

20. Locomotion and Movement

POINTS TO REMEMBER :

Types of Movement :

- **Amoeboid movement:** This movement takes place in phagocytes where leucocytes and macrophages migrate through tissue. It is affected by pseudopodia formed by the streaming of protoplasm (as in amoeba)
- **Ciliary movement:** These movements occur in internal organs which are lined by ciliary epithelium.
- **Muscular Movement:** This movement involves the muscle fibers, which have the ability to contract and relax.

MUSCLES :

Properties of Muscle :

- Excitability
- Contractility
- Extensibility
- Elasticity

Types of Muscles :

- **Skeletal muscles or striated muscles –**
 - Closely associated with skeleton.
 - They are striped appearance under the microscope and called **Striated muscles**.
 - They are under voluntary control of nervous system, hence called voluntary muscles.
 - These involved in locomotion and change of body postures.
 - Unbranched and multinucleated.
- **Visceral muscles or smooth muscles**
 - These are located in inner wall of hollow visceral organ.
 - Spindle shaped and uni-nucleated.
 - They do not exhibit any striation and are smooth in appearance.
 - They are called smooth muscles or non-striated muscles.
 - Their activities are not under voluntary control of nervous system hence called as **involuntary muscles**.
 - They assist in transport of food through digestive tract and gametes through the genital tract.
- **Cardiac muscles –**
 - The muscles of heart, involuntary in nature.
 - Cardiac muscle cells assemble in a branching pattern to form a cardiac muscle.
 - These are uni-nucleated with characteristic **intercalated disc**.

Structure of skeletal muscle :

- Each organized skeletal muscle in our body is made of a number of muscle bundles called **fascicles** held together by common fibrous covering called **fascia**.
- Each fascicle consists of a number of muscle fibres (cell) covered by a common fibrous **perimysium**.
- Each muscle fibre is lined by the plasma membrane called **sarcolemma**, enclosing cytoplasm called **sarcoplasm**.
- The sarcoplasm contain endoplasmic reticulum, called **sarcoplasmic reticulum** is the store house of **calcium ion**.

- Muscle fibre is a **syncytium** as the sarcoplasm contain many nuclei.
- Muscle fibres contain a large number of parallelly arranged filaments in the sarcoplasm called **myofilaments** or **myofibrils**.
- There are two types of myofibrils are present in the sarcoplasm –
 - Thin filament – Actin
 - Thick filament – Myosin.
- The arrangement of thick and thin filament gives the characteristic striated appearance.
- The light bands contain only actin filaments and are called **I-band** or isotropic band.
- The dark band called '**A**' or **anisotropic band** contains both actin and myosin.
- In the centre of each 'I' band is an elastic fibre called 'Z' line which bisects it.
- The thin filaments or actin are firmly attached with the 'Z' line.
- The thick filaments or myosin in the 'A' band are also held together in the middle by a thin fibrous membrane called '**M**' **line**.
- The portion between two successive 'Z' lines is considered as the functional unit of the muscle called **sarcomere**.
- Each 'A' band contains two overlap zone of thick and thin filament called 'O' band.
- The central part of thick filament, not overlapped by thin filament is called 'H' band.
- 'A' band = 2(O) + H.

Structure of Contractile proteins :

Thin filament or Actin :

- Each actin filament is made of two 'F' actins helically wound to each other.
- Each 'F' actin is made of polymer of monomeric 'G' (Globular) actin.
- Each 'F' actin associated with another protein, **tropomyosin** also run throughout its length.
- Another complex protein, Troponin is distributed at regular intervals on the tropomyosin.
- Each troponin has three component –
 - Troponin-C binds with calcium.
 - Troponin-M, binds with the tropomyosin.
 - Troponin T, masks the active site on the 'G' actin (thin filament)
- In the resting state a sub-unit of Troponin (Tn-T), masks the active binding sites on the thin filaments for myosin.

Thick filament :

- Each myosin (thick) filament is consists of many monomeric protein called **Meromyosins**.
- Each meromyosin has two parts –
 - Heavy meromyosin (HMM) - A globular head with a short arm.
 - Light meromyosin (LMM) – a tail.
- The HMM component, i.e. the head and short arm projects outwards at regular distance and angle from each other from the surface of a polymerized myosin filament and is known as **cross arm**.
- The globular head is an active ATPase enzyme and has **binding sites for ATP** and **active sites for actin**.

Mechanism of muscle contraction :

- Mechanism of muscle contraction is explained by sliding filament theory which states that contraction of a muscle fibre takes place by the sliding of the thin filaments over the thick filaments.
- Muscle contraction is initiated by a signal sent by the central nervous system via a motor neuron.
- A motor neuron along with the muscle fibres connected to it constitutes a **motor unit**.
- The junction between a motor neuron and the sarcolemma of the muscle fibre is called **neuromuscular junction** or **motor-end plate**.
- Neurotransmitter releases here which generates an action potential in sarcolemma.
- These causes release of Ca^{++} into sarcoplasm.
- These Ca^{++} binds with troponin, thereby remove masking of active site.
- Myosin head binds to exposed active site on actin to form a cross bridge, utilizing energy from ATP hydrolysis.
- This pulls the actin filament towards the centre of 'A' band.
- 'Z' lines also pulled inward thereby causing a shortening of sarcomere i.e. contraction.
- 'I' band get reduced, whereas the 'A' band retain the length.
- During relaxation, the cross bridge between the actin and myosin break.
- Ca^{++} pumped back to sarcoplasmic cisternae.
- Actin filament slide out of 'A' band and length of 'I' band increases. This returns the muscle to its original state.
- Repeated muscle contraction causes accumulation of lactic acid, produced from anaerobic breakdown of glycogen leads to **muscle fatigue**.
- Muscle contains red coloured oxygen storing pigment called **myoglobin**.
- Muscle with myoglobin called red muscle fibres, they are also contain large number of mitochondria which can utilize large amount of oxygen stored in them for ATP production also called **aerobic muscle**.
- Some muscles possess very less quantity of myoglobin and less mitochondrion hence called **white fibres**. Amount of sarcoplasmic reticulum is high in these muscles. They depend on anaerobic process for energy.

SKELETAL SYSTEM :

- Human skeleton consists of 206 bones in adult.
 - Axial skeleton – 80 bones
 - Appendicular skeleton – 126 bones.
- **Axial skeleton :**
 - **Skull – 29 bones.**
 - **Cranium** – 8 bones forms the brain box.
 - **Facial** – 14 bones forms the front part of the face.
 - **Hyoid** – a single U-shaped bone at the base of the buccal cavity.
 - **Ear ossicles** – 6 bones- 3 on either side (Malleus, Incus and stapes)
 - The skull region articulates with the superior region of the vertebral column with the help of two occipital condyles hence called **dicondylic skull**.
 - **Vertebral column** – 26 bones
 - **Cervical** – 7 vertebrae.

- **Thoracic** – 12 vertebrae.
 - **Lumber** – 5 vertebrae.
 - **Sacral** – 1 vertebra. (fused five bone)
 - **Caudal** – 1 vertebra (fused four bones)
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- **Sternum** or **breast bone** – 1 bone in the middle line of the thorax.
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- **Ribs** – 12 pairs – (24 bones)
 - 1-7 are **true ribs** (connected to the sternum directly)
 - 8th, 9th, 10th pairs are called **false ribs** they attached to the 7th ribs.
 - 11th and 12th not connected ventrally hence called **floating ribs**.
 - Ribs attaché dorsally to the vertebra and ventrally with the sternum by **hyaline cartilage**.
 - Thoracic vertebrae, ribs and sternum together form the rib cage.
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- **Appendicular skeleton: 126 bones**
 - **Fore limb – 60 (30 in each)**
 - **Humerus** – 1 bone
 - **Radius** and **ulna** – 2 bones
 - **Carpals** (wrist bones) – 8 in numbers.
 - **Metacarpals** (palm bones) – 5 in numbers
 - **Phalanges** (digits) – 14 in number.
 - **Hind limb – 60 (30 in each)**
 - **Femur** (thigh bone- the longest and heaviest bone) – 1 number.
 - **Tibia** and **fibula** – 2 bones.
 - **Tarsals** (ankle bone) – 7 bones.
 - **Metatarsals** – 5 in numbers.
 - **Phalanges** (digits) – 14 in numbers.
 - **Patella** (knee cap) – 1 bone.
 - **Pectoral girdles:** consists of 2 bones each = 4 bones.
 - Helps in articulation of fore limb with the axial skeleton.
 - Each pectoral girdle made of two half.
 - Each half made of two bone the **clavicle** and **scapula**.
 - Scapula is a large triangular flat bone situated in the dorsal part of the thorax between the second and the seventh ribs.
 - Scapula is characterized by spine with **acromion** process.
 - Below acromion, is **glenoid cavity** to which head of humerus fits.
 - Clavicle is commonly called **collar bone**.
 - **Pelvic girdle:** 2 bones.
 - Pelvic girdle consists of two coxal bones.

- Each coxal bone is formed of fusion of three bones
 - Ilium
 - Ischium
 - Pubis.
- At the point of fusion of the three bones is a cavity called **acetabulum** to which the femur articulates.
- Two halves of the pelvic girdle meets ventrally to form the **pubic symphysis** containing fibrous cartilage.

JOINTS :

- Joints are the points of contact between bones, or between bones and cartilages.
- Force generated by the muscles is used to carry out movement through joints, where joint acts as a **fulcrum**.
- Joints are classified into three types:
 - **Fibrous joint**
 - **Cartilaginous joint**
 - **Synovial joint**

Fibrous joints :

- Do not allow any movements.
- Found in flat bones which fuse end-to-end with the help of dense fibrous connective tissues in the form of sutures.
- These types of joints are found in the bones of cranium.

Cartilaginous joints :

- The bones involved are joined together with the help of cartilages.
- Permits very little movements.
- Joint between the vertebral column are the example of such joints.

Synovial joints :

- Characterized by the presence of a fluid filled **synovial cavity** between the articulating surfaces of the two bones.
- Allow free movement between two bones.
- The fluid inside it called synovial fluid covered by synovial membrane.
 - **Ball and socket joint** - between humerus and pectoral girdle
 - **Hinge joint** – knee joint
 - **Pivot joint** – between atlas and axis.
 - **Gliding joint** – between carpals.
 - **Saddle joint** – between carpals and metacarpals of thumb.

DISORDERS OF MUSCULAR AND SKELETAL SYSTEM :

Myasthenia gravis :

- It is an auto-immuno disorder.
- Affects the neuromuscular junction leads to fatigue.
- Caused weakening and paralysis of skeletal muscle.

Muscular dystrophy : Progressive degeneration of skeletal muscle mostly due to genetic disorder.

Tetany: rapid spasms (wild contractions) in muscle due to low Ca^{++} in body fluid.

Arthritis : inflammation of joints.

Osteoporosis : age related disorder characterized by decreased bone mass and increased chances of fractures. Decrease levels of oestrogen are a common cause.

Gout : inflammation of joints due to accumulation of uric acid crystals.