CHAPTER - 00
LOCOMOTION AND MOVEMENT

- Movement is the change in position of a body part or an organ. It is the significant feature of all living beings.
- Study of movement is called **KINESIOLOGY**
- Examples of movements $\rightarrow$ streaming of protoplasm in Amoeba, movement of cilia, flagella and tentacles by many organisms, movement of limbs, jaws, eyelids, tongue etc.
- **Locomotion** : It is the change of place or location by an organism. Eg. Walking, running, climbing, flying, swimming, creeping etc.
- Locomotory structures need not be different from those affecting other types of movements.

For eg:- 1. In paramoecium, cilia helps in the movement of food through cytopharynx and in locomotion as well.

2. Hydra can use its tentacles for food capture and locomotion

3. Humans use their limbs for changes in body postures and locomotion as well

- All locomotions are movements but all movements are not locomotions
- Methods of locomotion performed by animals vary with their habitats and the demand of situation.

TYPES OF MOVEMENT

- Cells in human body exhibit 3 main types of movements - Amoeboid, ciliary and muscular
- Based on the presence or absence of muscles in body movements are classified into two types.

A) NON-MUSCULAR MOVEMENT **B) MUSCULAR MOVEMENT**

1) AMOEBOID MOVEMENT

- Here movement achieved by the streaming mechanism of protoplasm, it results the formation of finger like pseudopodia.

  Eg. Amoeba, Entamoeba, cells in our body like macrophages and leucocytes, such as Monocytes, Neutrophils and cytoskeletal elements like microfilaments.

2) CILIARY MOVEMENT

- Movement achieved by the lashing mechanism of hair like cilia
- It helps for the conduction of particles at a specific direction.

Eg. Paramoecium, Vorticella, Ciliated epithelium lines the trachea, bronchi, fallopian tubes, vasa efferentia etc.

3) FLAGELLAR MOVEMENT

- Movement achieved by the help of an enlarged cilia called flagellum or flagella.

Eg. Euglena, Trypanosoma, Leischmania, Spermatozoa, Collar cells or choanocytes in sponges.

MUSCULAR MOVEMENT

- Movement achieved by the contractile and relaxile mechanism of muscles.
- In human body locomotion is achieved by the co-ordinated activity of muscular, skeletal and neural systems.

MUSCULAR SYSTEM

- It is a mesodermally derived organ system formed with specialised tissues called muscles.
- Study of muscles are called **MYOLOGY** or **SARCOLOGY**
- About 40 - 50% of the body weight of human adult is contributed by muscles.
- Muscles show some properties such as ; **excitability, contractility, extensibility** and **elasticity**
- Muscles are the major effector organs of body, and it can pull but not push.

CLASSIFICATION OF MUSCLES

- Based on the location, appearance and nature of regulation of their activities, they classified into three types.

1. SKELETAL / STRIATED MUSCLES

- These are attached to the bones or skeletal elements
- Cylindrical in shape and striated
- Multinucleated or syncitial in nature
- Under the control of central nervous system, so these are voluntary muscles
- Easily fatigue
- Primarily involved in locomotory actions and changes of body posture

2. SMOOTH / VISCERAL / NON-STRIATED MUSCLE

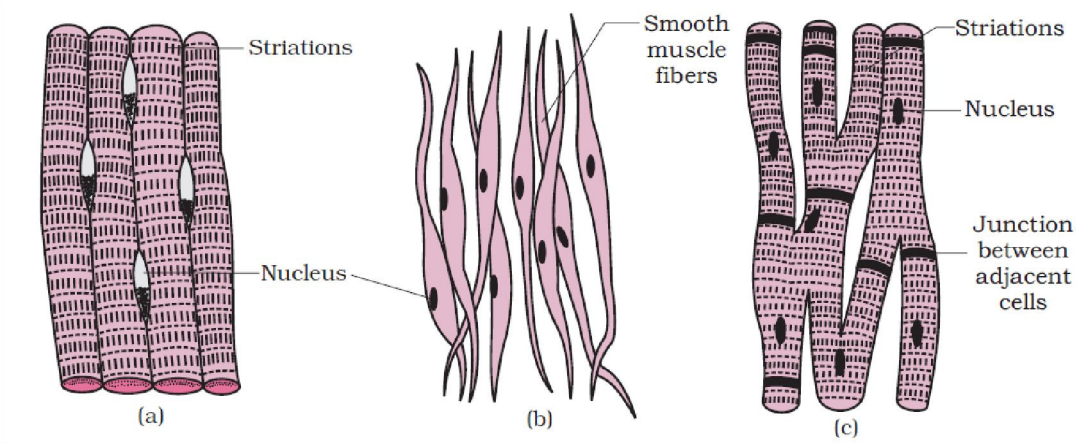
- These are located in the inner walls of hollow visceral organs like alimentary canal, reproductive tract, urinary tract, urinary bladder, blood vessels, iris etc.
- Spindle shaped fibres with fusiform ends.
- Striations are absent hence it is smooth muscles
- Uninucleated in nature
- Unbranched muscle fibres present
- Under the control of autonomic nervous system, so these are Involuntary muscles
- Non-fatigue muscles

- It helps for the transportation of food through digestive tract and gametes through genital tract

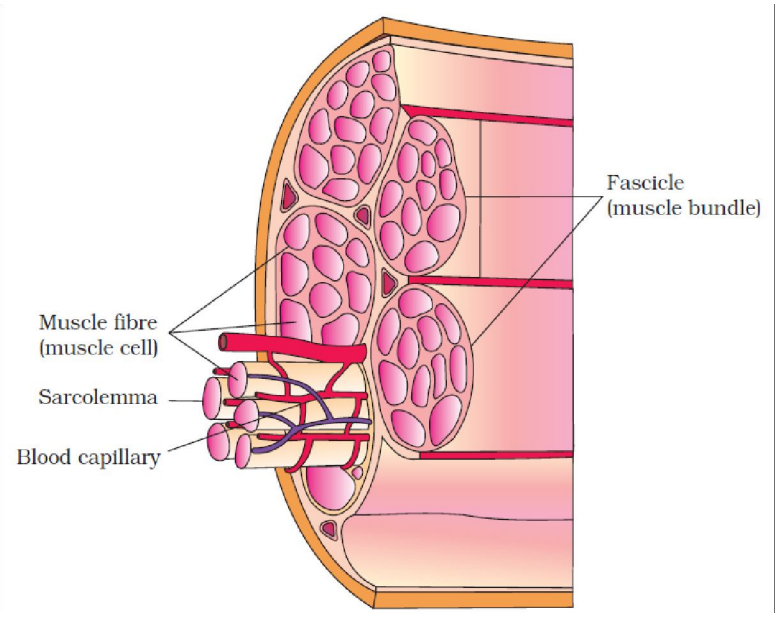
3. CARDIAC MUSCLES

- These are found in the walls of heart or myocardium.
- Cylindrical muscle fibres, but it is branched
- Uninucleated in nature
- Striations are present
- Under the control of ANS so these are involuntary muscles.
- Immune to fatigue
- Cell junctions are adhered with Z-like intercalated discs and they acts as impulse boosters

SKELETAL MUSCLE **SMOOTH MUSCLE** **CARDIAC MUSCLE**



SKELETAL MUSCLES

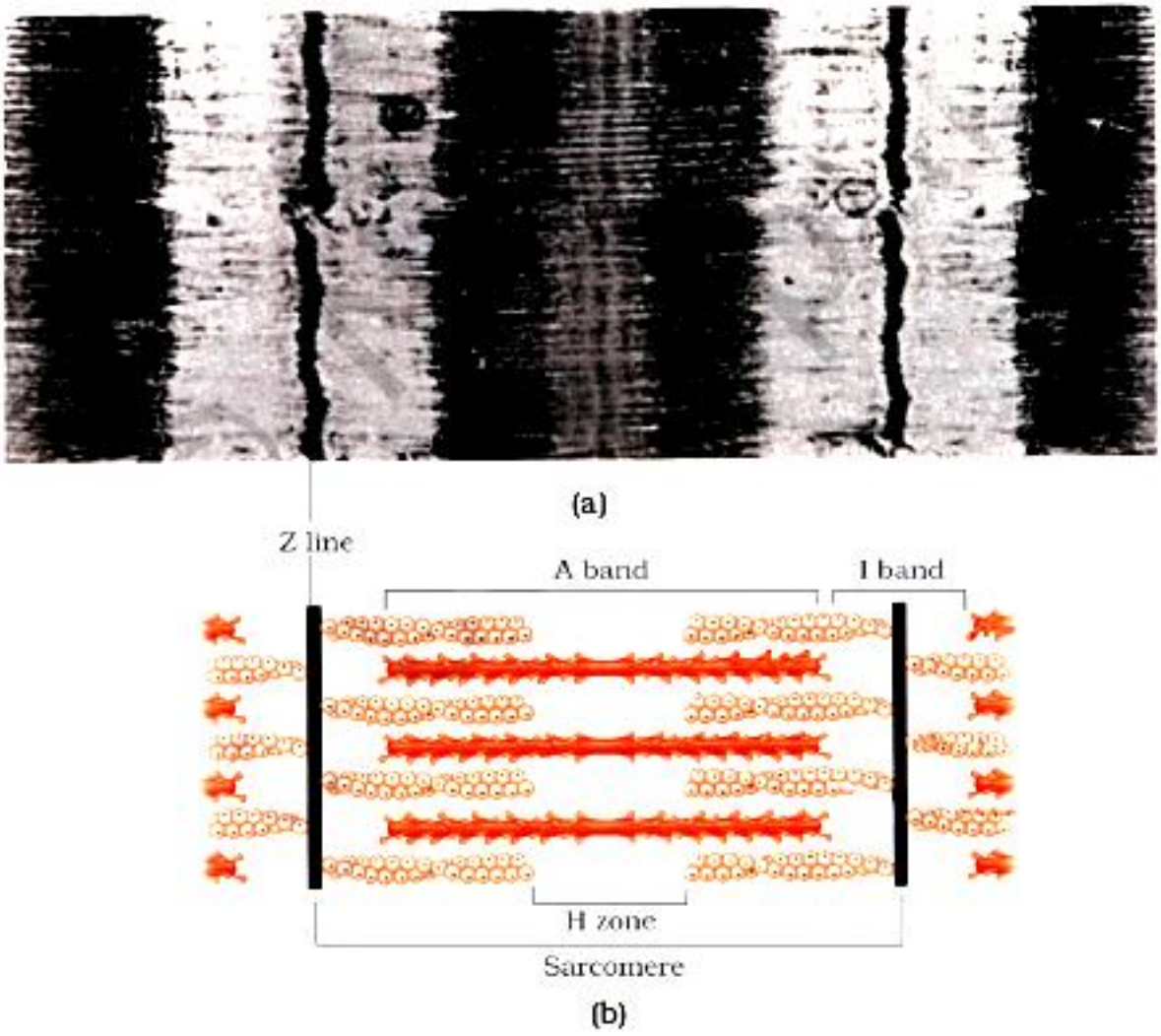


Diagrammatic cross sectional view of a muscle showing muscle bundles and muscle fibres

- These are the most abundant type of muscles in human body.
- It contributes 40% of the total body weight of a person.
- It attached on to the skeletal elements like bones through tendons.
- Skeletal muscles has a middle part called belly and two tapering ends
- Tendon attach one end of muscles to a fixed bone is "**Origin**" and the tendon attach other end of muscle to a movable bone is called "**Insertion**"
- Skeletal muscle are made up of numerous bundles of muscle fibres called "**Fascicles**" or "**muscle bundles**"
- A connective tissue layer covering each fascicle are called "**PERIMYCIUM**".
- While a connective tissue layer cover all the fascicles is called "**EPIMYCIUM**"
- All the fascicles are held together by a common collagenous connective tissue layer called "**FASCIA**". It is the outermost layer of muscle.
- Each fascicles contain a number of **muscle fibres**. These are the basic cell unit of muscle.
- Muscle fibres are otherwise called myocytes
- Each muscle fibre is externally covered with a connective tissue layer called "**ENDOMYCIUM**"
- Plasma membrane of muscle fibre is "**Sarcolemma**" while its cytoplasm called "**Sarcoplasm**" and mitochondria called "**Sarcosome**".
- Many elongated oval shaped nuclei are scattered on the periphery of its sarcoplasm, so it is multinucleated / syncitial in nature.
- Its endoplasmic reticulum called "**Sarcoplasmic reticulum**" (SR) with terminal projections called "**Terminal cisternae**" or "**Sarcoplasmic cisternae**".
- SR is responsible for the storage and release of calcium ions, for beginning of muscle contraction.
- Along with mitochondria certain glycogen granules are also scattered in sarcoplasm, both of them provides energy to muscles.
- In most of the muscle fibres a red coloured oxygen storing pigment present called **myoglobin**.
- Sarcolemma of muscle fibres contain certain Acetyl choline receptors, if helps to receive impulses from motor neuron.
- Certain Transverse tubules (T-tubules) extends from sarcolemma to sarcoplasm. It conduct impulses to sarcoplasmic cisternae.
- One T-tubule with two sarcoplasmic cisternae together formed as a "**TRIAD SYSTEM**" (T-system)
- Each muscle fibre contains many, elongated, filamentous, unbranched and striated structures called "**MYOFIBRILS**".
- Each myofibril has alternate dark and light bands throughout its length, hence the myofibrils are striated in nature.
- It is due to the distribution of two parallely arranged contractile **myofilaments** or **proteins** throughout its length such as "**ACTIN**" and "**MYOSIN**".

- Both of these proteins arranged as rod-like structures, parallel to each other and also to the longitudinal axis of the myofibrils.
- Light band contain "**ACTIN**" and it is isotropic to polarised light, hence actin containing region is represented as "**I-band**".
- **Dark band contains "MYOSIN" filaments** and are called "**A-band**" because it is anisotropic to polarised light.
- Actin filaments are very thin, but myosin are very thick filaments
- A-band contain both Myosin and two halves of thin filaments / Actin filaments.
- In the centre of each 'I' band an elastic fibre present called "Z-line"/ "Zwischenschiebe line / Krause's membrane"
- It bisect each 'I' band into two equal halves.
- Bisected halves of thin filaments are firmly attached to the "Z-line".
- Thick filaments in the A-band are also held together in the middle by a thin fibrous membrane called "M-line".
- The 'A' and 'I' bands are arranged alternately throughout the length of myofibrils
- The portion of myofibril between two successive Z-lines are called "SARCOMERE"
- It is the basic functional unit of muscle for contraction
- In the resting state, the edges of thin filaments on either side of the thick filaments partially overlap the free ends of thick filaments, living the central part of the thick filament.
- This central part of thick filaments not overlapped by thin filaments is called "H-zone" or "Hensen's zone".
- During **muscle contraction length of sarcomere decreases, H-zone disappears and the width of I-band reduces.**
- M - line is in the middle of H-zone
- In a cross sectional view, on each sides of Myosin, that surrounded by six actin filaments.

Diagrammatic representation of anatomy of muscle fibre showing a saromere



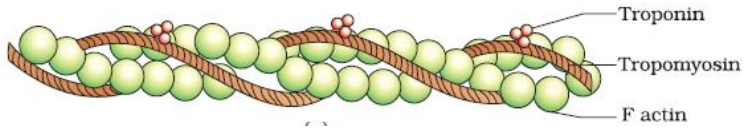
STRUCTURE OF CONTRACTILE PROTEINS (MYOFILAMENTS)

STRUCTURE OF ACTIN

- Actin is a secondary myofilament present in I-band and A-band
- Each "ACTIN" is formed with two fibrous filamentous proteins such as F-actins.
- Two F-actins are helically wound to each other.
- **Each F-actin is a polymer of monomeric 'G' (Globular) actins**
- Each G-actin has an active site for binds with myosin head, called **Myosin binding sites.**
- Another two complex filamentous proteins called "**TROPOMYOSINS**" also runs close to the F-actins throughout its length.
- A complex regulatory protein called "**TROPONIN**" is distributed at regular intervals on the tropomyosin
- Each troponin is formed with three peptide units such as **Troponin-I, Troponin-T** and **Troponin-C** (Troponin complex)

- During resting state a subunit of troponin (Troponin-I) masks the myosin binding sites of actin.
- At the same time Tropomyosin also masks the myosin binding sites of Actin.
- Troponin-T always attached on to tropomyosin as well as to the other troponin components.
- Troponin-C binds with calcium ions at the beginning of muscle contraction.

a) Structure of an Actin filament



STRUCTURE OF MYOSIN

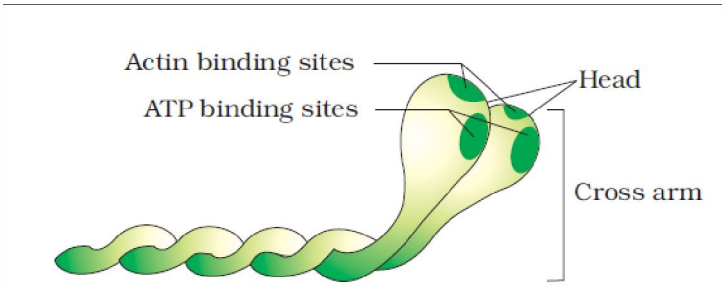
- Myosins are primary myofilaments present only in A-band and it is very thick.
- It is a polymeric protein formed with many monomeric proteins called "MEROMYOSINS" (Myosin molecule)
- Many meromyosins together constitute one myosin or thick filament.
- Each meromyosin has two parts

  1. A globular head with short arm

  2. Elongated tail
- Head and short arm are made up of **Heavy meromyosin (HMM)** and the tail is made up of **Light Meromyosin (LMM)**
- Head and short arm projects outwards at regular distance and angle from each other, from the surface of polymerised myosin to form as "**Cross arm**"
- Globular head contains an "ACTIN BINDING SITE" and "ATP - BINDING SITE"
- The globular head is an active ATPase enzyme.
- It hydrolyse ATP with the presence of Mg^{++} ions and release energy, ADP and inorganic phosphate.

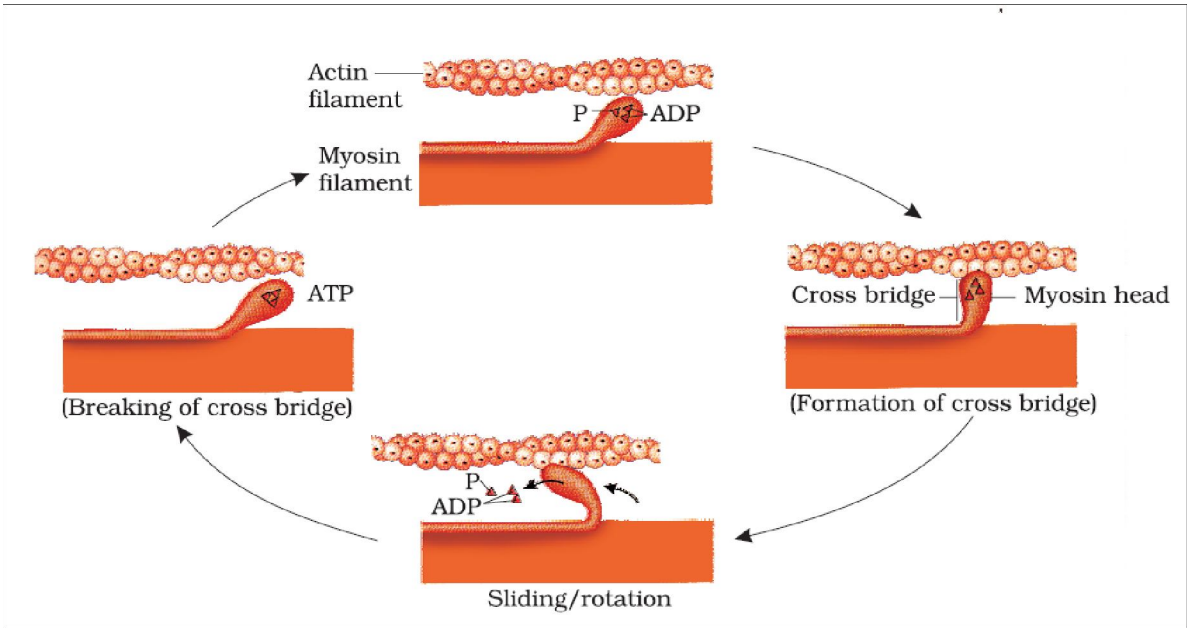
$$ATP \xrightarrow[Ca^{++},\, Mg^{++}]{ATP-ase} ADP + Pi + Energy$$

b) Myosin monomer (Meromyosin)

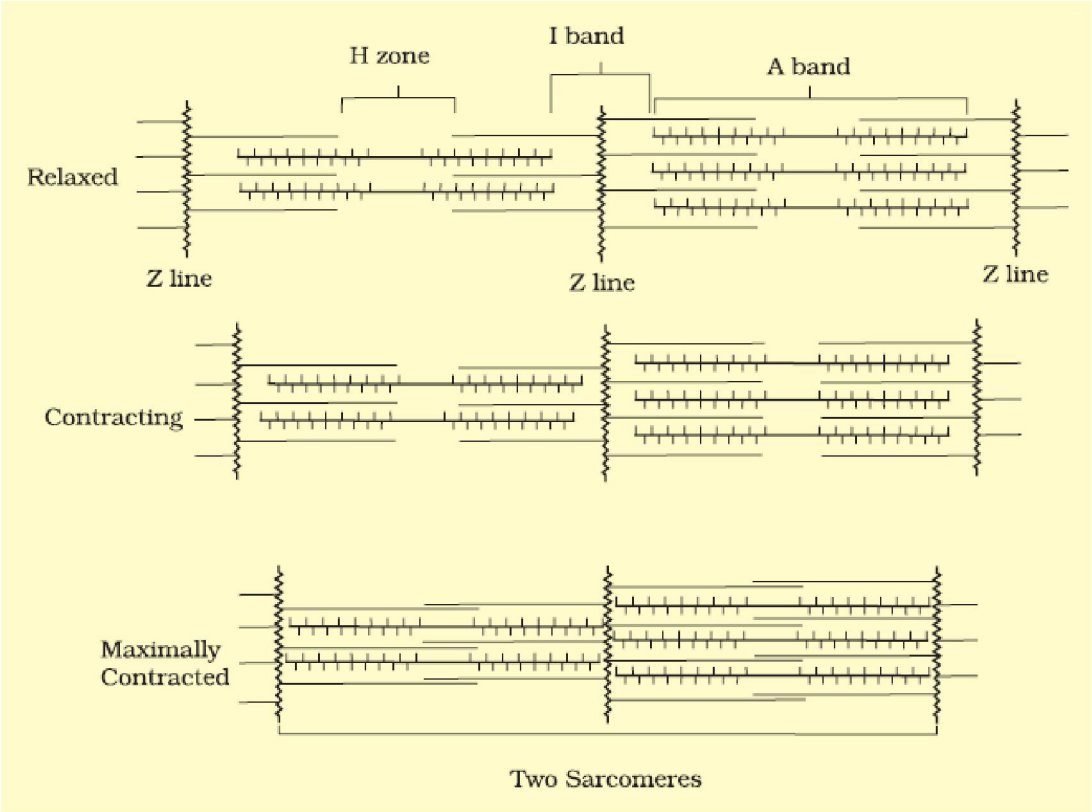


MECHANISM OF MUSCLE CONTRACTION

- It is explained through **Sliding - Filament theory** proposed by A.F. Huxley and H.E. Huxley in 1954
- According to this during muscle contraction, partially overlapped actin filaments are slide over to the surface of myosin and gets inserted into the middle of "A-band"
- At the beginning of contraction a signal sent by the CNS via a motor neuron
- A motor neuron along with the muscle fibres connected to it constitute a **motor unit.**
- At this motor unit area synaptic knob has a close contact with sarcolemma of muscle fibre to form as a **neuromuscular junction or motor end plate.**
- When the neural signals reaches motor end plate then a neurotransmitter called Acetyl choline releases which generate an action potential / depolarisation in the sarcolemma
- Signals passes through the T-tubules into the sarcoplasm to reach the part called **Triad**.
- From Triad, action potential spreads into SR and cause release of Ca^{+} ions
- Increase in Ca^{++} level leads to the binding of calcium with a subunit of troponin on actin filament
- Now troponin displaces tropomyosin and mask like Troponin-I laterally to expose the active sites of F-actin.
- Utilising the energy from ATP hydrolysis, the myosin head now binds to the exposed myosin binding site on actin to form as a **Cross bridge** or **Actomyosin complex**.
- Rotation or tilting of cross bridges causes sliding of thin filaments towards the centre of A-band
- The Z-lines attached to these actins are also pulled inwards thereby causing a shortening of the sarcomere. ie, contraction.
- During contraction, the width of 'I' bands gets reduces, whereas "A-band" retains the same length.
- The myosin releasing the ADP and Pi goes back to its relaxed state. A new ATP binds and the cross-bridge is broken.
- The ATP is again hydrolysed by the myosin head and the cycle of cross bridge formation and breakage is repeated causing further sliding.
- In complete contraction I bands reduces its width, H-zone disappears, Z-lines come to lie on either side of A-band but length of thin and thick filaments does not changes.
- The process continues till the Ca^{++} ions are pumped back to the sarcoplasmic cisternae, resulting in the masking of actin filaments
- This causes return of Z-lines back to their original position ie, relaxation.



Steps in cross bridge formation, rotation of head and breaking of cross bridge



Sliding filament theory of muscle contraction

[Movement of thin filaments and the relative size of the I band and H-zones]

Biochemical events in Muscle Contraction

- The immediate energy for muscle contraction is derived from the break down of ATP in the presence of ATPase and Mg^{++} ions.
- When ATP is not available in sufficient quantity, creatine phosphate (Phosphocreatine) is used to produce ATP.
- But when creatine phosphate of muscle is also depleted, muscle glycogen is used. Muscle glycogen is then converted to glucose and oxidised to provide energy.
- Anaerobic breakdown of glucose produces lactic acid accumulation, it leads to muscle fatigue
- Conversion of lactic acid into glucose or glycogen by liver is called **Cori's cycle** or **Lactic acid cycle**

DIFFERENCE BETWEEN RED AND WHITE MUSCLES

RED MUSCLE	WHITE MUSCLE
1) Abundant myoglobin, which gives red colour	1) Myoglobin absent or present in very little quantity
2) Storage of O_2 is very high for ATP production	2) Storage of O_2 is very low
3) Plenty of mitochondria and very few SR	3) Mitochondria are very few, but SR is very high
4) It shows aerobic breakdown of energy production	4) Anaerobic breakdown to produce energy and lactic acid is accumulated
5) Slowly fatigue	5) Easily fatigue
6) Slow and sustained contraction for a long time	6) Fast contraction but only for a short time
7) Slow and aerobic muscles	7) Fast and anaerobic muscles
8) Numerous blood capillaries lining it. Eg. Flight muscles in kite	8) A few blood capillaries lining it. Eg. Flight muscles in sparrow

SKELETAL SYSTEM

- It is a mesodermally derived organ system composed with **Bones** and **Cartilages**
- Bones and cartilages are specialised skeletal connective tissues
- Bone matrix is very hard due to c**alcium salts** and collagen fibres, but matrix of cartilage is slightly pliable due to **chondroitin salts**
- Human endoskeleton is composed with **206** number of bones
- Based on the distribution of bones in body, endoskeleton is divided into two

A) Axial Skeleton [80] **B) Appendicular Skeleton [126]**

A) AXIAL SKELETON [80]

- Here bones are distributed on to the central or median axis of body
- Axial skeleton constitutes,

1) Skull (29) 2) Vertebral column (26) 3) Ear ossicles (6) 4) Hyoid bone (1)

1. SKULL (29)

- Skull is mainly formed with 22 bones, such as 8 cranial bones and 14 facial bones.
- 8 cranial bones are tightly joints with each other to form a Brain box / Cranial cavity
- It provide protection to the brain
- Cranial bones are classified into 6 different types

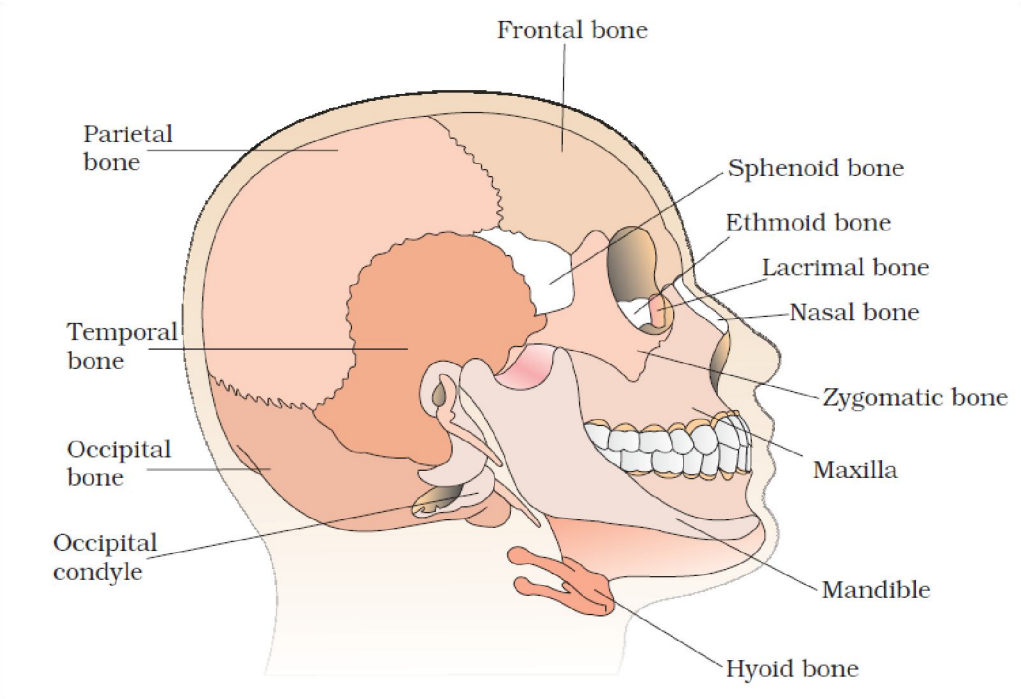
1) 1 FRONTAL
2) 2 PARIETALS
3) 1 OCCIPITAL
4) 2 TEMPORALS
5) 1 SPHENOID
6) 1 ETHMOID

→ CRANIAL FORMULA

- **Parietals** and **Temporals** are paired cranial bones.
- **Sphenoid** bone has a small depression called **sella turcica**. Pituitary gland located in it.
- Two small protruberances or articulating facets present in occipital bone is called **occipital condyles**.
- So human skull is **Dicondylic** in nature
- Through these occipital condyles skull region articulates with the superior region of vertebral column
- Occipital bone has a narrow passage called **Foramen magnum**, by which medulla oblongata passes through it and connected to the spinal cord.
- Facial bones are 14 in number which form the front part of the skull
- Facial bones are classified into 8 different types

1) 2 LACRYMALS
2) 2 NASALS
3) 2 INFERIOR NASALIS
4) 2 ZYGOMATIC BONES (cheek bones)
5) 1 VOMER BONE
6) 2 MAXILLAE (Upper jaw bones)
7) 2 PALATINE BONES
8) 1 MANDIBLE (Lower jaw bone)

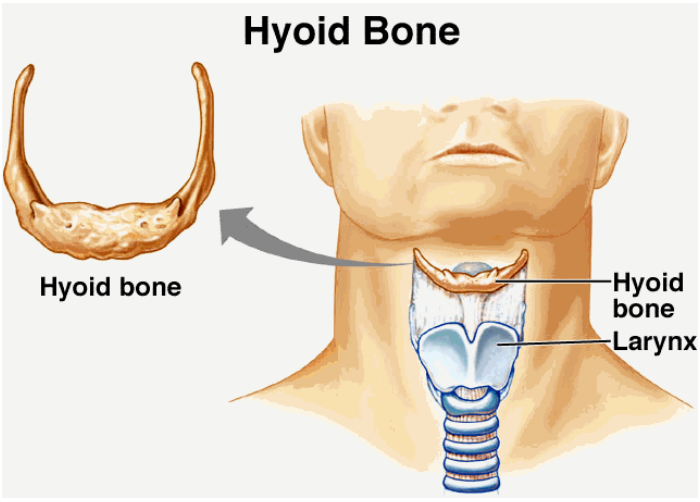
- **Mandible** is the only movable bone in skull



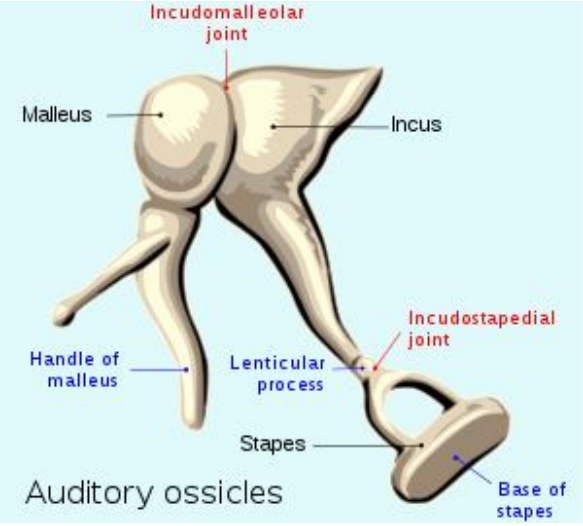
Diagrammatic view of human skull

HYOID BONE : It is a single 'U' shaped bone located at base of buccal cavity.

- It provides support to the throat and tongue, hence it named as "Tongue bone"
- Hyoid is the only skull bone does not have an articulation with any other skull bone.



2. EAR OSSICLES (6)



- These are 3 small / tiny bones present in each middle ear.
- It transmit sound vibrations from external ear to inner ear
- 3 ear ossicles are ;
  1. Malleus (Hammer shaped)
  2. Incus (Anvil shaped)
  3. Stapes (Stirrup shaped)
- Stapes is the smallest bone in human body.

VERTEBRAL COLUMN [26]

- It is an elongated skeletal element extends from basal part of skull to pelvic girdle
- It constitute the main frame work of **trunk**
- V.C is formed by 26 serially arranged units called **vertebrae**
- In between each vertebrae fibrous cartilage and ligaments are present
- Between 2nd cervical vertebrae and sacrum an **intervertebral disc** (Fibrous cartilage) is present, that acts as a shock absorber.
- Human vertebra is **Amphiplatyan / Acoelous** in nature
- A central **neural canal** present in each vertebra through which spinal cord passes
- First vertebra is **Atlas**, it articulates with the occipital condyles and allow movement only in one plane.

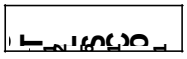
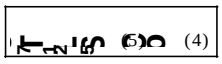
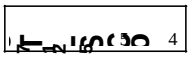
- Second vertebra is Axis, and it has a small peg / spine like projection called **odontoid process**.
- Odontoid process of axis articulated into the odontoid fossa (cavity) of atlas and allows a partial rotatory movement.
- Vertebrae in vertebral column are differentiated into 5 different categories.

  1) 7 - CERVICAL VERTEBRAE (Dorsal to neck)

  2) 12 - THORACIC VERTEBRAE (Dorsal to thorax)

  3) 5 - LUMBAR VERTEBRAE (Dorsal to abdomen)

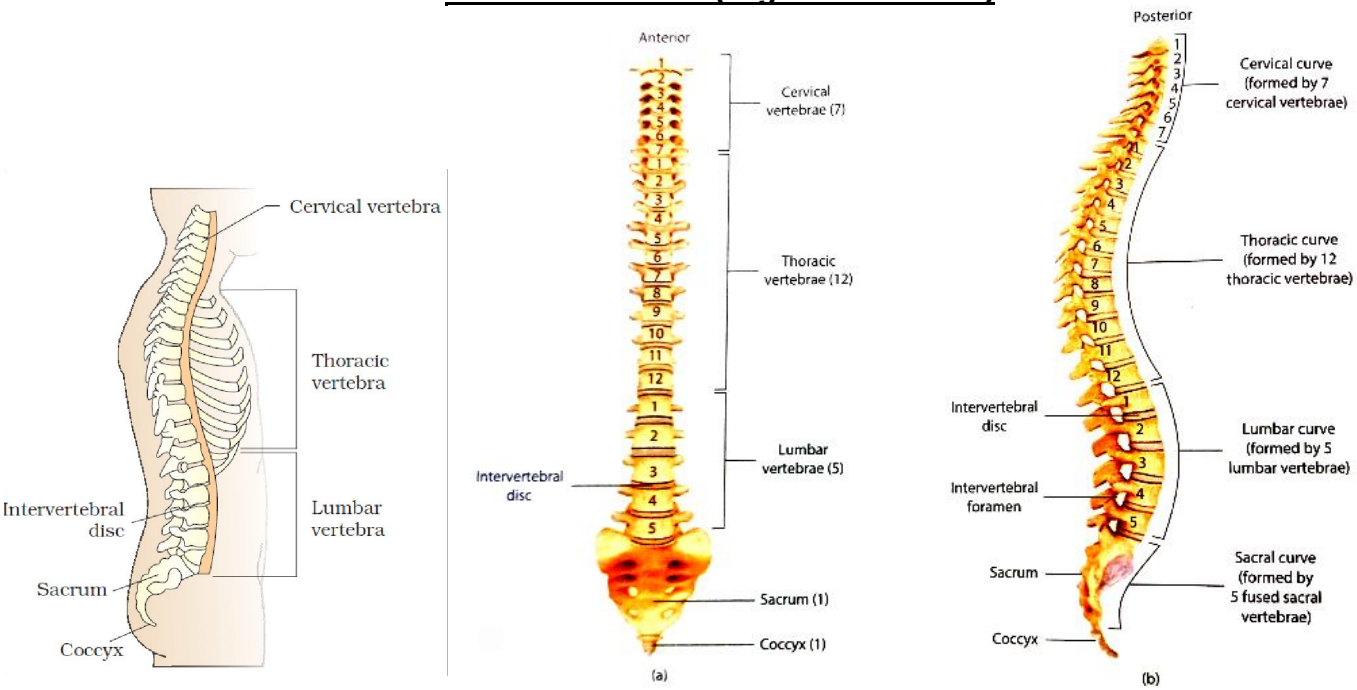
  4) 1 - SACRUM
  5) 1 - COCCYX
  → Fused Vertebra in V.C

- The number of cervical vertebra is 7 in almost all mammals
- 12 pairs of ribs arising from thoracic vertebrae
- Lumbar vertebra are more stronger and larger than others
- Adult vertebral formula is  or 
- Child vertebral formula is written as 
- Vertebral column protects the spinal cord, supports the head and serves as the point of attachment for the ribs and muscularature of the back.
- Vertebral column has 4 curves :

  1. Cervical curve 2. Thoracic curve
  3. Lumbar curve 4. Sacral curve

- These curves increase the strength of vertebral column, maintaining balance in the upright position, absorbing shocks during walking and protects the vertebrae from fracture.

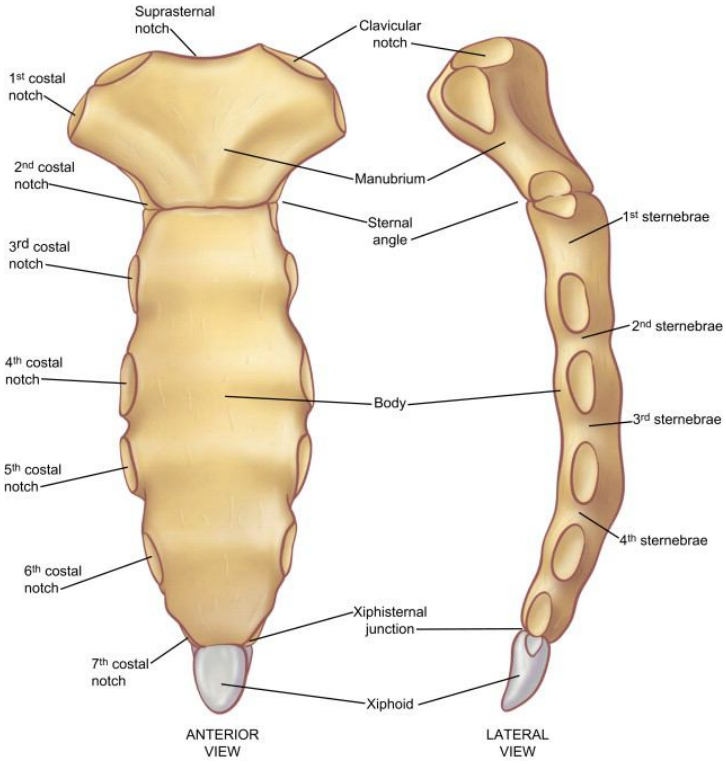
Vertebral Column (Rigid lateral view)



Vertebral column (a) Anterior view showing regions of the vertebral column and (b) Posterior view showing four normal curves.

STERNUM [1]

- It is a thin, flat, short and stout bone present at the mid ventral line of thorax.
- It commonly called as “Breast bone”.

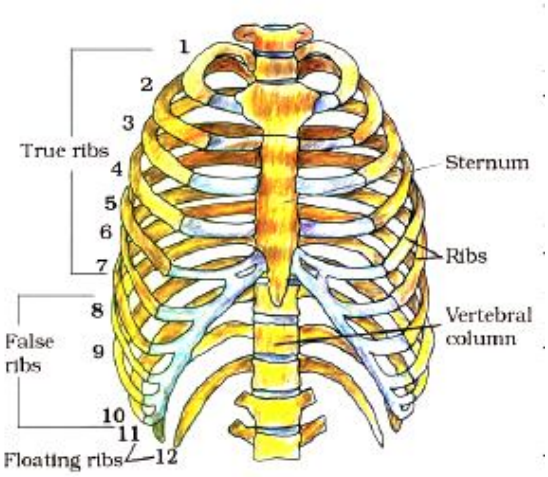


- Sternum has 3 different regions
  1) Manubrium
  2) Mesosternum
  3) Xiphisternum (xiphoid process)
- Clavicle bone and Ist pair of ribs attached to the manubrium.
- 2nd to 7th pair of ribs attached on to the mesosternum with the help of hyaline cartilage
- Xiphoid process is the lower pointed part of sternum

RIBS [12 PAIRS]

- These are 12 pairs of (24 number) semicircular thin and flat bones connected dorsally to the vertebral column but ventrally to the sternum.
- It has two articulation surface on its dorsal end, hence it called "Bicephalic".
- Two articulating heads of ribs are **TUBERCULUM** and **CAPITULUM**.
- **Ist 7 pairs** of ribs have direct attachment to the sternum through hyaline cartilage - so these are called "**TRUE RIBS**" and they dorsally attached on to thoracic vertebrae and hence it named as "**VERTEBROSTERNAL RIBS**".
- **8th, 9th and 10th pairs** of ribs do not articulate directly with the sternum but joins with the costa of **7th rib through** hyaline cartilage. These are called "**FALSE RIBS** / **Vertebrochondral**" ribs.
- **Last 2 pairs (11th and 12th)** of ribs are not connected ventrally, hence they are freely floating. These are called "**FLOATING RIBS**".
- Floating ribs provide protection to the kidneys so they are called "RENAL RIBS"
- Thoracic vertebrae, Ribs and Sternum together form the rib cage (37 bones)

RIBS AND RIBCAGE



APPENDICULAR SKELETON [126]

- Bones of the limbs along with their girdles constitute the Appendicular skeleton. So it differentiated into two.

1. LIMB BONES (120)

- Here the bones are distributed on to the four number of limbs and so it divided into two types.

FORE LIMB BONES (60)

- Each forelimb has 30 bones that divisible into 6 different types.

1) 1 HUMERUS [Upper arm bone]

2) 1 RADIUS — Inner fore arm bone
3) 1 ULNA — Outer fore arm bone
→ Fore arm bones

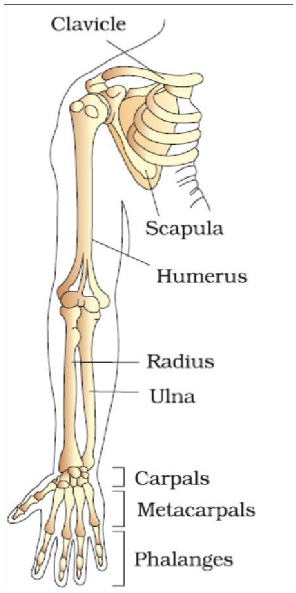
4) 8 CARPALS [Wrist bones]

5) 5 METACARPALS [Palm bones]

6) 14 PHALANGES [Wrist bones]

- Proximal ball like end of humerus bone articulated into the Glenoid cavity of scapula and allows a rotatory movement in all directions.
- Proximal projected end of Ulna is called **Olecranon process** articulate with humerus bone.
- Phalangeal formula of man is written as, $\boxed{2,3,3,3,3}$

Right pectoral girdle and upper arm (Frontal view)



HINDLIMB BONES [60]

- Each hind limb has 30 bones, that classified into 7 different types.

  1) 1 FEMUR BONE [Thigh bone] Longest, heaviest and strongest bone in body

  2) 1 TIBIA — Inner shank bone
  3) 1 FIBULA — Outer shank bone, smaller than tibia

  → Shank bones (shin bones)

  4) 1 PATELLA [Knee cap] Small cup like triangular bone cover the knee ventrally

  5) 7 TARSALS [Ankle bones]

  6) 5 METATARSALS [Foot / sole bones]

  7) 14 PHALANGES [Toe bones]

- Tibia articulate with femur bone through patella to form knee joint. Fibula helps to stabilize the ankle joint
- Patella is an example for "sesamoid bone" because it formed by the ossification of tendons
- Phalangeal formula in human foot $\boxed{2,3,3,3,3}$

GIRDLE BONES [6]

- These are the bones which connects limbs to the part of axial skeleton. It is of two types.

PECTORAL GIRDLE [4]

- Pectoral girdle helps for articulation of forelimbs to the sternum of axial skeleton
- It formed with two halves and each halves have 2 bones such as **CLAVICLE** and **SCAPULA**

1) SCAPULA (2) is a large, flat triangular bone situated in the dorsal part of thorax between the **second** and **seventh** ribs.

- Dorsal, flat triangular body of scapula has a slightly elevated ridge called **spine**, which projects as a flat expanded process called **ACROMION PROCESS**.
- Clavicle bone articulate with scapula through this acromion process (Acromio - clavicular joint)
- Below the acromion is a depression called **GLENOID CAVITY** which articulates with the head of humerus to form shoulder joint.
- Dorsal or anterior projected part of scapula is **CORACCOID PROCESS**, to which tendons of muscles and ligaments attach.
- Scapula is commonly called as "SHOULDER BLADE"

CLAVICLE (2) [COLLAR BONE] -

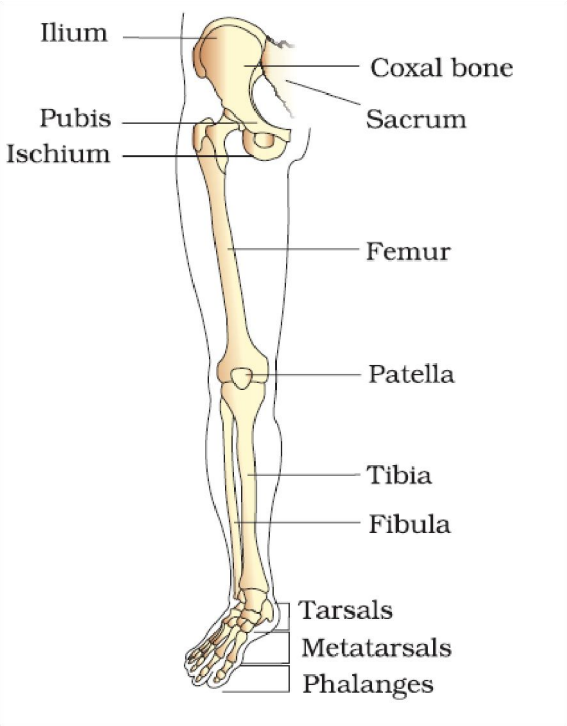
- It lies horizontally across the anterior part of thorax, superior to first rib.
- It is an elongated 'S' shaped bone extends from shoulder to manubrium of sternum.
- It formed with **two curvatures**.(Sterno-clavicular joint) (sternal end and acromial end)

PELVIC GIRDLE [2]

- It connects hind limb to the sacrum of vertebral column. It provides strong and stable support to vertebral column and pelvic and lower abdominal organs.
- Formed with two coxal bones / Os innominatum
- Each coxal bones are formed by the fusion of 3 other bones. Such as ;

  Superior / Dorsal ILIUM, Inferior / posterior, lower ISCHIUM and anterior / ventral PUBIS
- At the fusion of these three bones a cavity present called ACETABULUM to which thigh bone articulates.
- Two halves of pelvic girdle meet ventrally to form the "Pubic Symphysis" containing fibrous cartilage.
- Obturator foramen is a cavity present in each coxal bones.

Right pelvic girdle and lower limb bones (Frontal view)



JOINTS

- Joints are the place of articulation between two or more bones or between bones and cartilages.
- Study of joints are called "ARTHROLOGY"
- Force generated by the muscles is used to carry out movement through joints, where the joints acts as a **Fulcrum**.

- The movability of these joints varying depending on different factors.
- Joints are classified into mainly three types.
- On the basis of presence or absence of synovial cavity and the type of connective tissue that binds bone together, joints are classified into three major structural forms.

A) FIBROUS / FIXED / IMMOVABLE JOINTS [Synarthrosis]

- Here the bones are tightly joints with the help of dense fibrous connective tissue in the form of **sutures**.
- It is permanently fixed and cannot making any movement.

  Eg. Joints between Cranial Bones (Here the flat skull bones fuse end to end to form the cranium)

B) CARTILAGINOUS / SEMI-MOVABLE JOINTS [Amphiarthrosis]

- In this type bones are connected through fibrous / hyaline cartilages and can allow limited movements.

  Eg. Joints between adjacent VERTEBRAE OF V.C

  Joints between RIBS WITH STERNUM

  Joints between pubis of two coxal bones (PUBIC SYMPHYSIS)

C) SYNOVIAL JOINT / FREELY MOVABLE JOINT [Diarthrosis]

- Here the articulating surface of two bones are lined with a synovial membrane.
- It characterised by the presence of a fluid filled (synovial fluid) synovial cavity between the bones.
- This will allows considerable movements
- An articular cartilage (Hyaline) also present in these joints
- Synovial membrane and fluid reducing friction exerted on the joints during movement and locomotion.
- Here the two bones are externally connected with ligaments
- Based on the degree of movement allowed by these joints, they can be classified into 6 different types.

1. BALL & SOCKET JOINT

Ball like end of one bone articulated into the cavity of another bone and allows a rotatory movement in all directions. It allow movement in 360^{o} angle. It is the most freely movable joint.

Eg. 1) Between humerus and pectoral girdle (shoulder joint)

2) Between femur and acetabulum of pelvic girdle (Hip joint)

2. HINGE JOINT

Convex surface of one bone articulate with concavity of another bone and can allow movement only in one plane like a door. It allow movement in 180^{o} angle.

Eg. Elbow joint, Knee joint (Largest synovial joint)

Interphalangeal joint etc.

3. PIVOT JOINT

Fossa of one bone articulate with spine of another bone and allow partial rotation.

Eg. Atlas with Axis in Neck, Humerus with Radius and Ulna (Radio-Ulnar joint)

4. GLIDING JOINT

One or more bones are slide over to the surface of another bone and can allow movement from back to front, front to back and side to side.

Eg. Joints between carpals in wrist, joints between Tarsals in ankle.

5. SADDLE JOINT

It is a modified ball and socket joint and can allow partial rotatory movement. Articulated surface of one bone is saddle like.

Eg. Carpal with metacarpal of thumb.

6. CONDYLOID / ELLIPSOIDAL JOINT

- Here convex oval shaped projection of one bone articulate with the elliptical cavity of another bone and allow front to back / back to front and side to side movement.

Eg. Metacarpals with phalanges

Metatarsals with phalanges

MUSCULAR AND SKELETAL DISORDERS

1. **MYASTHENIA GRAVIS :** It is an autoimmune disorder by which neuromuscular junction became degenerated, that leads to fatigue, weakening and paralysis of skeletal muscles.
2. **MUSCULAR DYSTROPHY** : Progressive degeneration of skeletal muscle mostly due to genetic disorder. Lack of dystrophin protein causes muscular dystrophy due to mutation in genes.
3. **MUSCULAR TETANY** : It is the wild contraction or rapid spasm in muscles due to low Ca^{++} in body fluid or hypoparathyroidism or due to hypercalcitonism.
4. **OSTEOPOROSIS** : It is a low bone density disorder by which the chance for fractures of bones due to decreased bone mass. It is an age related disorder commonly seen in females at menopause because of the decreased level of estrogen. Hypocalcitonism and hyper parathyroidism also cause osteoporosis. Deficiency of Vit-D also causes this problem.
   - It is a microarchitectural deterioration of bone
5. **ARTHRITIS** : Inflammation of joints. It is of three types. They are ;

   a) Rheumatoid Arthritis : It is an autoimmune disorder characterised by painful inflammation in synovial membrane. It occurs due to pannus formation or abnormal granule formation in joints characterised by the presence of a rheumatoid factor **(IgM)** in blood. Commonly affects joints in hands and feet.

b) Osteoarthritis : It occurs due to the degeneration of articular cartilage between bones. As a result a permanent bending or fixation of joints occurs. Usually affects joints in knee, hands etc.

c) Gout / Gouty Arthritis : It occurs due to accumulation of uric acid crystals in joints. Excess amount of uric acid in blood reacts with sodium to form sodium urate salts in joints. It most often affects the joints in feet, especially at the base of big toes.

6. **OSTEITIS FIBROSA CYSTICA** : It is the inflammation in bones due to hypoparathyroidism or hypercalcitonism in blood.