the ends are covered by periosteum (Fig. 1.9).

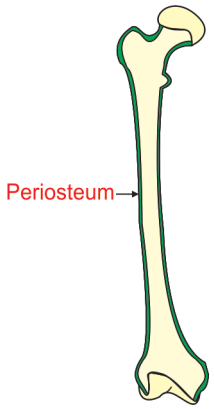


Fig. 1.9: Long bone—periosteum

A. **Features**
   a. At the ends of the bones, the periosteum blends with the fibrous capsule of the joints.
      I. External surface of any bone is, as a rule, covered by a membrane called periosteum.
      II. In long bones, only the *diaphysis* is covered by *periosteum*. It is present as far as epiphyseal line. Here it is continuous with the capsule of the joint.

b. Periosteum is *absent* in

I. Bones covered with articular cartilage,

II. Epiphyses of long bones, and

III. Sesamoid bone.

c. *Variation* of thickness: It is related to age. It is more vascular and thicker in children than adult.

d. Factors keeping the periosteum close to the bone.

I. Sharpey's fibres are very dense at the attachments of tendon and ligaments.

II. Blood vessels: They run from periosteum to the bone. They supply the bone substance and the marrow.

B. **Structure of periosteum** (Fig. 1.10): It consists of *2 layers*

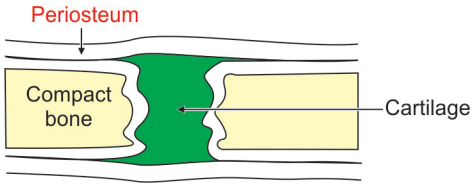


Fig. 1.10: Periosteum

a. Outer fibrous layer: It is made up of densely packed fibres with some connective tissue cells. It acts as a limiting membrane. It sends bundles of collagen fibres into the bone. These are perforating fibres of Sharpey.

I. They anchor the periosteum.

II. They are particularly strong at the attachments of tendons or ligaments.

III. The ends of long bones are covered with the articular cartilage except distal end of terminal phalanges.

b. Deeper vascular layer: It contains

I. Blood vessels, and

II. Cells: They are

i. *Osteoblast cells:* They are bone-forming cells. They lay down new bone on the surface of the shaft.

ii. *Osteoclast cells:* They are bone-destroying cells.

C. **Variation of attachment of periosteum to bone:** Attachment of periosteum varies with bone and age.

a. In relation to type of bone.

I. In long bones, it is more closely connected at the

i. Extremities of long bones,

ii. Prominences,

iii. Pressure points, and

iv. Over the areas to which the tendinous attachments are present.

II. On flat bones, it is less adherent.

b. In relation to age: In early life, it invests loosely than in adult

D. **Fate of periosteum**

a. At the ends of bone, it continues as fibrous capsule.

b. The anterior longitudinal ligament blends with the periosteum and loses its identity in the middle of the sacrum.

E. **Blood supply:** It is mainly supplied by periosteal vascular plexus. These are the branches of muscular arteries.

F. **Nerve supply:** It has rich nerve supply through somatic nerves. They are sensory nerves. They carry pain fibres. This is the reason why fractures are extremely painful.

G. **Lymphatic:** Lymphatic vessels are abundant in the periosteum.

2. **Functions of periosteum**

A. Osteogenic,
B. Protective,
C. Nutritional,
D. Growth of the bone, and
E. Repair of bone.

3. **Applied anatomy**

- If periosteum is removed, blood supply of the bone is lost. The bone underlying periosteum undergoes degeneration and death.
- Position of *nutrient* foramen of fibula is important clinically. When obtaining a graft surgically, the periosteum and nutrient artery are generally removed with the piece of bone. This helps graft to remain alive when transplanted to another site.
- When bone is fractured, the blood vessels and periosteum are damaged. These vessels bleed, and clot is formed between the broken ends of the fractured bone. It is called *fracture haematoma*.
- The periosteum is thick over the mandible. In fracture of mandible, the fractured bones are not displaced because of thick periosteum.
- Pain in Paget's disease is believed to result from the stretching of the periosteum.
- The inflammation of periosteum results in local pain and tenderness.

SN-5 Epiphysis

(*Epi*—above, *physis*—growth)

Introduction: The segment of bone which develops from secondary centre is called epiphysis. Secondary centre is one which develops after birth.

1. **Classification**

A. Based on *number of epiphysis* (structurally).

a. Simple: Ends of long bone develop from many epiphyses. They fuse independently with shaft, e.g. femur.

b. **Compound:** The ends of bone develop from many centres and these centres unite to form a single epiphysis. The single epiphysis subsequently fuses with shaft, e.g. head of humerus.

B. Based on *functions* (Table 1.2)

a. Pressure epiphysis
b. Traction epiphysis

Table 1.2: Comparison between pressure epiphysis and traction epiphysis

Particulars	Pressure epiphysis	Traction epiphysis
Definition	It is a protective cap to the metaphysis.	
Develop	As a result of transmission of weight.	As a result of pull of muscle
Takes part	In formation of joint (articular)	Does not take part in the formation of joint (non-articular)
Develops from	Secondary centre	Secondary centre
Covered by	Hyaline cartilage	Not covered by hyaline cartilage
Centre of ossification	Appears earlier	Appears late
Examples	• Upper end and lower end of humerus, • Radius, • Femur, and • Tibia	• Greater and lesser tubercle of humerus, • Greater and lesser trochanter of femur, • Radial tuberosity, • Tibial tuberosity, • Mastoid process, and • Styloid process

C. **Atavistic (a great grandfather's grandfather) epiphysis:** In the initial part of evolution, some part/s of bone/s were isolated bones. They were getting nutrition from the adjacent bones. In later part of evolution, such bone/s fuse/s with the adjacent bones and form part of the bone. Such bones are called atavistic bones.

a. *Coracoid* process of scapula

b. *Os trigonum*: It is triangular bone present at the back of talus. Sometimes it occurs as independent bone.

D. **Aberrant epiphysis** (wandering, diverging from an accepted standard, away from normal): The miniature long bones have only one epiphysis. It is usually at distal end of the miniature long bone except for the 1st metacarpal which is present at proximal end. Sometimes, some of the metacarpals, metatarsals may have additional epiphysis/es which are called aberrant epiphysis/es. Examples are:

a. Distal end of 1st metacarpal.
b. Proximal end of 2nd metacarpal and 2nd metatarsal
c. Proximal end of 5th metacarpal and 5th metatarsal

2. **Applied anatomy**

- The head of the femur receives blood supply from the *epiphyseal* artery. It pierces the epiphyseal cartilage. In case of separation of epiphyseal plate, from the neck of femur, there is a necrosis of head due to loss of blood supply.
- The artery supplying the upper end of the tibia does not pierce the epiphyseal plate. Hence, separation of the upper end will not result in loss of blood supply in the upper end.

SN-6 Diaphysis

(*Dia*—in between, *physis*—growth)

Introduction: It is the elongated part of long bone present between two growing ends. It develops from one primary centre. It forms the shaft of long bone (Fig. 1.11).

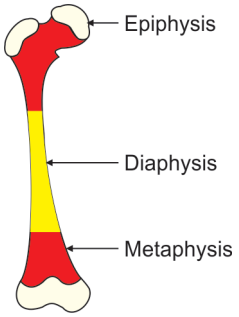


Fig. 1.11: Parts of a young long bone

1. **Blood supply** is mainly by nutrient artery, a branch of regional (of the respective region) artery. The direction of nutrient artery is opposite the direction of growing end.
2. **Structure:** It is described as:
   - **A. Periosteum:** It is compact and strong. It is adherent only to the shaft of long bone. It is fibrous in nature.
   - **B. Inner:** It is spongy and site of erythropoiesis.
3. **Growth**
   - A. Height by interstitial growth.
   - B. Thickness by appositional growth.
4. **Applied anatomy**

   Infection of the bone causes osteomyelitis.

SAQ-2 Metaphysis

(*Meta*—end, *physis*—growth)

Introduction: It is the epiphyseal end of diaphysis. It is the peripheral part of the shaft which is in contact with epiphyseal plate of cartilage.

1. **Characters**
   A. It is most
      a. Active part of bone
      b. Vascular part of bone, flooded in the lake of blood.
   B. It is the site of
      a. Attachment of tendons, and ligaments,
      b. Maximum pull, stress, strain and tension, and
      c. Maximum growth.

2. **Types of metaphysis**
   A. Intracapsular
      a. Metaphysis is present inside the capsule.
      b. Examples: Upper and lower ends of
         I. Humerus, and
         II. Femur
   B. Extracapsular
      a. Metaphysis is present outside the capsule.
      b. Examples: Upper and lower ends of
         I. Radius, and
         II. Tibia

3. **Blood supply:** It is by following arteries
   A. Nutrient artery,
   B. Periosteal artery, and
   C. Juxtaepiphyseal artery.

4. **Applied anatomy**
   - Metaphysis is susceptible to infection in the immature bone.
   - Infection of long bone primarily affects metaphysis. The nutrient arteries in the region of metaphysis form hairpin bend. The constricted area of nutrient arteries may get blocked by thrombus. It results in necrosis. It is the common site of osteomyelitis in children.
   - Infection can reach through the intracapsular metaphysis and cause septic arthritis.
   - Since muscles, ligaments and joint capsules are attached close to metaphysis, this is likely to be damaged by sheering strain of the muscle.
   - It is the region favouring haematogenous spread of infection.

SN-7 Blood Supply of the Long Bone

1. The blood supply of long bone (Fig. 1.12) is by following arteries
   A. Nutrient artery
      a. Features
         I. It is a branch of artery of the region.

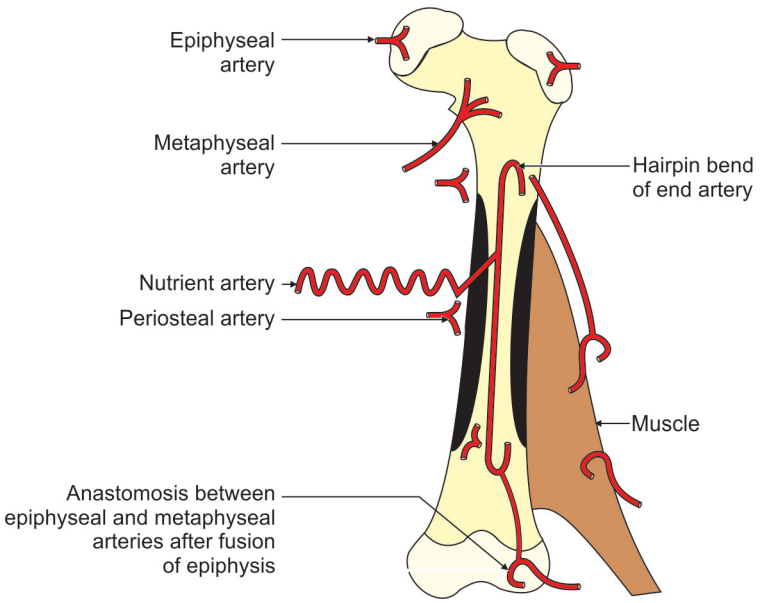


Fig. 1.12: Blood supply of long bone

II. Its direction is away from growing end.

III. The direction of the nutrient foramen (Table 1.3) is decided by the slogan.
"Towards the elbow I go, and away from the knee I flee."

Table 1.3: Direction of the nutrient foramen (Fig. 1.13)

Bone	Direction of nutrient foramen
Humerus	Downward
Radius, ulna	Upward
Femur	Upward
Tibia, fibula	Downward

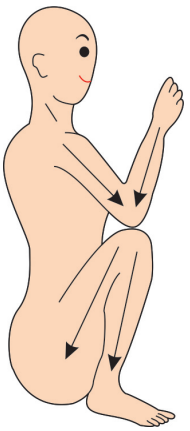


Fig. 1.13: The arrows indicate the directions of the nutrient foramina in long bones of upper and lower limbs

b. Peculiarities: It is tortuous before it enters the nutrient foramen for following reasons

I. For the uniform distribution of blood, and

II. To avoid rupture during contracting and relaxation of the muscle.

c. Number: It is usually one except in femur which has two nutrient foramina which transmit arteries.

d. Course

I. It enters the compact bone through nutrient foramen situated in the middle of shaft.

II. It divides into ascending and descending branches into the medullary cavity.

III. Each ascending and descending branch divides into many small branches which turn down to form a hairpin loop.

e. It anastomoses with

I. Periosteal artery,

II. Metaphyseal artery, and

III. Epiphyseal artery.

f. Distribution: *It supplies*

I. The inner two-thirds of compact bone,

II. The spongy bone, and

III. Haversian system of less than 2 mm diameter.

B. Metaphyseal artery

a. Arises from anastomosing arteries around joint.

b. Enters metaphysis through joint capsule.

c. It shows looping pattern during growth of bone.

C. Epiphyseal artery: Divides into two types—depending upon mode of blood supply (Table 1.4).

Table 1.4: The course of the epiphyseal artery at the upper end of femur and tibia

Particulars	Articular cartilage and epiphyseal cartilage are not continuous	Articular cartilage and epiphyseal cartilage are continuous
Mode of distribution	Supplies epiphysis without piercing epiphyseal cartilage	Supplies epiphysis after piercing the epiphyseal cartilage
Example	Upper end of tibia	Upper end of femur
Applied anatomy	Artery is not vulnerable for injury in epiphyseal separation. No vascular necrosis	Artery is vulnerable for injury in epiphyseal separation. It produces avascular necrosis in epiphyseal separation

D. Periosteal artery: It enters bone through Volkmann's of haversian system. It supplies outer one-third of the compact bone. It is branch of muscular arteries.

E. Muscular artery: It is a branch of muscular artery supplying adjacent muscles.

F. Endosteal artery: It supplies the inner surface of the bone.

2. **Applied anatomy**

- **Osteomyelitis:** The small embolus blocks the nutrient arteries at the site of hairpin bend. The distal part of the bone results into avascular necrosis. This condition is called osteomyelitis.
- Shaft of long bone is affected in congenital syphilis.

SAQ-3 Growing End

1. The active end of the long bone is called growing end. It is plate of cartilage between diaphysis and epiphysis. Examples: All long bones.
2. **Features**

A. The part of the bone which develops from secondary centre is called epiphysis. The epiphysis which appears first and fuses with the diaphysis (shaft) last is called growing end.

B. Each bone has two epiphyseal ends.

a. Growing end

b. Non-growing end

- Growing end does
  - I. More work,
  - II. For longer time, and
  - III. Faster.
- The non-growing end does
  - I. Less work,
  - II. For shorter time, and
  - III. Slow.

C. Bone increases in length at growing end.

D. The *growing end grows longer time and more rapidly* than the other end.

E. The growing end is opposite to the direction of nutrient foramen. The direction of nutrient foramen is decided by a slogan. **"Towards the elbow I go, and away from the knee I flee".**

Table 1.5 shows the growing end of different long bones.

Table 1.5: The direction of nutrient foramen and growing end of long bones

Bone	Direction of nutrient foramen	Growing end
Humerus	Downward	Upper end
Radius, ulna	Upward	Lower end
Femur	Upward	Lower end
Tibia, fibula	Downward	Upper end

3. **Applied anatomy**

- The knowledge of growing end of the concerned long bone is necessary for surgeons to manipulate the space. The situation arises when a boy/girl meets an

accident. In a fracture of limbs, accompanied by severe infection, there are chances of rapid spread of infection. In rapidly and uncontrolled infection, amputation is advised to prevent the spread of infection. The lower end of the femur, being growing end, may continue to grow and pierce the skin and protrude out. To avoid such consequences, surgeon keeps extra space to accommodate the growth of bone.

- Damage to the growing end during growth leads more deformity than the damage to the less growing end.

SAQ-4 Primary Centre of Ossification

Introduction: It is the centre from which the elongated shaft of the bone ossifies.

1. **Appearance:** The primary centre appears before birth.
2. **Examples**
   A. Shaft of all long bones, and
   B. Short bones like talus, calcaneus and cuboid.
3. **Exception:** Carpal and tarsal bones, the centre for which appears after birth.

SAQ-5 Secondary Centre of Ossification

Introduction: The centre of the long bone which appears after birth is called secondary centre.

1. **Example**
   A. Ends of all long bones,
   B. Greater trochanter of femur, and
   C. Greater tubercle of humerus.
2. **Gender variation:** Secondary centres tend to appear earlier in females ♀ than males ♂.
3. **Exception**
   A. Lower end of femur, and
   B. Upper end of tibia, the centre for these bones appear at birth.
4. **Applied anatomy**

   The secondary centre for lower end of femur or upper end of tibia appears just after birth. This fact is used in determining the dead born child with the viable newborn. This is confirmed by taking the X-ray of knee joint. Presence of centre at lower end of femur or upper end of tibia confirms viability of child and exclude stillbirth. Please note, absence of secondary centre does not exclude viability.

CHAPTER

2

Joints

SN-8 Classification of Joints

Joints are classified depending upon:

A. Structure,
B. Function, and
C. Region.

A. Structure of binding material

a. Fibrous joint: Bones are kept together by fibrous tissue. They are subclassified depending upon nature of fibres

I. Suture: The bones are kept together by a thin fibrous tissue or ligaments.

II. Syndesmosis: The bones are kept together by fibrous tissue which is in the form of band or interosseous membrane.

III. Gomphosis: The bones are kept together by fibrous tissue which is in the form of periodontal membrane.

b. Cartilaginous joint: Bones are kept together by cartilage. They are subclassified depending upon the type of cartilage

I. Primary cartilaginous joints or synchondrosis

II. Secondary cartilaginous joints or symphysis

c. Synovial joint: Bones are kept together by synovial fluid.

B. Function: They are subclassified depending upon degree of mobility.

a. *Synarthroses* are fixed joints at which there is no movement. The articular surfaces are joined by tough fibrous tissue. Often the edges of the bones are fixed into one another as in the sutures of the skull.

b. *Amphiarthroses* are joints at which slight movement is possible. A pad of cartilage lies between the bone surfaces, and there are fibrous ligaments to hold the bones and cartilage in place. The cartilages of such joints also act as shock absorbers, e.g. the intervertebral discs between the bodies of the vertebrae, where the cartilage is strengthened by extra collagen fibres.

c. *Diarthroses* or synovial joints are known as freely movable joints. In some joints, the movement is restricted by the shape of the articulating surfaces and by the ligaments which hold the bones together. These ligaments are of elastic connective tissue. The bones forming the synovial joint have articular surfaces. These are covered by articular cartilage. There is fluid, produced by the membrane lining the fibrous capsule. It is called synovial membrane. The fluid produced by synovial membrane is called synovial fluid. It spreads inner surface of the cavity. It acts as a lubricant. It produces free movements.

C. Regional

a. Skull type: Immovable.

b. Vertebral type: Slightly movable.

c. Limb type: Freely movable.

SN-9 Fibrous Joints

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 subtypes.

1. **Sutures** (Fig. 2.1): 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. temporoparietal 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, e.g. inferior tibiofibular joint (Fig. 2.2).

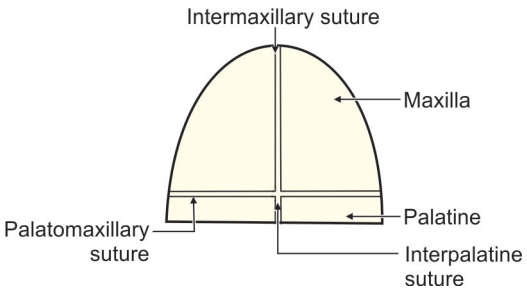


Fig. 2.1: Sutures

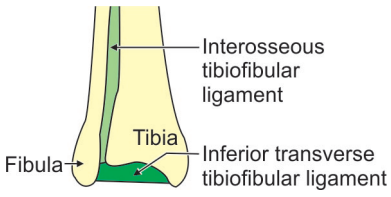


Fig. 2.2: Fibrous joint—inferior tibiofibular joint

3. **Gomphosis** (peg and socket joint). Example: Root of the tooth in its bony socket (Fig. 2.3).

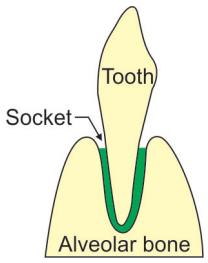


Fig. 2.3: Gomphosis

SN-10 Suture

(*Suture*—stitch, seam)

Introduction: Joints of skull are connected by fibrous tissue.

1. **Functions**
   A. They allow the growth of brain in the cranial cavity.
   B. They help moulding of head during labour.
2. **Movement:** No movement.
3. **Types:** Depending upon articular margin, they are subdivided into:
   A. Plane (Fig. 2.4): Margins are straight, e.g.
      a. Interpalatine
      b. Intermaxillary (Fig. 2.1)
      c. Palatomaxillary (Fig. 2.1).

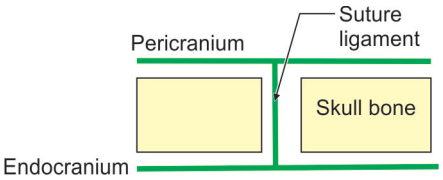


Fig. 2.4: Plane sutures

   B. Serrate (Fig. 2.5A and B) (saw): Margins are wavy (saw-like), e.g.
      a. Sagittal suture
      b. Coronal suture.
   C. Denticulate: The articulating margins resemble teeth. The tips are broader than the roots to have effective interlocking, e.g. lambdoid suture (suture between parietal and occipital bone, Fig. 2.6).
   D. Squamous (Fig. 2.7): The articulating margins are bevelled, e.g. temporoparietal
   E. Schindylesis (splinting a piece of wood): The ridged bone fits into a groove, e.g. rostrum (beak) of sphenoid overlapped by ala (wing) of vomer (Fig. 2.8).

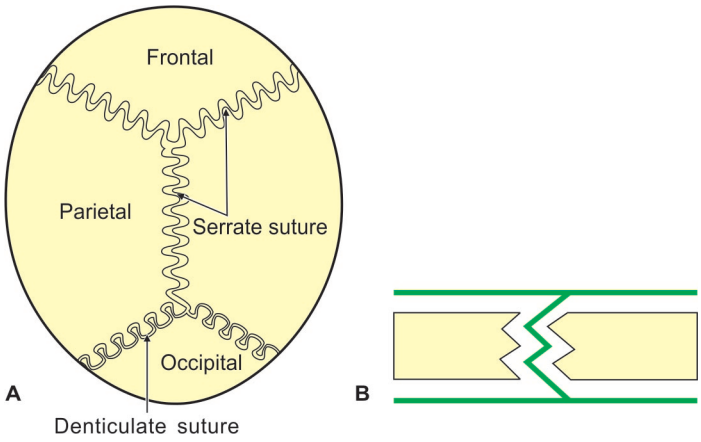


Fig. 2.5A and B: (A) Cranial vault showing serrate and dentate suture; (B) Serrate suture

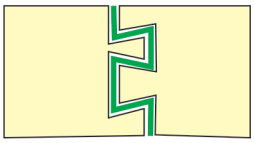


Fig. 2.6: Denticulate suture

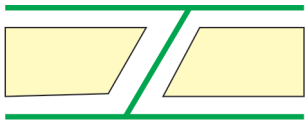


Fig. 2.7: Squamous suture

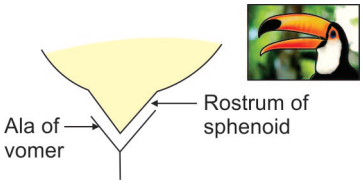


Fig. 2.8: Schindylesis

F. Gomphosis (wedge-shaped nail or bolt): Peg and socket type of joint, e.g. tooth and socket (refer to Fig. 2.3).

G. Limbus (border): Borders are mutually ridged or serrated.

4. **Age changes**

A. Ossification of sutural membrane starts at the age of 20 years and is slow.

B. Ossification completes at late twenties.

SN-11 Syndesmoses

(*Syn*—fusion, *desmos*—band)

Introduction: Bony surfaces are joined together by interosseous membrane or ligament.

1. **Characters**

A. It is a type of fibrous joint.

B. The bones are kept together at a distance by interosseous membrane.

C. The interosseous membrane persists throughout life.

2. **Movement:** Slight degree of movement is possible, e.g. IMP

Inferior tibiofibular joint,

Middle radioulnar joint, and

Posterior sacroiliac joint.

SN-12 Primary Cartilaginous Joint (Synchondrosis)

1. **Characters** (Fig. 2.9)
   A. The articulating surfaces are covered by a hyaline cartilage.
   B. They are immovable and strong.
   C. They are temporary in nature.
   D. Cartilaginous plate is replaced by bone synostosis.

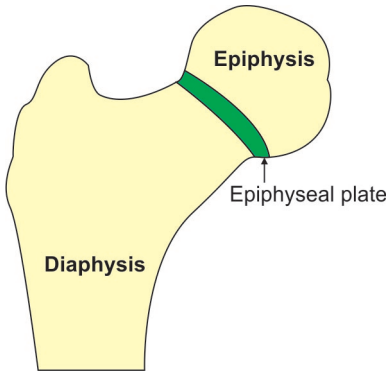


Fig. 2.9: Primary cartilaginous joint (synchondrosis)

2. **Example:** First, CDSS

   First chondrosternal joint
   Costochondral
   Diaphysis and epiphysis of long bone
   Spheno-occipital
   Sternoxiphisternal

SN-13 Secondary Cartilaginous Joint (Symphysis)

Introduction: The articulating surfaces of bones are covered by a hyaline cartilage. These hyaline cartilages are separated by a fibrocartilage (Fig. 2.10).

1. **Characters:** The thickness of fibrocartilage is directly related to range of movements.
2. **Functions** of secondary cartilaginous joints. They
   A. Act as shock absorber.
   B. Help in flexibility.
   C. Help in weight transmission.
3. **Site:** All midline joints of body except
   A. Symphysis menti (atypical and temporary joint).
   B. Joint between sternum and xiphoid.
4. **Fate:** Movements are limited.

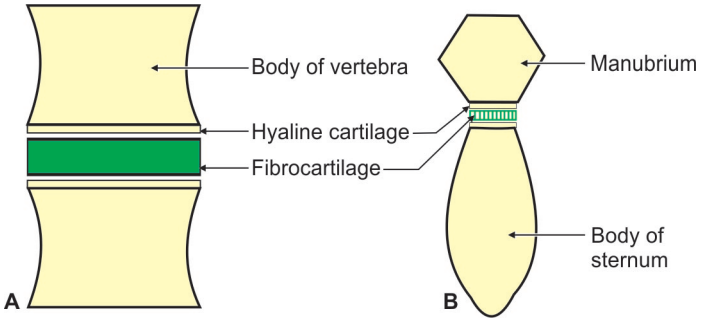


Fig. 2.10: Secondary cartilaginous joint

5. **Duration:** Persists throughout life.

6. **Example:** IMPS
   Intervertebral joint
   Manubriosternal
   Pubic symphysis
   Sacral joint

SN-14 Typical Synovial Joint

Introduction: The synovial joints have free movements. There is a cavity between the articulating bones. Hence, they are also called cavitatory joint.

1. **Characters:** Synovial joints are characterized by following features (Fig. 2.11):
   A. Articular cartilage: Articular surfaces are covered by a layer of hyaline cartilage.

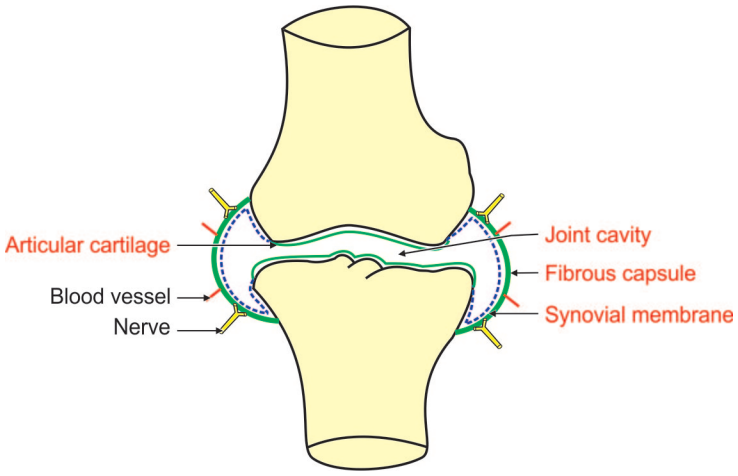


Fig. 2.11: Structure of a simple synovial joint

B. Fibrous capsule

a. It consists of longitudinal and interlacing bundles of white connective tissue fibres. It is attached to articulating ends of the bones and forms as a cuff. It encloses a joint cavity.

b. It is pierced by blood vessels and nerves.

c. It acts as watch dog, i.e. it prevents the excessive movements and protects the joint from dislocation.

d. It has rich nerve supply, hence it is highly sensitive.

C. Ligaments: It is strengthened by

a. Accessory ligaments, and

b. Muscles surrounding the joint.

D. Synovial membrane

a. Characters

I. It lines the inner surface of fibrous capsule.

II. It is deficient at articular surfaces.

III. It secretes hyaluronic acid which is responsible for viscosity of the synovial fluid.

IV. The viscosity of the fluid varies with the movements.

V. The quantity of the fluid also varies. The knee which is the largest joint contains 0.5 ml.

b. Functions of synovial fluid

I. Lubrication, and

II. Nutrition.

E. Joint cavity: All synovial joints are enclosed in a joint cavity.

F. Movements: The joint is capable of varying degrees of movements.

2. **Functions:** Varying degrees of movements.

3. **Applied anatomy**

- Tuberculosis and gonococcal infection affects synovial joint.
- More than one joint may have same nerve supply, e.g. hip and knee joints supplied by obturator nerve. Hence, diseases of one joint may cause referred pain to other joint.

SN-15 Classification of Synovial Joint

Synovial joints are subclassified depending upon axis, number of bones, presence of cartilage and the shape of articulating surfaces **ABCS**

1. Axis

A. Plane joints: No axis.

B. Uniaxial: Movements in only one axis. It is subclassified depending upon the direction of axis.

a. *Hinge* variety, if the direction of axis is horizontal.
For example
I. Elbow joint
II. Knee joint
III. Ankle joint

b. *Pivot* variety, if the direction of axis is vertical.
For example
I. Superior and inferior radioulnar joints
II. Atlantoaxial joint.

2. Number of bones

A. *Simple*, if the number of articulating bones is two.
For example
a. Shoulder joint
b. Hip joint.

B. *Compound*, if the number of articulating bones is more than two.
For example
a. Wrist joint
b. Knee joint.

3. Presence of cartilage: Complex joint, when joint cavity is divided by an intra-articular disc into upper/lower, medial/lateral compartment it is called complex joint, e.g.
A. Temporomandibular joint,
B. Acromioclavicular joint, and
C. Sternoclavicular joint.

4. Shape of the articulating bones

A. *Ball-and-socket* or spheroidal joints  : The articular surface of one bone is spherical and it fits into socket of corresponding bone. Examples are:
a. Shoulder joint,
b. Hip joint,
c. Talonavicular joint, and
d. Incudostapedial joint

B. Sellar or saddle joints  **:** The articular surface of one bone is convex and concave and reciprocating surface is concave convex. Examples can be recollected by funny Hindi sentence which is followed by body gesture. The sentence is *Mera dimag ghutane me nahi hai* (esjk fnekx ?kqVus esa ugh gSA) meaning "My mind is not Kneeling". The words of the sentence represent as:
Mera represents "sternoclavicular joint".
Dimag represents "temporomandibular joint and incudomalleolar joint".
Ghutane me represents "patelofemoral joint".

Nahi represents "calcaneocuboid joint".

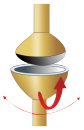
Hai represents "joint of the thumb"

C. Condylar or bicondylar joints  :

Examples are:

a. Knee joint, and

b. Temporomandibular joint.

D. Ellipsoid joint 

a. Atlanto-occipital joint,

b. Wrist joint, and

c. Metacarpophalangeal joint.

SN-16 Pivot Joint

(*Pivot*—a pin on which anything turns) 

Introduction: It is a uniaxial (transverse axis) synovial joint (Table 2.1).

Table 2.1: Comparison of superior radioulnar joint with median atlantoaxial joint

Joint	Superior radioulnar joint	Median atlantoaxial joint
• Bones	• Radius and ulna	• Atlas and axis vertebrae
• Articulating surfaces	• Head of radius and radial notch on ulna	• Posterior surface of body of atlas and anterior surface of odontoid process of axis
• Axis (vertical)	• Radius	• Odontoid process of axis vertebra
• Formation of ring	• Annular ligament	• Posterior arch of atlas
• Structure of ring	• Bone and fibrous tissue	• Bone
• Mechanism during movement • Ring • Axis • Movements	• Fixed • Moving • Supination, pronation	• Moving • Fixed • Side-to-side movement (no movement)
• Range of movements	• More	• Less
• Applied anatomy	• In children, subluxation of superior radioulnar joint is common	• Death in hanging is due to rupture of transverse ligament of atlantoaxial joint

CHAPTER

3

Muscles

OLA-1 What is a sarcomere?

1. Features
   A. A sarcomere is segment of the fibre between *successive Z bands*.
   B. It is the smallest structural and functional contractile unit of the muscle.
   C. Repeating contractile units are seen along the entire length of each myofibril.
   D. Highly characteristic features of the sarcoplasm of skeletal and cardiac muscle fibres. It is 2.5μ long.
   E. It contains
      a. "A" band, and
      b. 1/2 of "I" band.
   F. *Myofibril* is the finer structural and functional unit of the sarcomere.
2. The *sarcomere has a central dark and peripheral light* band.
3. The dark staining band contains thick myosin filaments.
4. The light staining band contains thin actin filaments.
5. Actin and myosin filaments are precisely aligned.
6. They are stabilised within individual myofibrils. The sarcomeres are stabilised by accessory proteins.
7. The thin actin filaments are bound to the protein called α-actinin. This binds them to the dense Z line (band).
8. The thick myosin filaments are anchored to the Z line by the very *large* protein called *titin*. Titin keeps myosin filament in the centre of the Z line. It acts like a spring between the end of the myosin filament and the Z line.

SAQ-6 Pennate Muscles

1. Unipennate (Fig. 3.1A): The fleshy fibres have a linear or narrow origin. The appearance is that of 1/2 of a feather;

A. Examples

a. Extensors

I. Extensor digitorum longus

II. Peroneus tertius

b. Flexor: Flexor pollicis longus

c. Adductor: Palmar interossei

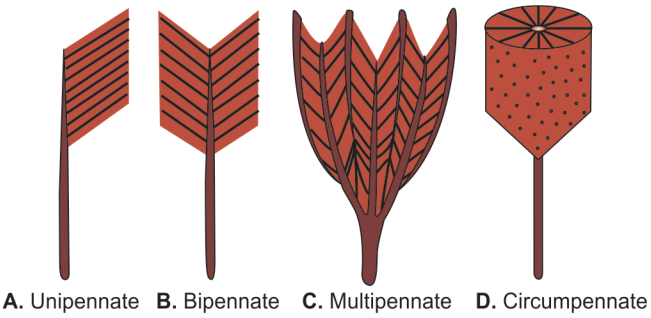


Fig. 3.1A to D: Pennate muscles

2. **Bipennate (Fig. 3.1B):** The fleshy fibres arise from a long broad surface, e.g.
   A. Muscle of thigh: Rectus femoris
   B. Muscles of sole:
      a. Flexor hallucis longus,
      b. Dorsal interossei, and
      c. Peroneus longus (Fig. 3.1E and F)
3. **Multipennate (Fig. 3.1C):** The septa extend into the origin and insertion. It gives the appearance is that of many feathers, e.g.
   A. Subscapularis
   B. Deltoid (acromial fibres)
4. **Circumpennate (Fig. 3.1D)**, e.g. tibialis anterior

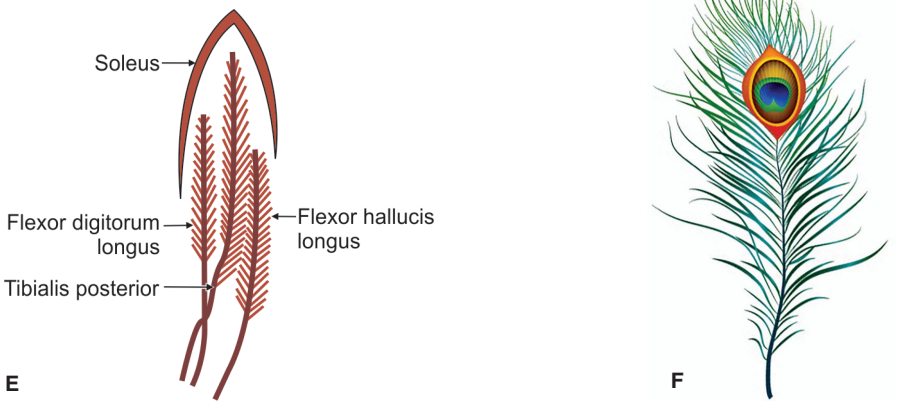


Fig. 3.1E and F: (E) Three bipennate muscles resembling three plumes; (F) Peacock plume

SN-17 Prime Movers (Agonists)

Introduction: The muscles which initiate and carry out the desired action by active contractions (shortening) are called prime movers, e.g. in the flexion of elbow joint, the biceps muscle is prime mover.

1. A muscle may perform all the 4 roles under different situations. Flexor carpi ulnaris is a prime mover in flexion at the wrist and an antagonist in extension. It acts as a fixator in flexion of the thumb and is a synergist in extension of the thumb.
2. **Contraction of muscle** may be isotonic or isometric (Table 3.1).

Table 3.1: Types of contraction of the muscle

Type of contraction	Tone	Length	Movement
Isotonic	Equal	Changes	Yes
Isometric	Changes	Equal	No

3. **Isotonic** (*iso*—equal, *tonic*—tone)**:** During contraction, the length of the muscle decreases to 1/3rd and the tone of the muscle remains unchanged. It is associated with the movement, e.g. in flexion of the elbow joint, length of biceps is decreased but the tone remains unchanged.
4. **Isometric** (*iso*—equal, *metric*—measurement)**:** During contraction, the length of muscle fibre remains unchanged but the tone of the muscles changed, e.g. after semiflexion of the elbow joint against resistance, the length is not decreased but tone is changed.
5. **Following are the forces opposing the action of the muscle**
   A. **Antagonist**
   B. **Gravity:** It is a valuable aid to some movements, depending upon the position of the limb of the body, e.g. on raising the arm from the side, the deltoid is a prime mover at the shoulder and the gravity (certainly if there is a weight in the hand) is sufficient to lower the arm.
   C. Connective tissue resistance.
   D. Active resistance.
6. **The range and force of movement is directly proportional to**
   A. Length of the fibres, and
   B. Number of the fibres.
7. **Law of Sherrington:** When the agonists or prime movers are active, antagonists are inhibited by reciprocal innervation. When a muscle receives a nerve impulse to contract, its antagonist muscle receives simultaneously an impulse to relax. Flexion of wrist joint is opposed by the extensor.
8. **Action of paradox:** When a prime mover helps opposite action by active controlled lengthening against gravity, it is known as action of paradox, e.g. putting a glass on a table is assisted by gravity but controlled by gradual, active lengthening of biceps.

SN-18 Antagonists

Introduction: They oppose the prime movers. They help the prime movers by active controlled fractional relaxation, so that the desired movement is smooth and precise.

Thus, the antagonists cooperate rather than oppose the prime movers. This is due to reciprocal innervation of the opposite groups of muscles, regulated by the spinal cord through stretch reflex. Antagonist muscles pass over the opposite side of the axis of rotation.

Flexion of wrist joint is done by flexor carpi radialis and ulnaris, which is opposed by extensor carpi radialis longus, brevis and extensor carpi ulnaris.

- Flexion of digit is done by efficient extension of wrist joint. This is done by flexor digitorum superficialis and profundus helped by extensor digitorum, which is antagonist.

Box 3.1

Note: In addition to the above description, please add points 2, 3, 4, 5 and 6 of prime movers.

SN-19 Fixators

Introduction: The accessory muscles which steady the proximal joint to bring the desired action on the joint under consideration.

In flexion of wrist joint, the rotator cuff (subscapularis, infraspinatus and teres minor) fix the shoulder joint, to have the smooth movement at wrist joint.

Box 3.2

Note: In addition to the above description, please add points 2, 3, 4, 5 and 6 of prime movers.

SN-20 Synergists

Introduction: Muscles that assist prime movers are called synergists. When a prime mover passes over more than 1 joint, certain muscles are required to steady the unstable joint such muscles are called synergists. Muscles cross the same site of axis of rotation.

1. During flexion of elbow, biceps muscle brings flexion of elbow assisted by brachialis which is synergist.
2. Flexion of digit is efficiently done by efficient extension of wrist joint. This is done by flexor digitorum superficialis and profundus helped by extensor digitorum which is antagonist.
3. In most instances, motion at a joint is initiated by one set of synergistic muscles and brought to close by the antagonists. For example, controlled flexion of the forearm at the elbow joint is initiated by flexor muscles and slowed or stopped at any desired position by extensor muscles.
4. Simultaneous contraction of both synergists and antagonists produces maximal joint stability (dynamic stability) with a little or no movement.

Box 3.3

Note: In addition to the above description, please add points 2, 3, 4, 5 and 6 of prime movers.

CHAPTER

4

Cardiovascular System

OLA-2 Enumerate 4 arteries commonly used for palpating peripheral pulsations

1. Upper limb—radial artery
2. Lower limb
   A. Femoral artery
   B. Dorsalis pedis artery
3. Head, neck and face—superficial temporal artery

SN-21 Anastomosis

Introduction: It is a precapillary or/and postcapillary communication of vessels. The blood passing through these communications is called collateral circulation.

1. Types: *The anastomosis may be of following types*

A. Arterial anastomosis: Anastomosis between the two arteries or branches of the two arteries. It is further divided into

a. Actual arterial anastomosis: The main arteries communicate with each other. In this, the blood spurts through the cut ends on both the sides, e.g.

I. Circle of Willis
II. Palmar arches
III. Labial artery (branch of facial artery).

b. Potential arterial anastomosis: Communication takes place between the terminal arterioles. Such communication is gradually through collateral circulation. Blockage of main artery may fail to compensate the blood, e.g.

I. Coronary arteries
II. Cortical branch of cerebral arteries.

B. Venous anastomosis: It is the communication between veins or tributaries of veins, e.g. dorsal venous arch of foot and hand.

C. Arteriovenous anastomosis (shunt): It is the communication between an artery and vein. When an organ is active these shunts are closed, and the blood circulates through capillaries. It is divided into simple shunts, e.g. skin of nose, lips and external ear.

D. Specialized, e.g. Skin of digital pads and nail beds. These form a number of small units called glomeruli.

E. Preferential through channels**:** The blood passes through the capillary network and they form microcirculatory units.

2. Functions: The nutrition of the organ is maintained, in case of blockage of the artery.

SN-22 End Arteries

Introduction: The arteries which do not communicate with neighbouring arteries are called end arteries.

1. Types: They are of following types

A. **Functional** end arteries.

a. These are not true end arteries.

b. Structurally, they communicate,

c. But the blood flowing through these communication channels fail to meet the required demand, e.g. coronary arteries.

B. **Structural** end arteries

a. There is no structural communication between these arteries.

b. These are true end arteries, e.g. (Fig. 4.1)

I. Central artery of retina,

II. Central arteries of the cerebrum,

III. Renal arteries, and

IV. Arteries of spleen.

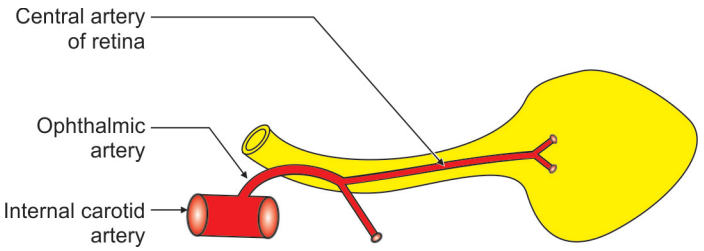


Fig. 4.1: End artery

2. Applied anatomy

- Occlusion of an end artery causes serious nutritional disturbances resulting in death of tissue supplied by it, e.g. in case of blockage of right coronary artery, the muscles of the heart undergo ischaemia and results into myocardial infarction.
- In case of rupture of central artery of retina, the blood supply of eyeball is lost and person becomes blind.

SN-23 Bursa

(*Bursa*—purse)

Introduction: It is a pocket-like space lined by synovial membrane containing synovial fluid.

1. Types

A. **Communicating:** Some bursae communicate with joint cavity, e.g. subscapular bursa of shoulder joint.
B. **Non-communicating:** For example, infrapatellar bursa of knee joint.

2. Functions

A. It reduces the friction between two mobile and tightly opposed surfaces.
B. It permits complete freedom of movement within limited range.

3. Classification: It is classified depending upon the situation

A. Subcutaneous: Deep to the skin.
B. Subtendinous: Deep to the tendon, e.g. subscapular bursa: It communicates with the shoulder joint. It lies deep to scapula and present between superior and inferior glenohumeral ligaments.
C. Submuscular: Deep to the muscle, e.g. semimembranosus bursa: Deep to semimembranosus muscle.
D. Subfascial: Deep to the fascia.

4. Applied anatomy

- **Bursitis:** Inflammation of bursa is called bursitis, e.g. olecranon bursitis (miner's elbow, student's elbow): Inflammation and enlargement of the bursa over the olecranon process of ulna. This bursa lies between olecranon process and the overlying skin.
- **Clergyman's knee:** It is present below patella and is superficially placed. The person gets pain in movement of knee joint.
- **Morrant Baker's cyst:** The swelling behind the knee is caused by escape of synovial fluid which lies in space or membrane. It is prominent during extension and disappears during flexion. It is associated with the tendons of semimembranosus or gastrocnemius.
- **Housemaid's knee:** The bursa between the skin and anterior surface of patella is called prepatellar bursa and it is inflamed in housemaid.
- **Weaver's bottom:** The bursa over ischial tuberosity is inflamed in weavers.