# 17 Locomotion and Movement

*Many people enjoy going to the gym and working out to strengthen their bodies. You can flex your biceps like a bodybuilder, but you can't control your internal muscles. It's a good thing they act on their own without your conscious involvement, because movement of these muscles is critical for survival. This is how cells in the muscular tissue of animals such as human beings work.*

## Topic Notes

- *Muscle and Types of Movement*
- *Skeletal System and Disorders*

# MUSCLE AND TYPES OF MOVEMENT 1

## TOPIC 1

## MUSCLE AND MOVEMENT

### Locomotion

It is the movement of an individual from one place to another. In fact, it is difficult to separate movement from locomotion, because an animal cannot change its place without movement. Thus, movements are primarily connected with locomotion.

### Movement

It is one of the most important characteristics of living organisms. Non-living objects do not move. If non-living objects show movement, that is always due to some external force, while the movements of living things are autonomic (self-sustained).

Amoeboid, ciliary, and muscular motions are the three basic types of movements that cells in the human body show. These movements are summarised as follows:

#### Amoeboid (Pseudopodial) Movement

Certain specialised cells in the human body, such as macrophages and leucocytes in blood, move in an amoeboid fashion. It is influenced by pseudopodia generated by protoplasm streaming (as in *Amoeba*). Amoeboid mobility is further aided by cytoskeletal components such as microfilaments.

#### Flagellar Movement

Flagellar movement helps in the swimming of spermatozoa, maintenance of water current in the canal system of sponges and in locomotion of Protozoans like Euglena.

#### Ciliary Movement

Most of our organs are lined by ciliated epithelium. These exhibit ciliary movement. The synchronised motions of cilia in the trachea help in the removal of dust particles and some foreign chemicals ingested together with the ambient air. Similarly, the cilia of the fallopian tubes (oviducts) and vasa efferentia in human females and males, transport eggs and sperms respectively.

#### Muscular Movement

Muscular action is required for the movement of our limbs, mouth, tongue, and so on. Humans and the bulk of multicellular creatures employ the contractile characteristic of muscles for locomotion and other activities. Locomotion necessitates the precise coordination of muscular, skeletal, and neurological systems. The universal property of this mechanism is to exert a force by alternate contraction and relaxation.

**Example 1.1: What are the different types of movements exhibited by the cells of the human body? [NCERT]**

**Ans.** Amoeboid, ciliary, and muscular motions are the three basic types of movements that cells in the human body show.

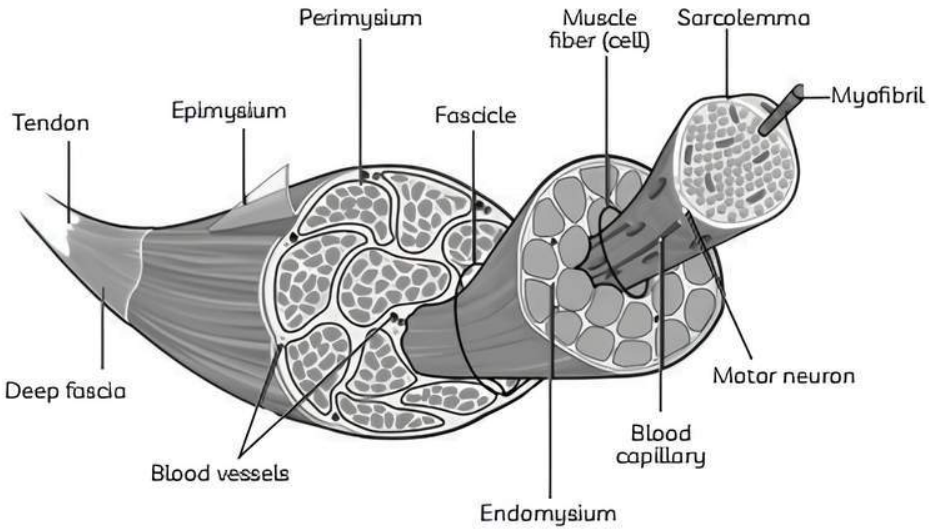
#### Locomotion in Humans

Locomotion in humans depends on the movements of muscle fibres (muscle cells). Skeletons and joints also help in locomotion.

### Skeletal Muscle

Each skeletal muscle tissue in our body is made of a set of muscle bundles or fascicles that are linked together by a shared collagenous interconnecting tissue layer known as fascia. Each fascicle contains a number of muscle fibres (muscle cells). Each muscle fibre has a sarcolemma, which is a plasma membrane that surrounds the sarcoplasm. The endoplasmic reticulum, also known as the sarcoplasmic reticulum of muscle fibres, is a calcium ion storage house. The presence of a large number of parallelly arranged filaments in the sarcoplasm known as myofilaments or myofibrils is a distinguishing feature of muscle fibres. Each myofibril has alternatively placed dark and light bands.

This is depicted in a diagram that follows:




*Morphology of a striated muscle fibre*

# TOPIC 2

# CONTRACTILE PROTEIN

## Structure of Contractile Proteins

### Actin Filament

The actin or thin filament is composed of three different proteins called actin, tropomyosin and troponin.

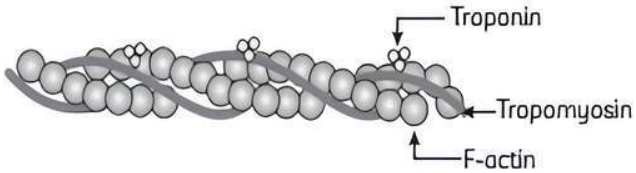
(1) **Actin:** It is a globulin protein and if generally has low molecular weight. It occurs in two forms, the monomeric G-actin and the polymeric F-actin. G-actin (where G stands for globular) polymerises to the fibrous form whereas F-actin (where F stands for fibrous) in the presence of $Mg^{2+}$.

(2) **Tropomyosin:** Tropomyosin is a double-standard α-helical rod. It is a fibrous molecule that is attached to F-actin in the groove between the filaments. In the resting state, the tropomyosin is believed to lie on top of the active sites of the actin strands so that attraction cannot occur between the action and myosin to cause contraction.

(3) **Troponin:** It is a complex 3 polypetides. Troponin T (TpT) binds to tropomyosin as well as to the other two troponin components. Troponin I (TpI) inhibits the F-actin myosin interaction and also binds to other components of troponin. Troponin C (TpC) is a calcium-binding polypeptide. The strong affinity of the troponin for calcium ions is believed to initiate the contraction process.

**Important**

➥ *The major component of muscle is water. Potassium is an abundant mineral element in muscle. Other minerals such as Na, P and Mg are present in trace amounts. Muscle usually stores glycogen. They have oxygen carrying pigment myoglobin or muscle haemoglobin. Muscles and also contain ATP, phosphocreatine, creatine urea, etc.*




*Troponin and tropomysoin in the contractile protein: actin*

### Myosin Filament

The myosin or thick filament is composed mainly of myosin protein. The myosin contributes 55% of muscle protein by weight.

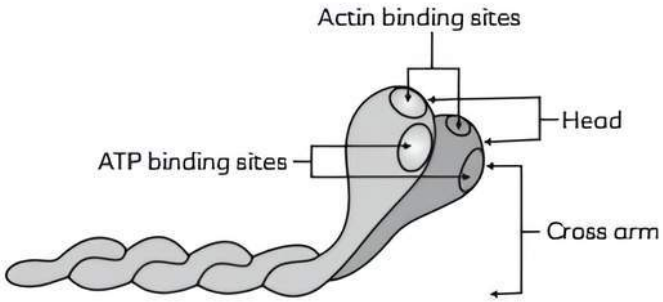
Monomeric units of myosin are meromyosins. Each meromyosin has a tadpole-like appearance. A meromyosin is formed of two identical heavy chains (Heavy meromyosin-HMM) and four light chains (Light meromyosin-LMM). Head and tail are important parts of meromyosin.

**Head:** One end of each heavy chain is folded into a globular protein mass called the myosin head. Thus, there are two free heads lying side by side at one end of the double-headed myosin molecule.

The four light chains are also part of the myosin heads, two to each head. Thus, the head is formed of both HMM and LMM. Each globular head is an active ATPase enzyme and has ATP binding site and an actin-binding site.

Projected head along with a short arm is known as a cross arm. The protruding arms and head together are known as cross-bridges. Thus, each cross-bridge has head and an arm. Both ends of an arm are flexible due to the presence of hinges.

**Tail:** The two heavy chains wrap spirally around each other to form a double helix, this elongated portion of the coiled helix is called myosin tail. Thus, the tail is exclusively formed of HMM. The tail points towards the M-line is the centre of the sarcomere. Tails of neighbouring myosin molecules lie parallel to one another.




*Mysosin's ATP binding sites and structure*

## Mechanism of Muscle Contraction

The mechanism of muscle contraction can be best understand by the sliding filament theory that states contraction of muscle fibre takes place by the sliding of the thin filament (actin filament) over the thick filament (myosin filament).

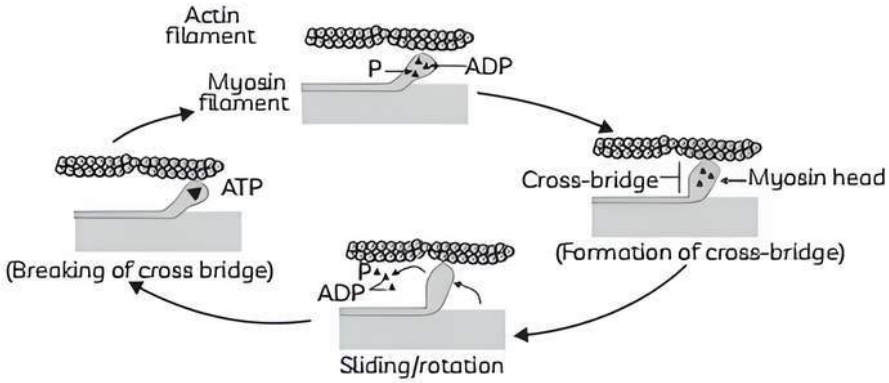
The sliding filament model of muscle contraction was given by Hugh Huxley and Jean Hanson in the year 1954. Formulation of the model and subsequent proof was driven by the pioneering work of Hugh Huxley.

### ⚠ Caution

➥ *There are four stages of sliding filament theory, myosin head attaches to an actin filament, bend to pull the actin filament close together, then releases reattaches and pulls again.*

The sliding filament theory, which states that contracting of a muscle fibre occurs due to sliding of thin filaments over the thick filaments, best explains the mechanism of muscular contraction. A signal transmitted by the central nervous system (CNS) *via* a motor neuron causes muscle contraction. A motor unit is made up of a motor neuron and the muscle fibres that link to it.

The neuromuscular junction, also known as the motor-end plate, is the intersection between a motor neuron and the sarcolemma of a muscle fibre. When a neuronal signal reaches this junction, it causes a neurotransmitter (Acetylcholine) to be released, resulting in an action potential in the sarcolemma. This travels along the muscle fibres, causing calcium ions to be released into the sarcoplasm. Increased $Ca^{2+}$ levels cause calcium to bind with a troponin subunit on actin filaments, removing the masking of active sites for myosin.

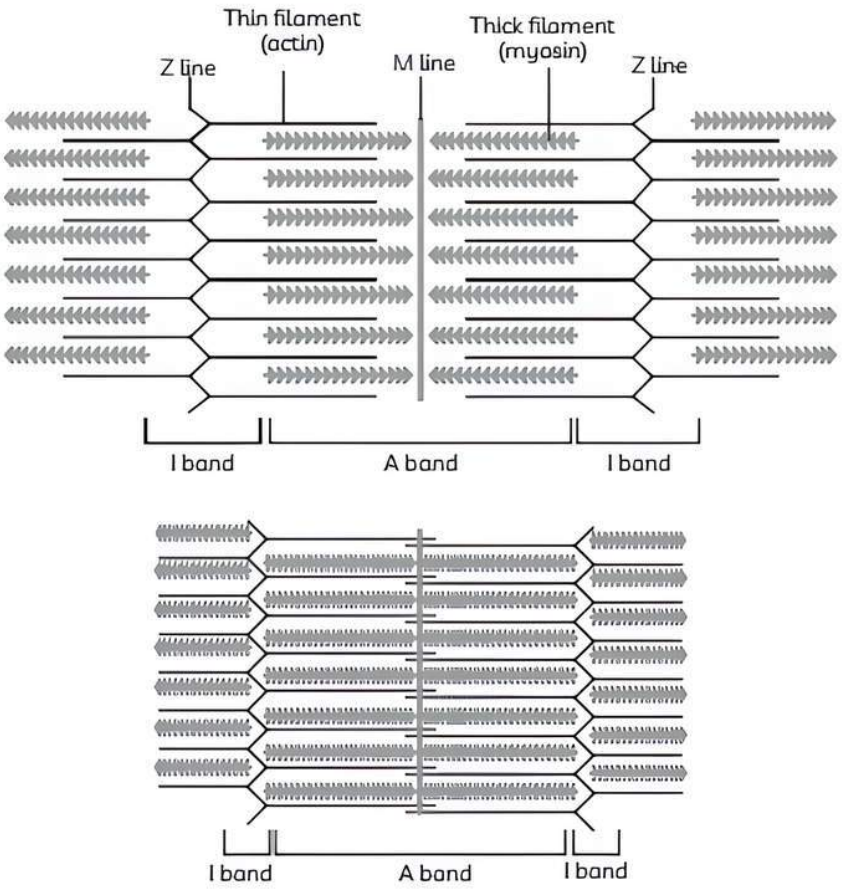



*Interaction between actin and myosin*

This attracts the connected actin filaments to the centre of the 'A' band *i.e.* H-zone. The 'Z' line linked to these actions is likewise dragged inwards, causing the sarcomere to shorten, *i.e.* contract. It is obvious from the preceding phases that during muscular shortening, *i.e.* contraction, the 'I' bands shorten, while the 'A' bands retain their length. The myosin returns to its relaxed state after releasing ADP and Pi.

### Important

➥ *The cross-bridge is destroyed when a fresh ATP binds. The myosin head hydrolyzes ATP again, and the cycle of cross-bridge formation and breakage is repeated, generating further sliding. The procedure is repeated until the $Ca^{++}$ ions are pushed back into the sarcoplasmic cisternae, obscuring actin filaments. This causes the 'Z' lines to revert to their previous position, i.e. relaxation. The response time of the fibres varies amongst muscles.*




*Sliding of actin and myosin*

## Muscle Fatigue

The reduction in the force of contraction of a muscle after prolonged stimulation is called muscle fatigue.

### Cause

A muscle is able to contact for a short time in the absence of oxygen. But it gets fatigued sooner because in the absence of oxygen, the metabolic products of glycolysis mainly lactic acid accumulate. the accumulation of lactic acid leads to muscle fatigue. Pain is experienced in the fatigued muscle. The site of fatigue is the junction between nerve and muscle. A muscle gets fatigued sooner after a strenuous exercise than after a mild exercise.

### Remedy

Fatigued muscle needs extra oxygen to dispose off excess lactic acid. After a strenuous exercise, faster breathing should be continued for some time to supply extra oxygen for oxidising excess lactic acid. This results in the disappearance of fatigue.

### Caution

➥ *Hypertrophy: Increase in the size of muscle called hypertrophy.*

➥ *Atrophy: Reduction in the size of individual muscle cells is called atrophy.*

### Important

➥ *Myoglobin, a red-coloured oxygen-storing pigment, is present in muscles. Some of the muscles have a high myoglobin concentration due to which they appeared reddish in colour. These muscles are known as red fibres. These muscles contain a huge number of mitochondria, which can utilise the large quantity of oxygen stored in them to produce ATP. As a result, these muscles are also known as aerobic muscles. Some muscles, on the other hand, have a very low amount of myoglobin and so seem pale or whitish. These are white muscle fibres. They also have a low number of mitochondria, but a high quantity of sarcoplasmic reticulum. They get their energy from anaerobic processes.*

**Example 1.4: Case Based:**

*A scientist observed two sets of muscles under the microscope. Unfortunately, due to a misplacement of labels, she doesn't know which fibre it was, so she calls them Set A and Set B. Set A has reddish fibres and a high amount of mitochondria. Set B has yellowish fibres and a very low amount of mitochondria in the cells. She also knows that both the sets are of mammalian origin.*

**(A) What fibres are mentioned in the case presented to you?**

**(a) A and I-bands**
**(b) Red and white muscle fibres**
**(c) Myoglobin and Haemoglobin**
**(d) I-band and Z-band**

(B) **Which of the following options is the incorrect difference between red and white muscle fibres?**

(a) **White muscle fibres can react quicker than red muscle fibres inside the human body.**

(b) **Red muscles have very little quantity of Sarcoplasmic Reticulum.**

(c) **White muscle fibres have high quantities of mitochondria since they need to react to stimuli very quickly.**

(d) **More than one option is incorrect.**

(C) **Where do muscle contractions derive their energy from?**

(D) **What is the reason for the colour difference in the samples?**

(E) **Assertion (A): Muscles with high mitochondria are red in colour.**

**Reason (R): These muscles are high in haemoglobin.**

(a) **Both A and R are true and R is the correct explanation of A.**

(b) **Both A and R are true and R is not the correct explanation of A.**

(c) **A is true but R is false.**

(d) **A is false but R is true.**

**Ans.** (A) *(b) Red and white muscle fibres*

**Explanation:** Set A has reddish fibres and a high amount of mitochondria. In mammalian tissues, this occurs in red muscle fibres. These are supposed to provide long-term support during locomotion, such as while running marathons. Set B has pale yellow fibres and lower mitochondria but a substantial quantity of sarcoplasmic reticulum. They get their energy from anaerobic processes and are able to react very quickly to stimuli. This makes them extremely quick-reacting.

**Related Theory**

*Red muscles are termed so because they are thick with capillaries and extremely high in myoglobin and mitochondria which gives them a distinctive red look. White muscles, on the other hand, have fewer mitochondria and myoglobin content, which gives them a "whitish" look.*

(B) *(c) White muscle fibres have high quantities of mitochondria since they need to react to stimuli very quickly.*

**Explanation:** Some of the muscles have a high myoglobin concentration, giving them a reddish appearance. These muscles are known as red fibres. These muscles also have a huge number of mitochondria, which may use the large quantity of oxygen stored in them to produce ATP. As a result, these muscles are also known as aerobic muscles. Some muscles, on the other hand, have a very low amount of myoglobin and so look pale or whitish. These are white muscle fibres.

**Caution**

*It is important to note that, despite of having a low number of mitochondria, and a huge quantity of sarcoplasmic reticulum, white muscle fibres get their energy from anaerobic processes.*

(C) Every myosin molecule contains myosin ATPase, an enzyme at its head. In the presence of this enzyme along with $Ca^{2+}$, $Mg^{2+}$ ions, the inorganic phosphate, and ADP it is disintegrated by ATP to release energy from the myosin head. This energy causes myosin to cross bridges to bind to actin. These cross-bridges that are energised, move, resulting in the sliding of thin myofilaments with the thick myofilaments, thereby causing muscle contraction.

(D) Myoglobin, a red-coloured oxygen-storing pigment found in muscle fibre. Some of the muscle fibres have high myoglobin concentrations, giving them a reddish appearance. These muscles are known as red fibres. These muscles also have a huge number of mitochondria, which may use the large quantity of oxygen stored in them to produce ATP. As a result, these muscles are also known as aerobic muscles. Some muscles, on the other hand, have a very low amount of myoglobin and so seem pale or whitish. These are white muscle fibres. They also have a low number of mitochondria, but a high quantity of sarcoplasmic reticulum.

(E) *(c) A is true but R is false.*

**Explanation:** Some of the muscles have a high myoglobin concentration (not haemoglobin), giving them a reddish hue. These muscles are known as red fibres. These muscles also have a huge number of mitochondria, which may use the large quantity of oxygen stored in them to produce ATP.

# OBJECTIVE Type Questions

[ 1 mark ]

## Multiple Choice Questions

**1. Match the following and mark the correct option.**

| Column I | Column II |
|---|---|
| (A) Fast muscle fibres | (i) Myoglobin |
| (B) Slow muscle fibres | (ii) Lactic acid |
| (C) Actin filament | (iii) Contractile unit |
| (D) Sarcomere | (iv) I-band |

**Codes:**

**(a) (A)-(i), (B)-(ii), (C)-(iv), (D)-(iii)**

**(b) (A)-(ii), (B)-(i), (C)-(iii), (D)-(iv)**

**(c) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii)**

**(d) (A)-(iii), (B)-(ii), (C)-(iv), (D)-(i)**

**[NCERT Exemplar]**

**Ans.** *(c) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii)*

**Explanation:** Fast muscle fibres tend to anaerobically respire, thus leading to lactic acid accumulation in the muscles.

Myoglobin is associated with slow muscle fibres.

Actin filaments are present in the I-band of the sarcomere.

Sarcomere refers to the contractile unit of the human muscle.

### Related Theory

- *In the kind of runner who runs for a little period of time, there aren't many rapid muscle fibres. Due to anaerobic respiration and muscle exhaustion, they contain high levels of glycogen and lactic acid.*
- *For runners who need to run far and hard, slow muscle fibre is present. Because they require long periods of time or constant ATP synthesis, they have a huge number of mitochondria and myoglobin.*

**2. ATPase of the muscle is located in:**

**(a) Actinin** **(b) Troponin**

**(c) Myosin** **(d) Actin**

**[NCERT Exemplar]**

**Ans.** *(c) Myosin*

**Explanation:** Each myosin (thick) filament is a polymerised protein. One thick filament is made up of several monomeric proteins known as Meromyosins. Each meromyosin consists of two important parts, a globular head with a short arm and a tail. Each globular head of myosin is an active ATPase enzyme and has ATP-binding sites and actin-binding sites.

**3. Macrophages and leucocytes exhibit:**

**(a) Ciliary movement**

**(b) Flagellar movement**

**(c) Amoeboid movement**

**(d) Gliding movement** **[NCERT Exemplar]**

**Ans.** *(c) Amoeboid movement*

**Explanation:** Certain specialised cells in the human body, such as macrophages and leucocytes in blood, move in an amoeboid fashion.

**4. In a hurdle race, this is a primary source of energy for the leg muscles:**

**(a) Pyruvate**

**(b) Oxidative metabolism**

**(c) Lactate**

**(d) ATP**

**Ans.** *(b) Oxidative metabolism*

**Explanation:** In a hurdle race, a person requires higher energy production than the body can adequately deliver oxygen. In this case, our body generates energy anaerobically. By the process of glycolysis, glucose is converted into pyruvate. This pyruvate is converted into lactic acid when oxygen is limited in our body, which allows glucose breakdown and thus energy production is continued. The working muscle cells can continue this type of anaerobic energy production at high rates for one to three minutes, during which the leg muscles, during hurdle races, lead to a high quantity of lactic acid accumulation in muscles. Hence, In the hurdle race, oxidative metabolism is a major source of energy to the leg muscle.

**5. Statement A: Troponin is distributed at regular intervals of tropomyosin.**

**Statement B: In the resting state, subunit of troponin masks the active binding sites for myosin on actin filaments.**

**(a) Both A and B are correct.**

**(b) Both A and B are incorrect.**

**(c) Only A is correct.**

**(d) Only B is correct.**

**Ans.** *(a) Both A and B are correct.*

**Explanation:** Each actin (thin) filament is constructed by two filamentous actins that have been helical coiled together. A polymer of

monomeric 'G' (Globular) actins makes up each 'F' actin. Along its whole length, tropomyosin's two filaments likewise cling to the 'F' actins.

When the body is at rest, a troponin subunit obscures the actin filaments' active myosin binding sites.

**6.** **Statement A: Potassium ions play an important role in muscle contraction.**

**Statement B: Calcium binds with a subunit of troponin on actin filaments and thereby removes the masking of active sites for myosin.**

**(a) Both A and B are correct.**
**(b) Both A and B are incorrect.**
**(c) Only A is correct.**
**(d) Only B is correct.**

**Ans.** *(d) Only B is correct.*

**Explanation:** Calcium ions are what trigger the contraction of skeletal muscle. To unmask the actin's active site, these calcium ions attach to the protein complex troponin. The actin's active myosin-binding sites become visible as a result. When myosin is exposed, it attaches to actin and releases Pi from the ATP molecule that is attached to myosin. Myosin returns to a lower energy state as a result.

**7.** **Which of the following structures is correctly organised from large to small?**

**(a) Muscle, Muscle cell, Myofibril, Sarcomeres, Filaments.**
**(b) Muscle, Muscle fibres, Sarcomeres, Filaments, Myofibrils.**
**(c) Muscle, Sarcolemma, Myofibrils, Actin filaments, Myosin filaments.**
**(d) Muscle cells, Myofibrils, Filaments, Sarcoplasm.**

**Ans.** *(a) Muscle, Muscle cell, Myofibril, Sarcomeres, Filaments.*

**Explanation:** The correct organisation of the structures from large to small is: muscle, muscle cells, myofibrils, sarcomeres and filaments.

Muscle is a band or bundle of fibrous tissue that has the ability to contract, producing movement in or maintaining the position of parts of the body. Muscle cell is an elongated contractile cell that forms the muscles of the body. Myofibril is any of the elongated contractile threads found in striated muscle cells. Sarcomere is a structural unit of a myofibril in striated muscle consisting of a dark band and the nearer half of each adjacent pale band. A filament is a slender thread-like object or fibre, especially one found in animal or plant structures.

**8.** **Dheeraj was given a sample of two muscles marked as 1 and 2. When he compared the muscles he found that muscle 1 contains a large amount of myoglobin and utilises a large amount of stored oxygen for ATP production whereas muscle 2 contains little myoglobin, mitochondria and high sarcoplasmic reticulum. Identify the correct conclusion regarding the muscles 1 and 2 from the option given below.**

**(a) Both muscles are aerobic muscles.**
**(b) Both muscles are called red fibres and depend on the aerobic process for energy.**
**(c) Muscle 1 is called red fibres and are aerobic muscles whereas muscle 2 is called white fibres and depends on the anaerobic process for energy.**
**(d) Muscle 1 is called white fibres and whereas muscle 2 depends on the aerobic process for energy.**

**Ans.** *(d) Muscle 1 is called white fibres and whereas muscle 2 depends on the aerobic process for energy.*

**Explanation:** Red muscle fibre is dense with capillaries and is rich in mitochondria and myoglobin, giving the muscle tissue its characteristic red colour. It can carry more oxygen and sustain aerobic activity using fats or carbohydrates as fuel.

White muscle fibre contracts quickly and powerfully but fatigue very rapidly, sustaining only short, anaerobic bursts of activity before muscle contraction becomes painful. They contribute most to muscle strength and have greater potential for an increase in mass. Type 2 is anaerobic, glycolytic, "white" muscle that is least dense in mitochondria and myoglobin.

**9.** **There are three blanks in the following statement. Mark the correct option having suitable words for filling the blanks.**

**The thin filaments of a myofibril contain .....'A'..... actin and two filaments of .....'B'..... protein along with .....'C'..... protein for masking binding site for myosin.**

**Options:**

| | 'A' | 'B' | 'C' |
|---|---|---|---|
| (a) | 1F | troponin | tropomyosin |
| (b) | 1F | tropomyosin | troponin |
| (c) | 1F | troponin | tropomyosin |
| (d) | 1F | tropomyosin | troponin |

**Ans.**

| | 'A' | 'B' | 'C' |
|---|---|---|---|
| *(d)* | *1F* | *tropomyosin* | *troponin* |

**Explanation:** Each 'F' actin is a polymer of monomeric 'G' (Globular) actins. Each actin (thin) filament is made of two 'F' (filamentous) actins helically wound to each other.

Two filaments of another protein, tropomyosin also run close to the 'F' actins throughout its length.

A complex protein troponin is distributed at regular intervals on the tropomyosin. In the resting state, a subunit of troponin masks the active binding sites for myosin on the actin filaments.

Thin filaments of a myofibril contain two filaments of actin and two filaments of troponin, along with tropomyosin protein.

**10. Which of these statements is not true regarding skeletal muscles?**

**(a) They are also called voluntary muscles.**
**(b) They help in the movement of food through the oesophagus.**
**(c) They have striations.**
**(d) They are involved in changing of body posture.**

**Ans.** *(b) They help in the movement of food through the oesophagus.*

**Explanation:** Skeletal muscles are also known as voluntary muscles. They have striations and are also known as striated muscles. They are involved in changing of body posture but not in the movement of food through the oesophagus.

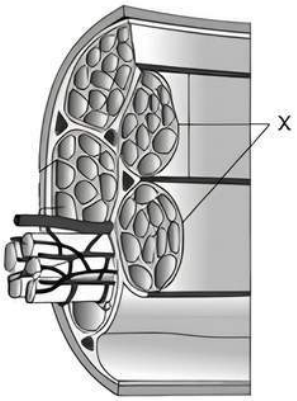
**11. About how much per cent of body weight of a human adult is contributed by muscles?**

**(a) 40 – 50** **(b) 50 – 60**
**(c) 45 – 55** **(d) 55 – 65** **[Diksha]**

**Ans.** *(a) 40 – 50*

**Explanation:** Muscles are tissues in the body that posses the ability to contract and relax, and are essential for the movement of the human body. Skeletal muscle accounts for 40% of total body weight, deteriorates quantitatively and qualitatively with aging.

**12. Identify the structure X shown in the figure.**

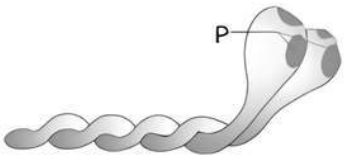



**(a) Fascia** **(b) Muscle fibre**
**(c) Sarcolemma** **(d) Fascicle**

**Ans.** *(d) Fascicle*

**Explanation:** The diagram given is that of the cross-sectional view of a muscle. The structure 'X' shown is a fascicle or a muscle bundle. A number of fascicles or muscle bundles are surrounded by a collagenous fascia.

**13. Identify the structure 'P' shown in the figure of meromyosin.**




**(a) LMM** **(b) Actin binding site**
**(c) ATP binding site** **(d) Cross arm**

**Ans.** *(c) ATP binding site*

**Explanation:** The structure 'P' shown in the figure is the ATP binding site. Each thick filament is made of meromyosin, which is a monomeric protein. Each meromyosin has a globular head which has an ATP binding site.

## Assertion-Reason(A-R)

**Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below:**

**(a) Both A and R are true and R is the correct explanation of A.**
**(b) Both A and R are true and R is not the correct explanation of A.**
**(c) A is true but R is false.**
**(d) A is false but R is true.**

**14. Assertion (A):** **Skeletal muscles are inextricably linked to the skeletal components of the body. These have a striped look under the microscope and are hence referred to as striated muscles, they are also referred to as voluntary muscles.**

**Reason (R):** **Their functions are controlled by the nervous system.**

**Ans.** *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** The skeletal muscles are able to work be under voluntary control due to the involvement of the nervous system.

**15. Assertion (A):** **There is a temporary stiffening of muscles after death.**

**Reason (R):** **There is a depletion of ATP that occurs with the stopping of cellular respiration.**

**Ans.** *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** This phenomenon is called "rigour mortis". There is a depletion of ATP that occurs with the stopping of cellular respiration that causes a stiffening of muscles.

**16.** **Assertion (A): The $Ca^{2+}$ ions play a crucial role in muscle contraction.**

**Reason (R): The $Ca^{2+}$ ions bind troponin causing the displacement of tropomyosin, allowing the myosin head to bind actin.**

**Ans.** *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** Muscle contraction is determined by the calcium ion level. The sliding of filaments is initiated by an increase in calcium ion levels in the sarcoplasm. The sarcoplasmic reticulum stores calcium ions. Calcium ions are released from the sarcoplasmic reticulum into the sarcoplasm around the thick and thin filaments when an action potential arrives. The calcium ions then bind to troponin, causing the troponin molecule's shape to change. Because troponin is bound to tropomyosin, the position of tropomyosin shifts. As a result, the tropomyosin-covered myosin-binding sites on actin are now exposed. Myosin head can now bind actin, causing the filaments to slide and contract the muscle.

**17.** **Staying active is vital for overall health, and it is also the best way to build skeletal muscle. People are best able to improve their muscle mass by performing the right exercises and eating particular foods.**

**Assertion (A): Muscular tissues have several unique properties. Examples are contraction, extension, excitation, elasticity, *etc.***

**Reason (R): Muscles originate from the ectodermal germinal layer.**

**Ans.** *(c) A is true but R is false.*

**Explanation:** Muscles originate from the mesodermal layer. The reason provided is incorrect.

## CASE BASED Questions (CBQs)

[ **4** & **5** marks ]

**Read the following passages and answer the questions that follow:**

**18.** *Each muscle fibre has a sarcolemma, which surrounds the sarcoplasm. Because the sarcoplasm includes several nuclei, muscle fibre is a syncytium. The sarcoplasm also contains sarcoplasmic reticulum, which, is a calcium ion storage compartment.*

*The sarcoplasmic reticulum (SR) can be functionally defined as a specialised form of the endoplasmic reticulum (ER) dedicated to $Ca^{2+}$ storage and release with respect to regulation of muscle contraction. The first studies showing the convoluted structure of the SR and the associated T-tubule system go back to the beginning of the 20th century when Veratti described a complex network of membrane structures, characterised by longitudinal tubules interconnected with large cisternae. The real structure of the SR was, however, fully appreciated only half a century later, following electron microscopy studies by Porter and Palade.*

**(A) Describe the role of calcium with regard to the changes in myofibril bands?**

**(B) What happens to the cross-bridge in a muscle fibre after ATP binding?**

**(C) Sarcolemma, sarcoplasm and sarcoplasmic reticulum are all different names for the parts of muscle. Which parts of the muscle do these names refer to?**

**Ans.** (A) As a result of the calcium changes, the connected actin filaments shift towards the middle of the A-band. The Z-line also moves inward, and the muscles contract due to sarcomere contraction. During muscular contraction, the I-band shortens while the A-band remains the same length. The cross-bridge is broken when the ADP and Pi-releasing myosin head return to its state of relaxation and then another fresh ATP binds, breaking the cross-bridge.

**Related Theory**

- *When ATP is hydrolysed again, cross-bridge formation and breakage occur.*
- *The process continues as the calcium ion concentration triggers the development of the action potential.*

(B) The cross-bridge is broken when a fresh ATP binds. The myosin head hydrolyses ATP again, and the cycle of cross-bridge formation and breakage is repeated, generating further sliding. The procedure is repeated until the $Ca^{2+}$ ions are pushed back into the sarcoplasmic cisternae, obscuring actin filaments. This causes the 'Z' lines to revert to their previous position, *i.e.*, relaxation.

(C) These names refer to the following parts of muscle:

**Sarcolemma:** Plasma membrane
**Sarcoplasm:** Cytoplasm
**Sarcoplasmic reticulum:** Endoplasmic reticulum

**19.** *The muscle fibre is a syncytium. A characteristics features of the muscle fibre is the presence of a large number of parallelly arranged filaments in the sarcoplasm called myofilaments or myofibril each myofibril has alternate dark and light bands on it.*

*Skeletal muscle fibres are classified into two types: type 1 and type 2. Type 2 is further broken down into subtypes.*

Type 1: These fibres utilise oxygen to generate energy for movement. Type 1 fibres have a higher density of energy-generating organelles called mitochondria. This makes them dark.

Type 2A: Like type 1 fibres, type 2A fibres can also use oxygen to generate energy for movement. However, they contain less mitochondria, making them light.

Type 2B: Type 2B fibres don't use oxygen to generate energy. Instead, they store energy that can be used for short bursts of movement. They contain even less mitochondria than type 2A fibres and appear white.

**[Mod. Delhi Gov. QB 2022]**

**(A) Why is muscle fibre called a syncytium?**
- **(a) As it is aseptate.**
- **(b) As it has more than one nuclei.**
- **(c) As it has more than one sarcoplasm.**
- **(d) As it has dark and light bands.**

**(B) Give a characteristic feature of muscle fibre.**
- **(a) Presence of myofilaments**
- **(b) Absence of myofilaments**
- **(c) Presence of branching pattern**
- **(d) Spindle-shaped appearance**

**(C) Name some visceral organs of the human body.**
- **(a) Femur, legs, arms**
- **(b) Oesophagus**
- **(c) Stomach**
- **(d) Both (b) and (c)**

**(D) Skeletal muscles are ..... .**
- **(a) Involuntary**
- **(b) Voluntary**
- **(c) Any of the above depending on the situation**
- **(d) Non-striated**

**(E) Assertion (A):** **Fatigue is the inability of muscles to relax.**
**Reason (R):** **It is due to lactic acid accumulation by repeated contractions.**
- **(a) Both A and R are true and R is the correct explanation of A.**
- **(b) Both A and R are true and R is not the correct explanation of A.**
- **(c) A is true but R is false.**
- **(d) A is false but R is true.**

**Ans.** (A) *(b) As it has more than one nuclei.*

**Explanation:** Muscle fibres, also known as skeletal muscle cells, are multinucleated syncytia that form during development when myoblasts, mononucleated progenitor cells, combine.

(B) *(a) Presence of myofilaments*

**Explanation:** The muscles are made up of muscle bundles in which the muscle fibres are arranged parallelly.

There are thick (myosin) and thin filaments (actin) that slide onto each other. The protein (actin) contributing to the myofilaments belongs to the group of cytoskeletal proteins - microfilaments.

The myofilaments are arranged in a functional unit known as a sarcomere.

**Caution**

- *Students usually get confused between myofilament and myofibril. Myofibrils are the building blocks of muscle fibres. The sarcolemma, which surrounds the muscle cell and contains the sarcoplasm, covers it. Myofilaments are found inside the myofibrils. They are lined up parallel to one another.*

(C) *(d) Both (b) and (c)*

**Explanation:** Visceral organs are the soft internal organs of the body, including the lungs, the heart, and the organs of the digestive, excretory, reproductive, and circulatory systems

(D) *(a) Involuntary*

**Explanation:** Skeletal muscles are voluntary muscles, meaning you control how and when they move and work.

(E) *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** The amount of ATP that is readily available decreases when voluntary muscles (skeletal muscles) are continuously activated or stimulated. Anaerobic and aerobic respiration then restores it. The rate of ATP synthesis by breathing eventually cannot meet the demands in the muscles if the continual stimulation persists. Fatigue occurs from this.

## VERY SHORT ANSWER Type Questions (VSA)

[ 1 mark ]

**20. Name the cells/tissues in the human body which:**
**(A) exhibit amoeboid movement**
**(B) exhibit ciliary movement**
**[NCERT Exemplar]**

**Ans.** (A) Macrophage cells and leucocyte cells.
(B) The Fallopian tube, trachea, and bronchioles.

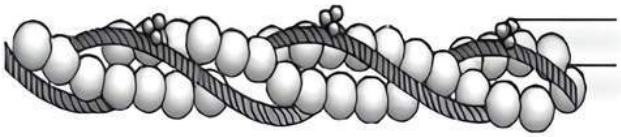
**21. ..... muscles possess no striation and are thus smooth in appearance.**

**Ans.** Smooth / Visceral

**22. Sarcolemma, sarcoplasm and sarcoplasmic refer to a particular type of cell in our body. Give the name of that particular cell to which all of the given parts belong.**

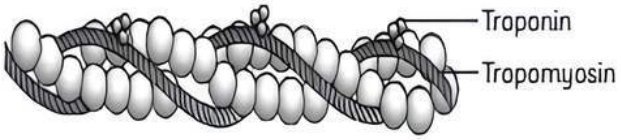
**Ans.** Muscle cells or muscle fibres

**23. Label the different components of actin filament in the diagram given below.**



**[NCERT Exemplar]**

**Ans.** Troponin and tropomyosin.




## SHORT ANSWER Type-I Questions (SA-I)

[ 2 marks ]

**24. Rahul exercises regularly by visiting a gymnasium. Later he gained weight. What could be the reason? [NCERT Exemplar]**

**Ans.** Rahul has gained weight owing to increased muscle and decreased fat since frequent exercise causes an increase in the quantity of sarcoplasm and thickness of myofibrils, as well as increased protein synthesis and a higher number of mitochondria.

**25. How is muscle contraction fuelled?**

**Ans.** ATP is the source of fuel for muscular contraction (Adenosine Triphosphate). In the presence of magnesium and calcium ions, an enzyme called ATPase located upon the head of the myosin molecule disintegrates into ADP and inorganic phosphate and emits in the head of the myosin.

**26. Radha was running on a treadmill at a great speed for 15 minutes continuously. She stopped the treadmill and abruptly came out. For the next few minutes, she was breathing heavily/fast. Answer the following questions.**
**(A) What happened to her muscles when she did strenuous exercise?**
**(B) How did her breathing rate change?**
**[NCERT Exemplar]**

**Ans.** (A) Her muscles become fatigued as lactic acid accumulated in the muscles as a result of the lack of oxygen throughout the workout.
(B) Breathing rate is altered because the body requires more oxygen during hard activity in order to produce more ATP to fulfil the energy requirement.

**27. Actin filaments are thicker than myosin filaments. True or false? Explain.**

**Ans.** Most of the cytoplasm consist of myofibrils, which and cylindrical bundles of two types of filaments—thick filament of myosin (about 15 nm in diameter) and thin filament of action (about 7 nm in diameter).

## SHORT ANSWER Type-II Questions (SA-II)

[ 3 marks ]

**28. What is muscle fatigue and what role does lactic acid play in this?**

**Ans.** Muscle fatigue is the reduction in the force of contraction of a muscle after prolonged stimulation. It has a number of possible causes including impaired blood flow, ion imbalance within the muscle, nervous fatigue, loss of desire to continue, and most importantly, the accumulation of lactic acid in the muscle.

The Krebs' cycle converts pyruvate produced by glycolysis into additional ATP molecules in the mitochondria during aerobic respiration. When there is insufficient oxygen, pyruvate cannot enter the Krebs cycle and accumulates in muscle fibre. Pyruvate is constantly converted into lactic acid.

Lactic acid production rises in response to pyruvate accumulation. The accumulation of lactic acid in muscle tissue lowers the pH, making it more acidic and causing the stinging sensation in muscles when exercising. This inhibits anaerobic respiration even more, causing fatigue.

**29. Name and elaborate the different "bands" found in a typical human myofibril.**

**Ans.** **'I' band:** Isotropic band; Light coloured, actin filaments attached to the two adjacent sarcomeres, thick and thin filaments do not overlap.

**'A' band:** Anisotropic band; Dark band; It contains overlapping actin filament and non-overlapping myosin filaments.

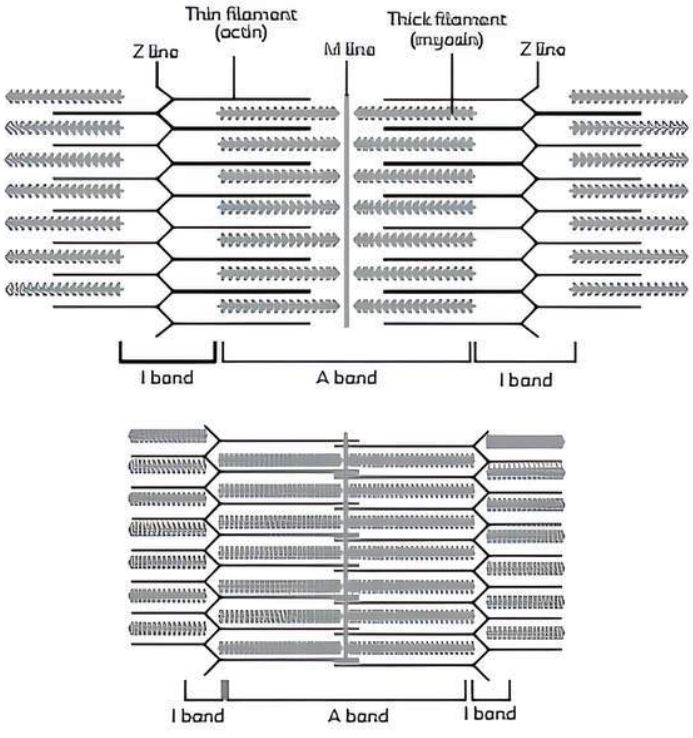
**'H' zone:** Middle portion of the thick filaments; part of thick filaments where thin filaments are absent, only thick filaments are present.

## LONG ANSWER Type Questions (LA)

[ 4 & 5 marks ]

**30. The sliding filament theory of muscle contraction is the most well accepted theory of muscle contraction. Explain this with a neat sketch.**

**Ans.** According to the sliding filament theory, muscle fibre contraction is caused due to the sliding of thin filaments over thick filaments. The thin filament is referred to as actin, as well as the thick filament is referred to as myosin. In muscle fibres with contractile protein filaments termed actin and myosin, alternate light and dark bands will be seen. The fibre that bisects each one of the I bands contains a Z-line elastic fibre.



Signals for muscle contraction come from the central nervous system *via* motor neurons. Signals reach the neuromuscular junction or motor end plate. As neural signals reach the terminal end of the axon, synaptic vesicles fuse with the axon membrane and release a chemical neurotransmitter acetylcholine. This acetylcholine binds with receptors and depolarisation of the membrane occurs. Due to this action potential is generated in sarcolemma. This spreads through the muscle fibre and causes the release of calcium ions into the sarcoplasm. Due to the increase in calcium ions in sarcoplasm, there is a binding of calcium ions with subunit of troponin present on actin filament and thus removes the masking of the active site for myosin. Now myosin head, by using energy produced by ATP hydrolysis, binds to the exposed active binding site on actin to form a cross bridge. This pulls the thin filaments towards the centre of thick filament (A - band). Z-line also pulled inwards causing the length of sarcomere to shorten, *i.e.* muscle contraction. But it is clear that during muscle contraction, length of the sarcomere gets reduced and also I-bands are reduced in length, but there is no change in the length of A-band *i.e.* thick filament. By releasing ADP and P*i*, the myosin goes back to its relaxed state.

**31. How does a muscle shorten during its contraction and return to its original form during relaxation? [NCERT Exemplar]**

**Ans.** The stages that occur during the contraction and relaxation of muscles are as follows:

(1) When the brain signal is given to the neuromuscular junction and acetylcholine is released, the neurotransmitter acetylcholine generates an action potential in the sarcolemma.

(2) Calcium ions are released as a result of this action potential, and they propagate across muscle fibres.

(3) Calcium ions attach to the troponin subunit on the actin filament owing to an increase in calcium ion concentration, further removing active sites in myosin.

(4) Myosin binds to actin, forming a cross bridge.

(5) As a result, the connected actin filaments shift towards the middle of the A-band. The Z-line is also pulled inward, and the muscles contract due to sarcomere contraction. During muscular contraction, the I-band shortens while the A-band remains the same length.

(6) The cross-bridge is broken when the ADP and P*i*-releasing myosin returns to its state of relaxation and then another fresh ATP binds, breaking the cross-bridge. When ATP is hydrolyzed again, cross-bridge creation and breakdown occur.

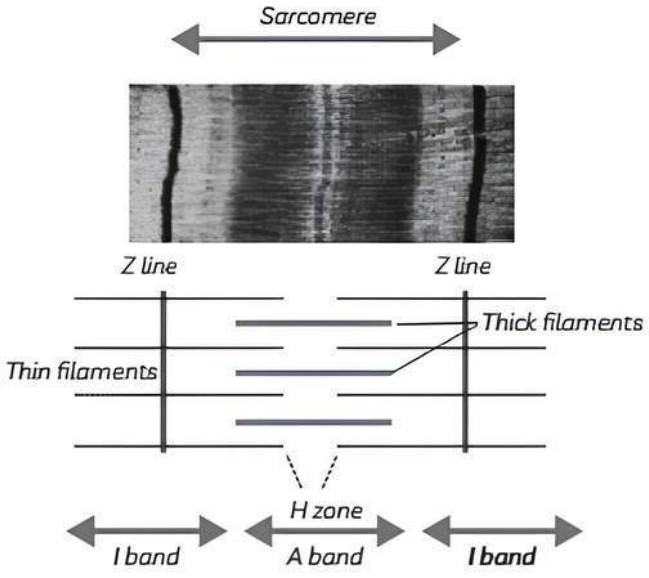
(7) The process continues as the calcium ion concentration triggers the development of the action potential.

**32. Sahil recently read about myofibril in a book which he bought from a book fair held in Patna. What is myofibril? Describe its structure.**

**Ans:** A large number of parallelly arranged filaments are present in the sarcoplasm called myofilaments or myofibrils. It is a distinguishing feature of muscle fibres. Each myofibril has dark and light bands present in an alternate manner.

The striated appearance is caused by the distribution pattern of two key proteins: Actin and Myosin. The light bands, known as I-bands or Isotropic bands, contain actin, whereas the dark bands, known as 'A' bands or Anisotropic bands, include myosin. Each 'I' band has an elastic fibre termed 'Z' line that bisects it in the middle. The tiny filaments are tightly wound around the 'Z' line.

A thin fibrous membrane termed the 'M' line, holds the thick filaments in the 'A' band together in the centre of this band. The 'A' and 'I' bands are alternately positioned throughout the span of the myofibrils. A sarcomere is a functional unit of contraction that is defined as the region of the myofibril between two successive 'Z' lines.




**Caution**

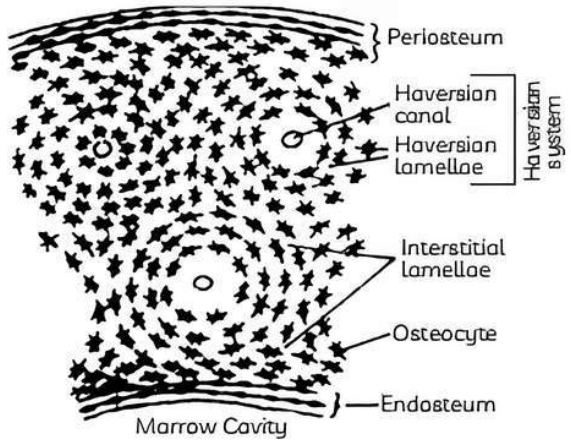
*Students should know that in a resting condition, the margins of the thin filaments on each end of the thick filaments partially overlap the free ends of the thick filaments, leaving the thick filaments' middle half exposed. The 'H' zone refers to the middle region of a thick filament that is not overlapped by thin filaments.*

# SKELETAL SYSTEM AND DISORDERS 2

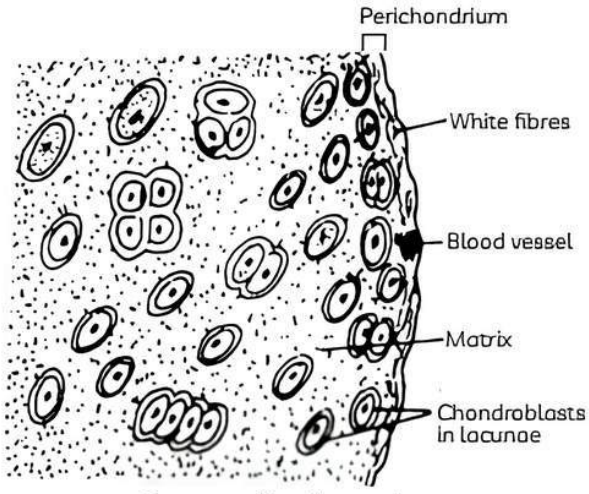
## TOPIC 1

## SKELETAL SYSTEM

The hard external and internal, supportive and protective structures of the organism form the skeleton or skeletal system. The hard external structures are called exoskeleton: Nails, hairs, *etc.* The hard, endoskeleton systems are present inside the body of animals. It consists of a framework of bones and cartilages. These are specialized connective tissues. Bones are hard and have a great tensile strength. Bones consist of a tough matrix containing cells in fluid, collagen fibres, blood vessels, nerves, minerals and fat. Strength of bone is due to collagen fibres and minerals inside the matrix. The minerals are calcium salts. Cartilages are softer than bones. It consists of a slightly pliable matrix due to chondroitin salts.




*T.S. of bone*




*Structure of hyaline cartilage*

### Functions of Skeletal System

(1) The skeleton system forms a rigid framework which provides support to the body.

(2) It provides protection to delicate body parts.

(3) It provides and maintains the shape of the body.

(4) It provides attachment for large muscles.

(5) It has a significant role in movement due to the contraction of muscles.

(6) It helps in breathing and hearing due to the presence of larynx, trachea, ribs and ear ossicles.

(7) It is the site of blood formation of RBCs, WBCs and Platelets (Bone marrow).

(8) It works as a reservoir of minerals (calcium and phosphorus).

In human beings, the skeletal system is made up of 206 bones and a few cartilages. On the basis of the position of skeletal structure, it is divisible into two parts: Axial skeleton (consists of skull, vertebral column, sternum and ribs) and appendicular skeleton (consists of pectoral and pelvic girdles and bones of arms and legs).

### Axial Skeleton

It occupies body's main axis. It comprises of 80 bones and includes four structures: Skull, Vertebral column, Sternum and Ribs.

#### Skull

It is the bony framework of the head and is supported on the top of the vertebral column. It is the hardest and densest part of the body and consists of two parts: Cranial and facial.

(1) **Cranial bones:** Cranials formed by 8 bones, which are: 1 frontal, 2 parietal, 2 temporal, 1 occipital, 1 sphenoid and 1 ethmoid bone. The most important function of this is to protect the brain by forming the hard protective outer covering.

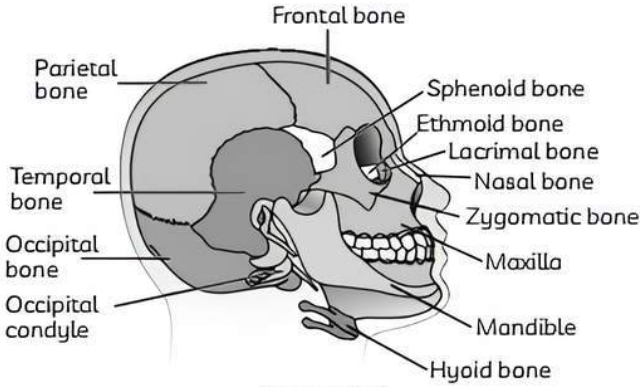
(2) **Facial bones:** There are 14 bones which form the skeleton of the face. It lies under the anterior part of the cranium. It includes 2 zygomatic, 2 maxilla, 2 nasal, 2 lacrimal, 2 palatines, 2 inferior nasal

conchae or turbinated bone, 1 mandible and 1 vomer. It forms the jaw to support the mouth and helps for cutting and masticating its food.

(3) **Hyoid bone:** It is located at the base of the buccal cavity. It serves as a point of attachment for some of the muscles of the tongue.

(4) **Ear ossicles:** Also known as auditory capsules present on either side of the cranium contain three small bones *i.e.*, 2-malleus, 2-incus and 2-stapes. These bones are movable to help in hearing.

At the posterior end of the cranium, there are two rounded protuberances, the occipital condyles that articulate with the region of the vertebral column. Thus the human skull is dicondylic.



*Human skull*

**Important**

➥ *Unossified parts of a newborn skull are called fontanelles.*

**Example 2.1: Case Based:**

*Skull is a large, hollow, rounded part of the skull. Its cavity is termed as cranial cavity. It encloses the brain during life. Hence it is also called the brain box. The dome shape of the cranium protects the brain as blows are more likely to glance off a rounded surface. Moreover, a rounded surface offers more mechanical strength than does a flat surface. The cranium is formed of eight flattened bones. A large hole at the base of the skull allows the brain to continue into the spinal cord located in the backbone. At the anterolateral aspects of the foramen magnum are a pair of large, smooth protuberances, the occipital condyles that movably articulate with the atlas vertebra forming a hinge joint that permits nodding of the head.*

(A) **The ..... is the only movable part of the skull.**
- (a) nasal conchae
- (b) mandible
- (c) vomer
- (d) maxilla

(B) **Which one of the following is not a skull bone?**
- (a) Sternum
- (b) Occipital bone
- (c) Vomer
- (d) Pterygoid

(C) **Give a reason why the atlas vertebra is also called 'yes' bone.**

(D) **What are sutures?**

(E) **Assertion (A): Skull is dicondylic in man.**
**Reason (R): A pair of occipital condyles located anterolateral to foramen magnum movably articulate with the atlas vertebra.**
- (a) **Both A and R are true and R is the correct explanation of A.**
- (b) **Both A and R are true and R is not the correct explanation of A.**
- (c) **A is true but R is false.**
- (d) **A is false but R is true.**

**Ans.** (A) *(b) mandible*

**Explanation:** The only bone in the skull that forms a freely movable part is the mandible while the rest of the bones are immovable.

(B) *(a) Sternum*

**Explanation:** Sternum is not a skull bone while occipital, vomer and pterygold are skull bones.

(C) Atlas vertebra is also called 'Yes' bone because atlas provides nodding movement to the skull.

(D) Sutures are fibrous bands of tissue that join the bones of the skull. The cranial bones fit together by wavy, immovable boundaries called sutures. This help to dissipate the shock of a blow to the head.

(E) *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** The skull of a man contains two condyles. These condyles arise from the occipital bone of the skull on either side of the foramen magnum and are articulated with Atlas, the first cervical vertebra. Hence man is said to have a dicondylic skull.

## Vertebral Column

The Vertebral column is also called backbone or spine. It consists of 26 bones, in this 5 sacral vertebrae are fused to form one sacrum and four coccygeal vertebrae are fused to form one coccyx. It extends from the base of the skull and constitutes the main framework of the trunk. It is lying in the mid dorsal line of the neck and trunk. The vertebrae are grouped into five groups:

(1) **Cervical Vertebrae:** These are 7 in number present in the neck. First cervical vertebra is called atlas and it articulates with the occipital condyles of the skull. Second cervical vertebra is called the axis.

(2) **Thoracic Vertebrae:** Thoracic vertebrae are 12 in number present in the chest region, they articulate with ribs.

(3) **Lumbar vertebrae:** These are 5 in number present in the abdomen. These are the largest and strongest.

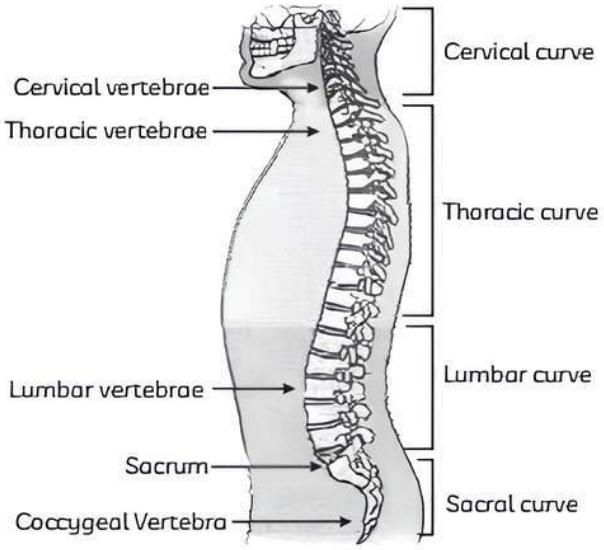
(4) **Sacrum:** Sacrum 1 in numbers. The five sacral vertebrae are fused to form one sacrum in adults. It lies between the bones of the pelvic girdle.

(5) **Coccyx:** Coccyx is also 1 in number. It is formed by the fusion of the four coccygeal vertebrae.

### Important

➥ *In females, the coccyx points inferiorly but in males, it points anteriorly. It is considered as vestigial tail.*

Each vertebra has a central hollow portion, *i.e.* neural canal through which the spinal cord passes. It protects the spinal cord. It strengthens the neck and trunk for upright posture, it supports the ribs and provides flexibility to trunk and free movement to head.




*Vertebral column*

### Sternum or Breast Bone

It is a flat bone which is located in the middle of the front of the chest or thorax. It is about 15 cm in length. Its shape is like a dagger and consists of three parts:

(1) the manubrium is the uppermost part,

(2) the body is the middle part and

(3) the xiphoid process is the tip of the bone.

Its main function is to protect the internal organs in the thoracic region. It also helps in muscle attachment and in respiratory mechanisms.

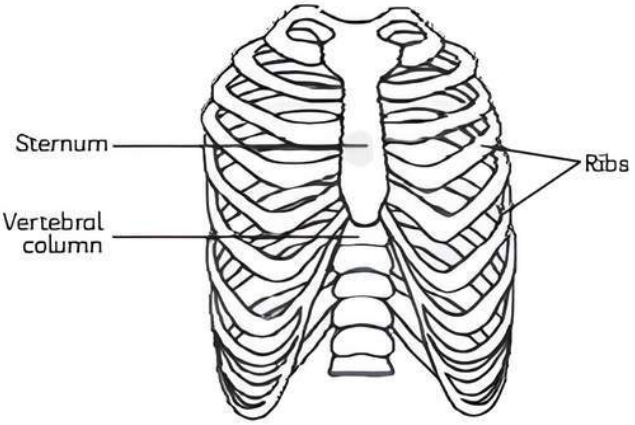
### Ribs

(1) There are 12 pairs of ribs. Each rib is a thin flat bone which is connected dorsally to the vertebral column (thoracic vertebrae) and ventrally with the sternum. The first seven pairs are called true ribs because they are attached directly to sternum by small piece of hyaline cartilage called costal cartilage.

(2) The eighth, ninth and tenth pair of ribs are false ribs because they do not articulate directly with the sternum but articulate by hyaline cartilage of the seventh rib.

(3) The last two pairs are called floating ribs because they are not attached to either the sternum or the cartilage of another rib. The floating ribs protect the kidneys.

The thoracic vertebrae, ribs and sternum together form the rib cage. The ribs protect the delicate organs like heart, lungs, etc., present in the thoracic cavity. Ribs provide the surface for the attachment of the muscles concerned with respiratory mechanism.




*Ribs and rib cage*

**Example 2.2:** **Fill in the blanks:**

**(A) All mammals (except a few) have ..... cervical vertebra.**

**(B) The number of phalanges in each limb of a human is ..... .**

**(C) ..... and ..... pairs of ribs are called floating ribs.**

**(D) The human cranium is made up of ..... .**

**[NCERT Exemplar]**

**Ans.** **(A)** seven

**(B)** fourteen

**(C)** Eleventh, twelfth

**(D)** eight

**Example 2.3:** **Write true or false. If false, change the statement so that becomes it true.**

**(A) Actin is present in thin filament.**

**(B) H-zone of striated muscle fibre represents both thick and thin filaments.**

**(C) Human skeleton has 206 bones.**

**(D) There are 11 pairs of ribs in a man.**

**(E) Sternum is present on the ventral side of the body.**

**Ans.** **(A)** True

**(B)** False - The striated muscle fibre's H-zone exclusively contains thick filaments.

**(C)** True.

**(D)** False - Man has 12 pairs of ribs.

**(E)** True.

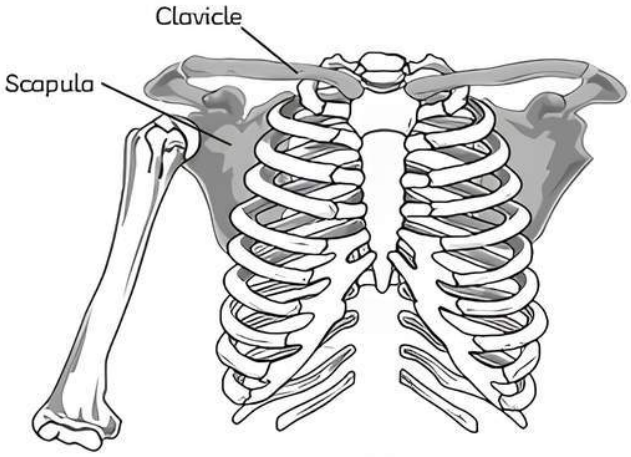
## Appendicular Skeleton

It is situated at the lateral sides which actually extend outwards from the principal axis. It mainly contains pectoral girdle and pelvic girdle and the bones of arms and legs.

### Pectoral Girdle

It is located on the posterolateral aspect of the upper region of the thorax. It consists of two bones: Clavicle and Scapula.

The clavicle also called the collar bone, is a rod-like bone. It extends horizontally from the base of the neck to the shoulder. Scapula is a large triangular flat bone situated in the dorsal part of the thorax between the second and the seventh ribs. The scapula is also known as the shoulder blade. Its dorsal, flat and triangular body has a slightly elevated ridge called spine. The end of the spines projects as a flattened and expanded process called acromion; this process articulates with the clavicle. Below the acromion is a shallow articular surface called glenoid cavity into which the head of the humerus is articulated and the main function of the pectoral girdle is to provide articulation to arm bones and attachment of the arm muscles.

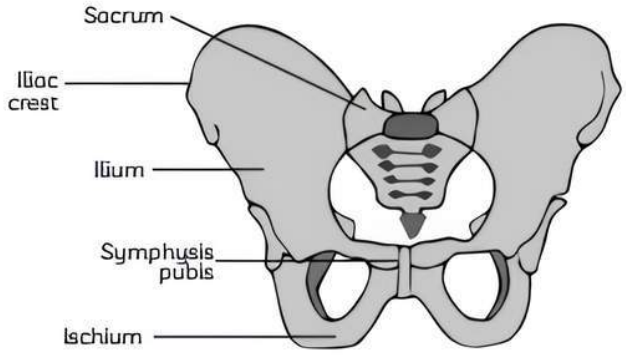



*Pectoral girdle*

### Pelvic Girdle

It is located in the lower part of the trunk. It consists of two coxal bones and each bone is formed by fusion of three bones: Ilium, ischium and pubis. These bones fused to form a stout hip bone, the innominate. On its outer surface, it has a deep depression called acetabulum where the head of the femur is articulated and forms a hip joint. The two halves of the pelvic girdle meet ventrally to form the pubic symphysis which is made up of white fibrous cartilage.

Apart from articulating with the legs, the pelvic girdle supports the posterior region of the trunk.




*Pelvic girdle*

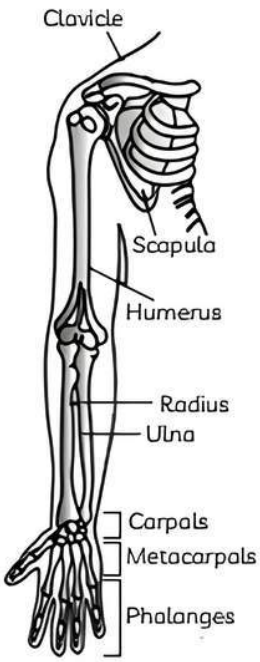
### Limb Bones

(1) **Arm bones:** Each arm consists of the 30 bones which are 1 humerus, 1 radius, 1 ulna, 8 carpal (wrist bone), 5 metacarpals (palm bones) and 14 phalanges (digits). Bones of arms provide strength to make the arms effective in working with them and give support to the shoulders by articulating the head of the humerus.

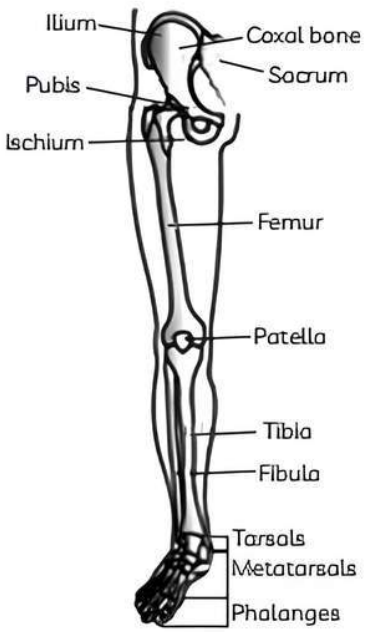
(2) **Leg bones:** Each leg consists of 30 bones which are 1 femur (longest thigh bone), 1 tibia, 1 fibula, 1 patella (knee cap), 7 tarsal bones (ankle bones), 5 metatarsal, 14 phalanges (digits). Bones of legs are for strengthening the legs to bear the body weight and to balance the body while standing and walking.

### Important

➥ *Patella is also called the largest sesamoid bone as these bones are formed by ossification in the tendons of quadriceps femoris muscle at the joints.*




*Pectoral girdle and upper arm*




*Pelvic girdle and lower limb*

**Example 2.4:** Differentiate between pectoral and pelvic girdles. [NCERT Exemplar]

**Ans.**

| S. No | Pectoral Girdle | Pelvic Girdle |
|---|---|---|
| (1) | It is found in the shoulder region. Hence, also called shoulder girdle. | It is found in the hip region. Hence, also known as the hip girdle. |
| (2) | There are two separated pectoral girdles. Each consists of two bones: One clavicle and one scapula (Total 4 bones) | There is one pelvic girdle formed by two innominate bones consisting of three bones: Ileum, ischium, and pubis. |
| (3) | It has no articulation with the vertebral column. | It has articulation with the vertebral column. |
| (4) | It has a glenoid cavity in which the head of the humerus is articulated. | It has a deep depression called acetabulum in which the head of the femur is articulated. |
| (5) | Bones are lighter because it is not subject to much stress. | Bones are thicker because it is subject to much stress. |

**Example 2.5:** Case Based:

*The femur is the longest and strongest bone in the body. Its upper end has a rounded head, a constricted neck and a greater trochanter. Head of the femur articulates into the acetabulum of the pelvic girdle. There is a long shaft. The lower end is divided into two condyles with an intercondylar fossa in between. Patella is a flat, sesamoid bone, formed by ossification in the tendon of quadriceps femoris muscle. Tibia is longer, thicker and lies more medially and front. Fibula is shorter, thinner and located more laterally and deeply. Each ankle is composed of seven tarsals.*

(A) Acetabulum is present in which joint:
(a) Hip (b) Knee
(c) Elbow (d) Shoulder

(B) Total number of bones present in the leg:
(a) 30 (b) 24
(c) 26 (d) 19

(C) How do ilium and ileum differ?

(D) What are the adaptations in the skeleton for upright posture?

(E) Assertion (A): Femur is located in the thigh of hindlimb.
Reason (R): Femur head is round and articulates in the glenoid cavity of pelvic girdle.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Ans.** (A) *(a) Hip*

**Explanation:** Acetabulum is the cup-shaped cavity of pelvic girdle into which the head of the femur fits so it is only present in hip bone whereas it is absent in others.

(B) *(a) 30*

**Explanation:** Each leg contains 30 bones: Femur, patella, tibia, fibula, 7 tarsals, 5 metatarsals and 14 phalanges.

(C) Ilium is the upper bone of pelvic girdle that helps in the movement or locomotion, ileum is the distal part of small intestine that help in absorption of digestion products.

(D) The adaptations for upright posture are: Foramen magnum is directed downward so head may rest vertically on vertebral column, four curves in backbone help to maintain balance and walk erect, legs bones are stronger than arms as the former carries the entire weight of the body and broad feet provide stability in the upright posture.

(E) *(c) A is true but R is false.*

**Explanation:** Femur is located in the thigh of the hindlimb and its head is round and articulates in the acetabulum of pelvic girdle whereas humerus head articulates in glenoid cavity of pectoral girdle.

## TOPIC 2

## JOINTS

The structural arrangement of tissues by which bones are joined together is called joint. Joints are points of contact between bones or between bones and cartilages. Force generated by the muscles is used to carry out movement through joints, where the joint acts as a fulcrum. According to mobility, joints are classified into three main structural forms: Fibrous or fixed or immovable joints, cartilaginous or slightly movable joints and synovial or freely movable joints.

### Fibrous or Immovable Joints

This type of joint is immovable, *i.e.* there is no movement between the bones as there are white fibrous collagen fibres which hold the bones together. This type of joint is seen between the bones of the skull or cranium. In this joint, the bones fused end to end.

### Cartilaginous or Slightly Movable Joints

The slightly movable joints are present between the vertebrae. The joint between the two adjacent vertebrae shows such a type of movement. There is a pad of white fibrocartilage between the ends of the bones which allows them for a slight movement. They are joined together with the help of cartilage. For example: The pubic symphysis of pubis and the joints between the vertebrae.

### Synovial or Freely Movable Joints

The freely movable joints are present mostly between the limb bones which shows great movement. The membrane of this joint contains secretory cells which secrete a thick sticky fluid called synovial fluid which acts as a lubricant to the joints. This fluid lubricates the joint to allow frictionless movement of bones. Bones ends are covered by articular cartilage. On the basis of the shape of bones and the types of movement, the synovial joints are of six types:

(1) **Ball and socket joint:** Can move nearly in all directions. A ball-like structure present on one bone fits into a socket-like structure of another bone. *Eg.* Shoulder and hip joints are the examples of ball and socket joints. Shoulder joint is present between the glenoid cavity of the pectoral girdle and head of the humerus and hip joint is present between acetabulum of pelvic girdle and head of femur.

(2) **Hinge joint:** Allows movement in one plane like the knee joint, elbow joint, ankle joint and interphalangeal joints.

(3) **Gliding joint:** It is the simplest synovial joint. It permits sliding movement over each other like between carpals and tarsals.

(4) **Pivot joint:** Allows only a rotary movement of one bone on another. These are the joints between the atlas and axis vertebrae.

(5) **Saddle joint:** This enables the thumb to move in many directions. This joint is present between the carpal and metacarpal of the thumb of the hand.

(6) **Ellipsoid joint:** Allows movement in two directions side to side or back and forth. This type of joint is found in metacarpals and phalanges and also wrist joints.

**Important**

➥ *The study of joints is called Arthrology.*

**Example 2.6: Name the type of joints between the following:**

**(A) Atlas / Axis**
**(B) Carpal / metacarpal of thumb**
**(C) Between phalanges**
**(D) Femur**
**(E) Between pubic bones in the pelvic girdle.**

**[NCERT Exemplar]**

**Ans.** (A) Pivot joint
(B) Saddle joint
(C) Hinge joint
(D) Ball and socket joint
(E) Ball and socket joint

## TOPIC 3

# DISORDERS OF MUSCULAR AND SKELETAL SYSTEM

### Myasthenia Gravis

It is an autoimmune disorder affecting neuromuscular junction leading to fatigue, weakening and paralysis of skeletal muscle.

### Muscular Dystrophy

Inborn genetic abnormality of muscle. In this disorder there is a progressive degeneration of skeletal muscles. Due to the lack of a protein called dystrophin, muscular dystrophy occurs.

### Tetany

It is a muscular disorder in which rapid spasms in muscles occur due to low calcium in the body fluid.

### Arthritis

It refers to inflammation of joints.

### Osteoporosis

It is a reduction in bone mass due to lost minerals and fibres from its matrix and increased chances of fractures. The common cause is decreased levels of estrogen. It is an age-related disorder.

### Gout

Gout is another form of arthritis related to diet in which the body forms excess amounts of uric acid and its salts. The crystals of uric acid and sodium urates are deposited in the synovial joints due to which movement becomes difficult.

# OBJECTIVE Type Questions

[ 1 mark ]

## Multiple Choice Questions

**1.** How many total bones are present in the human skull?

(a) 26 (b) 29

(c) 30 (d) 19

**Ans.** *(b) 29*

**Explanation:** The total number of bones present in the human skull is 29. Out of which, 8 are cranium bones, 6 are ear ossicles, 1 is hyoid bone and 14 are facial bones.

**2.** Which pair of ribs are called false ribs?

(a) First seven

(b) Eighth, ninth and tenth

(c) Last two pairs

(d) All of the above

**Ans.** *(b) Eight, ninth and tenth*

**Explanation:** The eighth, ninth and tenth pairs of ribs are called false ribs whereas the first seven are true ribs and last two pairs are floating ribs.

**Related Theory**

*These ribs are called false ribs because they are indirectly attached to the sternum. They articulate with the help of costal cartilage. For ribs 8–10, the costal cartilage is attached to the cartilage of the next higher rib. Thus, the cartilage of rib 10 attaches to the cartilage of rib 9, rib 9 then attaches to rib 8, and rib 8 is attached to rib 7.*

**3.** Which bone of the skull is found at the root of the tongue in the front of the neck or at the base of a buccal cavity?

(a) Sphenoid bone (b) Stapes

(c) Maxilla (d) Hyoid bone

**Ans.** *(d) Hyoid bone*

**Explanation:** Hyoid bone is a U-shaped bone which is found at the base of buccal cavity and upper part at the root of the tongue in the front of the neck whereas sphenoid bone is a bone of cranium, stapes is an ear ossicle and maxilla is a facial bone.

**4.** Which one of the following pairs is incorrect?

(a) Hinge joint: between the humerus and pectoral girdle.

(b) Pivot joint: between the atlas and axis.

(c) Gliding joint: between the carpals.

(d) Saddle joint: between the carpals and metacarpals of thumb.

[NCERT Exemplar]

**Ans.** *(a) Hinge joint: between the humerus and pectoral girdle*

**Explanation:** The humerus and pectoral girdle is not a hinge type joint. The joint between the humerus and pectoral girdle is the ball and socket joint where rest are all correctly paired.

**Related Theory**

*In the ball and socket joint, one bone forms a ball-like head whereas the other forms a socket in which the head fits. This type of joint can move nearly in all directions.*

**5.** Inter-articulated disc is found in:

(a) Limb bones (b) Vertebrae

(c) Skull bones (d) Hip bones

**Ans.** *(b) Vertebrae*

**Explanation:** The upper vertebrae are articulated and separated by the elastic pad of fibrocartilage called intervertebral discs.

**6.** Which of the following is an autoimmune disorder?

(a) Muscular dystrophy

(b) Myasthenia gravis

(c) Tetany

(d) Osteoporosis [Diksha]

**Ans.** *(b) Myasthenia gravis*

**Explanation:** Myasthenia gravis is an autoimmune disorder that affects neuromuscular junction whereas muscular dystrophy is a genetic defect, tetany is due to lesser calcium ions in body and osteoporosis is an age-related disorder.

**7.** Which joint is present between the carpals in the wrist?

(a) Hinge joint (b) Saddle joint

(c) Pivot joint (d) Gliding joint

**Ans.** *(d) Gliding joint*

**Explanation:** The joint present between the carpals in the wrist is a gliding joint as they permit sliding movement of two bones over each other whereas rest joints are not present in this.

**8.** Which one of the following is showing the correct sequential order of vertebrae in the vertebral column of human beings?

(a) Cervical - lumbar - thoracic - sacral - coccygeal

(b) Cervical - thoracic - sacral - lumbar - coccygeal

(c) Cervical - sacral - thoracic - lumbar - coccygeal

(d) Cervical - thoracic - lumbar - sacral - coccygeal

**Ans.** *(d) Cervical - thoracic - lumbar - sacral - coccygeal*

**Explanation:** The correct sequence of vertebrae in vertebral column of humans is 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 5 fused to form one sacral vertebrae, 4 coccygeal vertebrae fuse to form 1 coccyx.

**Related Theory**

➥ *Coccyx is a triangular bone that consists of 3 to 5 fused vertebrae, the largest of which articulates with the last sacral vertebra.*

**9. Which of these is an example of a hinge joint?**

(a) Between the carpals

(b) Between the carpal and metacarpal of thumb

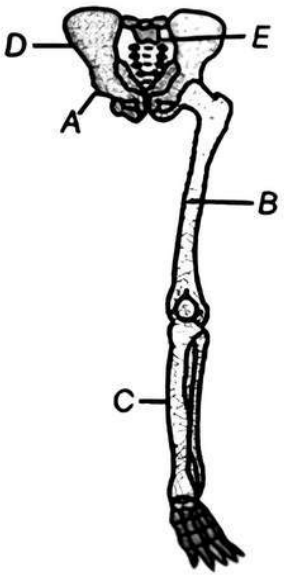
(c) Knee joint

(d) Between the atlas and axis

**Ans.** *(c) Knee joint*

**Explanation:** An example of a hinge joint is the knee joint. It is a type of synovial joint. Hinge joints are also present at the ankles, interphalangeal joints and elbows. It allows movement along only one axis.

**10. The diagram given below shows the pelvic girdle and lower limb.**




**Parts labelled as 'A', 'B', 'C', 'D' and 'E' respectively indicate:**

(a) Pubis, tibia, femur, ilium and sacrum

(b) Ilium, tibia, femur, pubis and sacrum

(c) Pubis, tibia, femur, ilium and ulna

(d) Pubis, femur, tibia, ilium and sacrum

**Ans.** *(d) Pubis, femur, tibia, ilium and sacrum*

**Explanation:** The hip bone is made up of the bones ilium, ischium and pubis. The sacrum is the bone that is joined with the hip bone to form the pelvis. The pubis or pubic bone is the bone at the bottom and in front of the pelvis in the pubic area. The head of the femur bone whose head fits into the cavity of the pelvic girdle. It is the thigh bone which is the longest bone of the body. The bone forming the inner lower leg is called tibia and the bone forming outer lower leg is fibula.

**11. A cricket player is fast chasing a ball in the field. Which one of the following groups of bones is directly contributing to this movement?**

(a) Femur, malleus, tibia, metatarsals

(b) Pelvis, ulna, patella, tarsals

(c) Sternum, femur, tibia, fibula

(d) Tarsals, femur, metatarsals, tibia

**Ans.** *(d) Tarsals, femur, metatarsals, tibia*

**Explanation:** Tarsals, femur, metatarsal and tibia are directly contributing to the movement when a cricket player is chasing a ball in the field. These are the bones of lower limb responsible for walking or running.

## Assertion-Reason (A-R)

**Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below:**

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true and R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

**12.** **Assertion (A):** The upper end of radius and ulna articulate with each other by the pivot joint.

**Reason (R):** The primary movement at the pivot joint is rotational.

**Ans.** *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** In the pivot joint, it allows only rotary movement of one bone on another which remains stationary. A round end of one bone fits into a shallow pit of another bone. The joint between radius and ulna is an example of a pivot joint.

**13.** **Assertion (A):** Synovial joints are immovable.

**Reason (R):** Presence of synovial fluid makes them freely movable.

**Ans.** *(d) A is false but R is true.*

**Explanation:** Synovial joints are freely movable because it contains synovial fluid which acts as a lubricant and enables their free movement by avoiding the friction. The examples are hinge joint, ball and socket joint.

**14.** **Assertion (A):** Acetabulum bone is found in the pelvic girdle.

**Reason (R):** Acetabulum is made up of one clavicle and one scapula.

**Ans.** *(c) A is true but R is false.*

**Explanation:** Acetabulum is found in the pelvic girdle and it is formed by the fusion of three bones- ilium, ischium and pubis which allow us to move freely and walk.

**15.** **Assertion (A):** Last two pairs of ribs are floating ribs.

**Reason (R):** Their sternal parts are not attached anywhere.

**Ans.** *(a) Both A and R are true and R is the correct explanation of A.*

**Explanation:** The last two pairs of ribs are floating because their anterior ends are not attached to either the sternum or the cartilage of another rib.

**16.** **Assertion (A):** Inflammation of a skeletal joint may immobilise the movement of joints.

**Reason (B):** Uric acid crystals in the joint cavity and ossification of articular cartilage leads to this condition.

**[Delhi Gov. QB 2022]**

**Ans.** *(a) Both A and R are true and R is the correct explanation of A*

## CASE BASED Questions (CBQs)

[ **4** & **5** marks ]

**Read the following passage and answer the questions that follow:**

**17.** *The remains of an individual were brought to attention in the 1980s when a citizen saw some of the bones on an outcropping in the mountains of Albion, Idaho. What remained was scattered bones and parts of decomposed clothes. The remains were the majority of a skeleton, with only the kneecaps, hands, wrists, hyoid, a few vertebrae and the skull missing. A newspaper was found in one the pockets of the decaying clothes, with a date in the 1920s. This allowed initial investigators to pinpoint the individual as one of three individuals who went missing in that time frame. From there investigators were able to get an identification by interviewing the families of those missing. The man was identified as a Ferrier (a craftsman who trims and shoes horses' hooves) in his late twenties. Once the remains had been identified, the case was turned over to the local pathologist to clearly determine manner and cause of death. Our age estimation, as seen in our result, is at an older range than the age identified. This is most likely due to the evident biomechanical stress, as seen in our 'pathologies' section – wear on the bone that can cause a skeleton to look older than it is. The bones also had prominent muscle attachments which is indicative of a heavily muscled individual, consistent with the occupation as a Ferrier.*

**(A) Give one difference between bone and cartilage.**

**(B) Write the functions of the skeleton in vertebrates.**

**(C) How many parts, the human skeleton is divided into? Name them.**

**Ans.** (A) Bones are solid, rigid made up of a matrix which contains calcium phosphates, calcium carbonates and magnesium whereas cartilage is firm and flexible due to the presence of chondroitin salts in the matrix.

(B) Skeleton serves a number of functions:

(1) It supports the body and forms a rigid framework which gives and maintains the shape of the body.

(2) It encloses vital organs and gives protection to them.

(3) Help in movement of body.

(4) Help in hearing, breathing and fat storage.

(C) The human skeleton is divided into two parts: Axial skeleton and Appendicular skeleton.

**18.** *As Sophia discovered in the beginning of the chapter, wearing high heels can result in a condition called metatarsalgia. Metatarsalgia is named for the metatarsal bones, which are the five bones that run through the ball of the foot just behind the toes.*

*Don't think you are immune to stress fractures just because you don't wear high heels! This injury also commonly occurs in people who participate in sports involving repetitive striking of the foot on the ground, such as running, tennis, basketball, or gymnastics. They may be avoided by taking preventative measures. You should ramp up any increase in activity slowly, cross-train by engaging in a variety of different sports or activities, rest if you experience pain, and wear well-cushioned and supportive running shoes. It is important to know that your cardiovascular and muscular systems adapt to an increase in physical activity much more quickly than the skeletal system.*

**(A) Which one of the following is not a function of bone?**

**(a) Place for muscle attachment.**

**(b) Protection of vital organs.**

**(c) Secretion of hormones for calcium regulation in blood and bones.**

**(d) Production of blood corpuscles.**

**(B) The hollow space in the middle of bones is filled with:**

**(a) air** **(b) blood**

**(c) bone cells** **(d) bone marrow**

**(C) Choose the incorrect option:**

**(a) Bones are where most blood cells are made.**

**(b) Bone serves as a storehouse for various minerals.**

**(c) Bone is a dry and non-living supporting structure.**

**(d) Bone protects and supports the body and its organs.**

**(D) What makes bones so strong?**

**(a) Silica**

**(b) Cartilage**

**(c) Blood and marrow**

**(d) Calcium and phosphorus.**

**(E) In mammals, lower jaw is made up of:**

**(a) Mandible** **(b) Maxilla**

**(c) Tibia** **(d) Fibula**

**Ans.** (A) *(c) Secretion of hormones for calcium regulation in blood and bones.*

**Explanation:** Bone plays an important role like it is site for muscle attachment and also protects the vital organs from injury and formation of blood corpuscles whereas it does not secrete hormones for calcium regulation in blood but it regulates calcium and phosphorus level in blood.

(B) *(d) bone marrow*

**Explanation:** Bone marrow is found in the hollow middle of bones. The cells of bone marrow are soft to produce red blood cells in the protected hollow space and release them to the bloodstream whereas blood runs through canals, not in the hollow space of bones and bone cells are not present in hollow space.

(C) *(c) Bone is a dry and non-living supporting structure.*

**Explanation:** Bone is a living structure with many functions whereas the other options are correct.

(D) *(d) Calcium and phosphorus.*

**Explanation:** Calcium and phosphorus are minerals that give bones their strength and make them strong while silica is not found in human bones, blood and marrow are found in bones, but they do not make bone cells strong and cartilage is softer than bone.

(E) *(a) Mandible*

**Explanation:** Lower jaw of mammalian mouth is made up of mandible bone.

## VERY SHORT ANSWER Type Questions (VSA)

[ 1 mark ]

**19. The three tiny bones present in the middle ear are called ear ossicles. Write them in the correct sequence beginning from the eardrum.** [NCERT Exemplar]

**Ans.** Malleus → Incus → Stapes.

**20. What is the role of girdle in the human skeleton?**

**Ans.** It provides a connection between the axial skeleton and limbs.

**21. Glenoid cavity is part of which girdle?**

**Ans.** Pectoral Girdle.

**Related Theory**

*The glenoid cavity articulates with the head of the bone of the upper arm and the humerus to form a shoulder joint.*

**22. Name the largest and the smallest bone of the human body.**

**Ans.** The largest bone is the femur and the smallest bone is the stapes.

**23. Where is the pivot joint present?** [Diksha]

**Ans.** Between the atlas and the axis.

**24. What lubricates the freely movable joints at the shoulder?**

[Delhi Gov. QB 2022]

**Ans.** Synovial fluid

## SHORT ANSWER Type-I Questions (SA-I)

[ 2 marks ]

**25. (A) Explain why the female pelvis is larger than male pelvis.**

**(B) What is Gout?** [NCERT Exemplar]

**Ans.** (A) The female pelvis is larger and broader than males because it is an adaptation for childbirth, their pelvis must allow for the birth of a baby.

(B) It is a form of Arthritis and it is related to our diet. Gout is the accumulation of uric acid crystals in synovial joints which makes the movement painful and difficult.

**26. (A) What is a cartilaginous joint? Give one example.**

**(B) Give the function of the pelvic girdle.**

**Ans.** (A) The cartilaginous joints are slightly movable joints due to the presence of white fibrocartilage between the ends of the bones. This pad allows limited movement at the joint. Example: The joint present between the vertebrae.

(B) The pelvic girdle supports the posterior region of the trunk. There are two main functions of this girdle—First, it provides articulation to the leg bones and the other provides a surface for the attachment of the muscles of legs, it protects soft organs present in the pelvic region.

**27. In old age, people often suffer from stiff and inflamed joints. What is this condition called? What are the possible reasons for these symptoms?** [NCERT Exemplar]

**Ans.** In old age, people often suffer from stiff and inflamed joints. This condition is called Arthritis.It is an autoimmune disease and a common disease of old age. The possible reasons are:

(1) The inflammation in the synovial joints. The cells of synovial joints are attacked by the immune system.

(2) Lack of exercise, diet and vitamin D deficiency can be the reason for the trigger behind the immune system.

**28. "X" is a large triangular flat bone situated in the dorsal part of the thorax between the "Y" and the seventh ribs. Identify "X" and "Y".**

**Ans.** Scapula (X) is a large triangular flat bone situated in the dorsal part of the thorax between the second (Y) and the seventh ribs.

## SHORT ANSWER Type-II Questions (SA-II)

[ 3 marks ]

**29. Differentiate between the humerus bone and femur bone.**

**Ans.**

| S. No. | Humerus bone | Femur bone |
|---|---|---|
| (1) | It is located at the upper arm of the forelimb. | It is located in the thigh of the hind limb. |
| (2) | Its head articulates in the glenoid cavity of the pectoral girdle. | Its head articulates in the acetabulum of the pelvic girdle. |
| (3) | Shaft possesses a deltoid ridge. | Shaft has no deltoid ridge. |

**30. Dhruv found it funny when his teacher taught him that ribs can be true, false and floating type. Differentiate between these true ribs, false ribs and floating ribs.**

**Ans.**

| S. No. | True ribs | False ribs | Floating ribs |
|---|---|---|---|
| (1) | They are seven pairs in number. | They are three pairs in number. | They are two pairs in number. |
| (2) | They are directly attached to the sternum by costal cartilage. | They are attached indirectly to the sternum and articulate by cartilage with the seventh rib. | They are not attached to either the sternum or the cartilage of another rib. |

## LONG ANSWER Type Questions (LA)

[ 4 & 5 marks ]

**31. Give a classification of synovial joints. Give one example of each type of joint.**

**Ans.** The synovial joints or freely movable joints mostly exist between the limb bones. Presence of synovial fluid is the feature of these joints. They permit a great deal of movement. The synovial joints are further classified into the following:

(1) **Ball and socket joint:** One bone forms a ball like a head that fits into a socket formed in the other bone. The bone with a head can move nearly in all directions. Example: Shoulder and hip joints.

(2) **Hinge joint:** This joint allows movements in one plane only. The knee joint, elbow joints are examples of this type of joint

(3) **Gliding joint:** This joint allows sliding movement over each other. The examples are between the carpals and tarsal bones.

(4) **Pivot joint:** This joint allows movement in only rotary movement. The examples are the joints between the atlas and axis and radius and ulna.

(5) **Saddle joint:** The joints between the carpal and metacarpal of the thumb of the hand are the example of saddle joints

(6) **Ellipsoid joint or Condyloid joint:** Allows movement in two planes, *i.e.* back and forth and side-to-side. This joint is present between the metacarpals and phalanges of the fingers.

**32. Give the location of the following:**

**(A) Tarsal**
**(B) Axis**
**(C) Immovable joints**
**(D) Freely movable joints**
**(E) Clavicle**

**Ans.** (A) Ankle
(B) Second cervical vertebra
(C) Between the bones of the cranium
(D) Between the limb bones.
(E) Shoulder (pectoral) girdle.

**Related Theory**

*The second vertebra bears an odontoid process that allows side by side movement.*

**33. Draw a flow chart of the human skeleton.**

**Ans.**