Locomotion and Movement

OBJECTIVE TYPE QUESTIONS

Multiple Choice Questions (MCQs)

1. Which one of the following is correct pairing of a body part and the kind of muscle tissue that moves it?

(a) Iris – Involuntary smooth muscle
(b) Heart wall – Involuntary unstriated muscle
(c) Biceps of upper arm – Smooth muscle
(d) Pharynx – Smooth muscle

2. ATPase activity is found in

(a) myosin filament (b) actin filament
(c) both (a) and (b) (d) none of these.

3. Rigor mortis is

(a) contraction of muscles after death
(b) contraction of muscles before death
(c) shivering of muscles
(d) none of these.

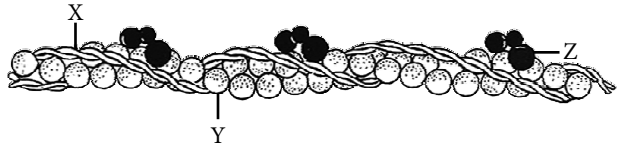
4. During muscle contraction, the length of _____ reduces.

(a) sarcomere (b) myofilaments
(c) A-band (d) all of these

5. Select the incorrect pair.

(a) Amoeboid movement – Phagocytes
(b) Muscular movement – Jaws
(c) Flagellar movement – Ova
(d) Ciliary movement – Fallopian tubes

6. Study the following diagram and select the correct options for X, Y and Z.



	X	Y	Z
(a)	F-actin	Troponin	Tropomyosin
(b)	Troponin	Tropomyosin	F-actin
(c)	Tropomyosin	Troponin	F-actin
(d)	Tropomyosin	F-actin	Troponin

7. In which of the following step of muscle contraction energy is utilised in the form of ATP?

(a) Back flow of calcium ion into sarcoplasmic reticulum
(b) Formation of cross bridge
(c) Breaking of cross bridge
(d) All of these

8. Inner walls of hollow visceral organs of body like the alimentary canal contains

(a) non-striated muscles
(b) skeletal muscles
(c) smooth muscles
(d) both (a) and (c).

9. The junction between the motor neuron and the sarcolemma of the muscle fibre is called the

(a) motor unit
(b) motor end plate
(c) neuromuscular junction (NMJ)
(d) both (b) and (c).

10. Read the following differences between A-band and I-band and select the incorrect ones.

	A-band	I-band
(i)	It is formed of myosin and actin filaments.	It is formed of only actin filaments.
(ii)	It gives light appearance.	It gives dark appearance.
(iii)	In the central zone, it has dark Krause's membrane or Z-line.	In the central zone, it has light Hensen's line or H-zone.
(iv)	It is anisotropic.	It is isotropic.

(a) (i) and (ii) (b) (iii) and (iv)
(c) (ii) and (iii) (d) (iv) only

11. Choose the correct order of muscle contraction from starting to completion.

(a) Stimuli → Neurotransmitter → Release of Ca^{2+} → Cross bridge formation → Excitation of T-system → Sliding of actin filament

(b) Stimuli → Neurotransmitter → Excitation of T-system → Release of Ca^{2+} → Cross bridge formation → Sliding of actin filament → 'H' band diminishes

(c) Stimuli → Excitation of T-system → Neurotransmitter secretion → Cross bridge formation → Sliding of actin filament → H-band diminishes

(d) Stimuli → Neurotransmitter → Cross bridge formation → Excitation of T-system → Sliding of actin filament

12. Fill up the blanks in the following sentence. The thin filaments of myofibril contain polymeric (A) actin and two filaments of (B) protein along with (C) protein for masking binding site for myosin.

	A	B	C
(a)	G	troponin	tropomyosin
(b)	G	tropomyosin	troponin
(c)	F	troponin	tropomyosin
(d)	F	tropomyosin	troponin

13. Read the following statements carefully and select the correct ones.

(i) Cardiac fibres are branched with one or more nuclei.

(ii) Smooth muscles are unbranched and cylindrical.

(iii) Skeletal muscles can be branched or unbranched.

(iv) Smooth muscles are non-striated.

(a) only (iv) (b) (ii) and (iii)

(c) (iii) and (iv) (d) only (iii)

14. The protein whose removal enables myosin to bind actin in smooth muscle is

(a) tropomyosin

(b) caldesmon

(c) myosin light chain kinase

(d) calmodulin.

15. Amoeboid movement involves

(a) cytoskeletal elements like microfilaments

(b) coordinated beats of cilia

(c) whip like action of flagella

(d) none of these.

16. Which of the following are locomotory movements?

(i) Walking (ii) Running

(iii) Climbing (iv) Flying

(v) Swimming

(a) (i), (ii) and (iii)

(b) (ii), (iii) and (iv)

(c) (i), (ii) and (v)

(d) (i), (ii), (iii), (iv) and (v)

17. Ions that must be present for binding the cross bridge is

(a) Na^+ (b) Ca^{2+}

(c) K^+ (d) Mg^+

18. Immediate source of energy for muscle contraction is

(a) glucose (b) GTP

(c) ATP (d) creatine phosphate.

19. One myosin filament in the myofibril of skeletal muscle fibre is surrounded by how many actin filaments?

(a) Two (b) Four

(c) Six (d) Three

20. Accumulation of which of the following in muscle causes fatigue?

(a) Acetic acid (b) Carboxylic acid

(c) Hydrochloric acid (d) Lactic acid

21. Upon stimulation of skeletal muscles calcium is immediately made available for binding to troponin from

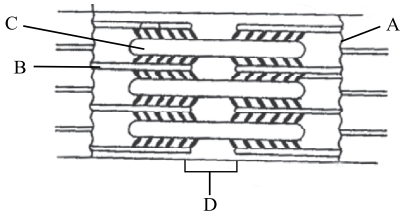
(a) blood

(b) lymph

(c) sarcoplasmic reticulum

(d) bone.

22. Which of the following is true for the labelled parts in the figure below?



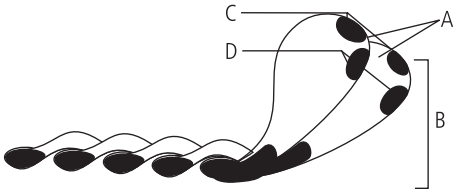
(a) A : Z-line – located at centre of I - band

(b) B : Thin filament – occurs in A-band only

(c) C : Thick filament – confined to I-band

(d) D : H-zone – located at centre of M-line

23. Label the correct part of the myosin monomer.



(a) (A) Actin binding site (B) Head
(C) ATP binding site (D) Cross arm

(b) (A) Cross arm (B) Actin binding site
(C) Head (D) ATP binding site

(c) (A) ATP binding site (B) Actin binding site
(C) Head (D) Cross arm

(d) (A) Head (B) Cross arm
(C) Actin binding site (D) ATP binding site

24. Which is a false statement about skeletal muscle structure?

(a) A myofibril is composed of multiple muscle fibres.
(b) Most skeletal muscles attach to bones by connective tissue tendons.
(c) Each end of a thick filament is surrounded by six thin filaments.
(d) A cross-bridge is a portion of the myosin molecule.

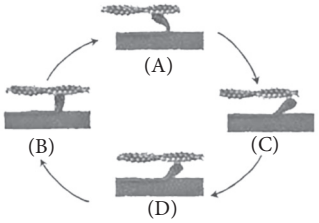
25. Methods of locomotion performed by animals vary with their

(a) habitats
(b) demand of the situation
(c) level of organisation
(d) both (a) and (b).

26. Which of the following correctly characterises as a "fast-oxidative" type of skeletal muscle fibre?

(a) Few mitochondria and high glycogen content.
(b) Low myosin ATPase rate and few surrounding capillaries.
(c) Low glycolytic enzyme activity and intermediate contraction velocity.
(d) High myoglobin content and intermediate glycolytic enzyme activity.

27. Consider the following figure and arrange them in correct sequence of muscle contraction.



(a) A-B-C-D (b) D-B-A-C
(c) C-B-A-D (d) A-D-B-C

28. I-band is bisected by

(a) Z-line (b) H-zone
(c) M-line (d) A-band.

29. White fibres differ from red fibres in having

(a) high number of mitochondria
(b) high amount of myoglobin
(c) high quantity of ATP
(d) high quantity of sarcoplasmic reticulum.

30. Which is not true in muscle contraction?

(a) Actin and myosin make actomyosin.
(b) Phosphate reserve comes from phosphocreatine.
(c) Chemical energy is converted into mechanical energy.
(d) Mechanical energy is converted into chemical energy.

Case Based MCQs

Case I : Read the following passage and answer questions from 31 to 35 given below.
Movement is an essential feature of all living beings which includes protoplasmic streaming, movement of cilia, flagella, fins, limbs, wings etc. Locomotion is the voluntary movement, which causes animal to change its place in search of food, shelter, mate etc. It requires coordinated muscular activities of skeletal, visceral and cardiac muscles. Skeletal muscles are further classified into red and white muscle fibres based on quantity of myoglobin.

31. The cytoplasmic movement that occurs inside the cells is

(a) amoeboid (b) ciliary
(c) flagellar (d) cyclosis.

32. Which of the following involves ciliary movement?
(a) Upper respiratory tract
(b) Phagocytes
(c) Sperms
(d) Macrophages

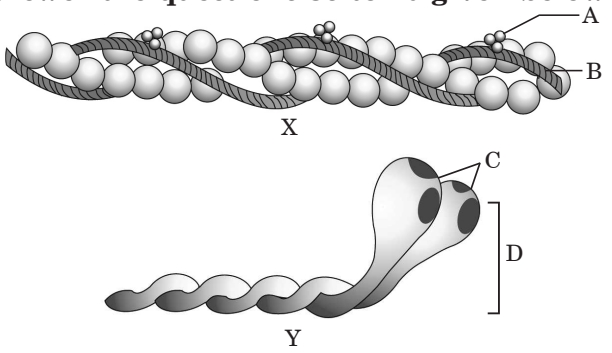
33. Which of the following is true regarding red muscle fibres ?
(a) Less mitochondria
(b) Less sarcoplasmic reticulum
(c) Less myoglobin
(d) Fast rate of contraction

34. The movement in leucocytes is
(a) ciliary
(b) amoeboid
(c) cyclosis
(d) muscular.

35. Identify from the given list, the characteristics of red muscles (A) and white muscles (B) and select the option that correctly segregates the characters.
(i) Less number of mitochondria
(ii) More number of mitochondria
(iii) Sarcoplasmic reticulum is abundant
(iv) High myoglobin content
(v) Sarcoplasmic reticulum is less
(vi) Aerobic muscles
(vii) Depend on anaerobic respiration for energy
(viii) Less myoglobin content

	A	B
(a)	(i), (iii), (vii), (viii)	(ii), (iv), (v), (vi)
(b)	(ii), (iv), (v), (vi)	(i), (iii), (vii), (viii)
(c)	(i), (iii), (iv), (vii)	(ii), (v), (vi), (viii)
(d)	(ii), (v), (vi), (viii)	(i), (iii), (iv), (vii)

Case II : Refer to the given figures and answer the questions 36 to 40 given below.



36. What does Y represent?
(a) Thin filament (b) Meromyosin
(c) Tropomyosin (d) Both (a) and (c)

37. Which of the following labelled part binds to Ca^{2+} to initiate the contraction process?
(a) A (b) B
(c) C (d) D

38. The labelled part C is also called
(a) cross arm
(b) light meromyosin
(c) heavy meromyosin
(d) F actin

39. Select the correct statements(s) regarding globular head of Y.
(a) It is an active ATPase enzyme
(b) It has binding site for ATP
(c) It has actin active sites
(d) All of these

40. B is a
(a) single stranded α-helical rod
(b) fibrous molecule that attaches to F-actin
(c) is a double stranded α-helical rod
(d) both (b) and (c).

Assertion & Reasoning Based MCQs

For question numbers 41-47, two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

41. Assertion : Athletic training enhances the capacity for aerobic contraction of muscles.

Reason : After strenous exercise, athletes are liable to much more oxygen debt than non-athlete.

42. Assertion : The contraction and relaxation of muscle fibre is controlled by nerve impulses.
Reason : The threshold stimulus is the minimum stimulus required for the beginning of contraction.

43. Assertion : Muscle contraction force increases with rise in strength of stimulus.
Reason : This is due to increased contraction of individual muscle fibres with increase in stimulus strength.

44. Assertion : Locomotion enables the animal to find its partner.
Reason : Locomotion enables the animal to shift its entire body from place to place.

45. Assertion : Movement of body parts serves to change the body posture.
Reason : Body parts move in relation to body axis.

46. Assertion : White muscles depend mainly on anaerobic glycolysis for energy production.
Reason : White muscles carry out anaerobic contractions, accumulate malic acid in considerable amounts during strenuous work and soon get fatigued.

47. Assertion : The synaptic channels on the end plate of skeletal muscle are activated by atropine.
Reason : Atropine is a neurotransmitter.

SUBJECTIVE TYPE QUESTIONS

Very Short Answer Type Questions (VSA)

1. Which type of movement facilitates transport of spermatozoa through vasa efferentia of male?

2. Locomotion requires a perfect coordinated activity of muscular, _____ and _____ systems.

3. What is the functional unit of a muscle?

4. Label the components of actin filament in the diagram given below.

5. Name the tissue which has intercalated disc. What is its function?

6. Name the genetic disorder that causes progressive degeneration of skeletal muscles.

7. Mention the locomotory structure of *Hydra* that is also involved in capturing food.

8. Mention the names of contractile proteins of muscles.

9. Write the name of proteins that constitute thin filament of a sarcomere.

10. State the cause and symptoms of tetany.

Short Answer Type Questions (SA-I)

11. What is the purpose of locomotion in animals?

12. Define muscles. What are the special properties of muscle tissue?

13. Classify the muscles based on following criteria and give examples for each.

(a) Location
(b) Appearance
(c) Nature of regulation

14. Name the type of involuntary muscles in human. Why they are involuntary in nature? Where are such muscles present?

15. Write the differences between actin and myosin filament.

16. Write a short note on the role of calcium ions and ATP in muscle contraction.

17. What are the major changes that occur in a sarcomere during muscle contraction?

18. Briefly describe the structure of a sarcomere.

19. All the multicellular organisms show a wide range of movements, but plants do not move from one place to another place. Why?

20. Differentiate between skeletal and visceral muscles.

Short Answer Type Questions (SA-II)

21. All locomotions are movements but all movements are not locomotions. Justify.

22. How do you distinguish between a skeletal muscle and a cardiac muscle?

23. Diagrammatically represent the stages in crossbridge formation between actin and myosin during muscle contraction.

24. (a) How does calcium help in muscle contraction?
(b) Which enzyme is involved in muscle contraction?

25. What are the different types of movements exhibited by the human cells? Explain each with the suitable examples?

26. Elucidate the importance of organ level movements.

27. How muscle gets energy for its contraction?

28. Describe the important steps of mechanism of muscle contraction in the form of flow chart.

29. (a) How is amoeboid movement effective in our body?
(b) Why ciliary movement is important in respiratory tract and Fallopian tube of humans?
(c) How flagellar movement helps in the movement of sperms?

30. (a) What are antagonistic muscles? Explain with examples.
(b) Explain the structure of a thin myofilament with the help of diagram only.

31. Explain briefly :
(a) Oxygen debt
(b) Muscle twitch
(c) Rigor mortis

Long Answer Type Questions (LA)

32. Explain the sliding filament theory of muscle contraction with suitable diagram.

33. (a) Draw a detailed labelled structure of a myofibril showing sarcomere.
(b) Differentiate between A-band and I-band.

34. Explain the electrical and biochemical events that occur during muscle contraction.

35. Write a brief note on myofilament of sarcomere.

ANSWERS

OBJECTIVE TYPE QUESTIONS

1. (a)

2. (a) : ATPase activity is found in myosin filament.

3. (a) : On animal's death, its muscles soon exhaust ATP and lose the ability to contract. They become rigidly locked in whatever position they were when all the ATP was used up. This postmortem stiffening of the body from hardening of muscle tissue is called rigor mortis.

4. (a) : During muscle contraction the thin myofilaments slides inward towards the H zone. The sarcomere shortens, but the length of thin and thick myofilaments do not change.

5. (c) : Flagellar movement is not seen in ova but sperms.

6. (d) **7. (d)**

8. (d) : Hollow visceral organs contain smooth or non-straited muscles. These are under the control of autonomic nervous system.

9. (d) : The portion of the muscle plasma membrane that lies beneath the nerve endings is called motor end plate. The axon terminals and the motor end plate together constitute the neuromuscular junction.

10. (b)

11. (b)

12. (d) : Actin of thin filament contains two forms, the monomeric G-actin and the polymeric F-actin. G-actin polymerises to fibrous form F-actin in the presence of Mg^{++}.

13. (a) : Smooth muscles are non-striated, unbranched and spindle shaped. Skeletal muscles are unbranched. Cardiac muscles fibres are uninucleated.

14. (a) : During muscle contraction the calcium ions bind to troponin causing a change in its shape and position. This in turn alters shape and the position of tropomyosin, to which troponin binds. This shift exposes the active sites on

the F-actin molecules. Myosin cross-bridges are then able to bind to these active sites.

15. (a)

16. (d) : Human beings can move limbs, jaws, eyelids, tongue, etc, some of the movements result in a change of place or location. Such voluntary movements are called locomotion. Walking, running, climbing, flying and swimming are all some form of locomotory movements.

17. (b)

18. (c) : Immediate source of energy for muscle contraction is ATP hydrolysis, the myosin head now binds to exposed active sites on cross bridges.

19. (c) : One myosin filament in the myofibril of skeletal muscle fibre is surrounded by six actin filaments.

20. (d) : During strenuous exercise, the pyruvic acid is converted into lactic acid in muscles. Accumulation of lactic acid in muscles causes fatigue.

21. (c) : On stimulation Ca^{2+} ion is released from sarcoplasmic reticulum to bind with troponin C.

22. (a) : A - Z line : located at centre of I-band

B - Thin filament : Occurs in both I-band and A-band

C - Thick filament : Occurs in A-band

D - H-zone : present at the centre of A-band.

23. (d)

24. (a) : Myofibril is composed of single muscle fibre made up of mainly actin and myosin.

25. (d) : Methods of locomotion performed by animals vary with their habitats and demand of the situation.

26. (d) : Fast-oxidative muscle fibres are an intermediate type that are designed to contract rapidly but to resist fatigue. They utilise both aerobic and anaerobic energy systems; thus, they are red fibers with high myoglobin content (which facilitates production of ATP by oxidative phosphorylation), but they also have a moderate ability to generate ATP through glycolytic pathways.

27. (b)

28. (a) : The myofibril has dark and light bands. The light bands are also called I-bands (isotropic bands). The I band has at its centre a dark membrane called Z-line.

29. (d)

30. (d) : Muscle cells have a contractile mechanism which is activated by the action potential. The action potential is transmitted along the muscle fibre and initiates the contractile response. The contractile proteins are actin and myosin. Actin and myosin get combined in presence of ATP and Ca^{2+} to form actomyosin to provide contraction in muscle.

Muscle contraction require energy, and muscle has been called a 'machine for converting chemical energy into mechanical work'. The immediate source of this energy is energy rich organic phosphate derivatives in muscle *i.e.*, ATP. In muscle there also exists another energy rich phosphate compound that can supply this energy for short periods. This compound is phosphocreatine which is hydrolysed to creatine and phosphate groups with release of considerable energy.

31. (d) : Cyclosis is cytoplasmic or protoplasmic movement found in cells that helps in distribution of materials within them.

32. (a) : Cilia of upper respiratory tract, fallopian tubes, vasa efferentia usually shows ciliary movement.

33. (b) : Red muscle fibres are dark red which is due to presence of high myoglobin content. It contains more mitochondria and have less sarcoplamsic reticulum.

34. (b) : Amoeboid movement is also called pseudopodial movement. It is found in leucocytes in the human lymphatic system.

35. (b) : Characteristics of red muscle fibres and white muscle fibres:

Red muscle fibres (A)	White muscle fibres (B)
Aerobic muscle	Depend on anaerobic respiration for energy
More number of mitochondria	Less number of mitochondria
High myoglobin content	Low myoglobin content
Sarplasmic reticulum is less	Sarcoplasmic reticulum is abundant

36. (b) : Y is myosin monomer (Mesomyosin). Many monomeric myosin proteins called meromyosins constitute one thick filament.

37. (a) : A is troponin which has strong affinity for calcium ions to initiate the contraction process.

38. (c) : Each meromyosin has two important parts, a globular head with a short arm and a tail, the former being called the heavy meromyosin (HMM) and the latter, the light meromyosin (LMM).

39. (d) : Globular head of myosin monomer is an active ATPase enzyme and has binding sites for ATP and active sites for actin.

40. (d) : B is tropomyosin. It is a double stranded α-helical rod. It is fibrous molecule that attaches to F actin in the groove between its filaments.

41. (c) : During strenous exercise, the muscles do not get sufficient oxygen to meet the energy needs immediately.

So they contract anaerobically and accumulates lactic acid, produced by anaerobic glycolysis. During recovery, the oxygen consumption of the muscle far exceeds that in the resting state. The extra oxygen consumed during recovery is called oxygen debt of the muscle. Athletic training enhances the capacity for aerobic contractions. Therefore, athletes incur far less oxygen debts after strenous exercise than non-athletes.

42. (b) : Each muscle fibre is supplied by a nerve. The latter conducts propagated changes of electrical potentials called nerve impulses to the muscle fibre. Besides nerve impulses, the muscle fibre may be stimulated by adequate strengths of electrical, mechanical, chemical or other form of stimuli also. But for being stimulated to contract, the muscle fibre always requires a specific minimum strength or intensity of the stimulus. If the nerve impulse or any other stimulus is below its threshold intensity, it fails to stimulate and contract the muscle fibre.

43. (c) : The muscle fibre always contracts with the maximum force and this force does not rise on increasing the strength of the stimulus. If the stimulus is of strength below the threshold, then the muscle fibre does not contract at all. This is known as All or None law. But the entire muscle does not obey this law, it means that force of contraction of muscle increases with rise in strength of stimulus. This is due to the fact that the strength of the threshold stimulus varies from muscle fibre to muscle fibre in a muscle.

44. (b) : Locomotion is the important characteristic of living organisms, especially of animals. It serves many purposes. Through enabling the animal to shift its entire body from place to place-

(i) it transfers the animal from an unfavorable environment to a favourable one,

(ii) it moves the animal away from predators,

(iii) it helps the animal to search out and produce food and water,

(iv) it also enables the animal to find its partner for reproduction and to reach favourable areas for egg - laying or rearing of the young.

45. (b) : Movement of body parts serves many purposes. Movement of limbs, appendages, head and trunk serve to change the body posture to maintain equilibrium against gravity. Limb movements are also required for carrying out locomotion. Prehension of food involves movements of tongue, jaws, snout, tentacles, limbs and appendages in different animals. Movements of eyeballs and pinna of ear help to collect information from the external environment. Food and urine are propelled by the movement of digestive and urinary tract respectively.

46. (c) : The white muscles carry out anaerobic contractions, accumulate lactic acid in considerable amounts during strenuous work and soon get fatigued.

47. (d) : The synaptic channel on the end plate of skeletal muscle are activated by acetylcholine, not by atropine. Acetylcholine, released from the alpha motorneurons nerve terminal, is a neurotransmitter at cholinergic synapses in the central, sympathetic and parasympathetic nervous system. The channels opened by acetylcholine receptor is equally permeable to Na^+ & K^+, and are not affected by the changes in the membrane receptor unlike the channels that produces the action potential.

Atropine, an anticholinergic alkaloid, acts as a competitive antagonistic of acetylcholine at muscarinic receptors, blocking stimulation of muscles and glands by parasympathetic and cholinergic sympathetic nerves.

SUBJECTIVE TYPE QUESTIONS

1. Ciliary movement

2. Skeletal, neural

3. Sarcomere is the functional unit of muscles.

4. 

5. Cardiac muscle tissue has intercalated discs. Intercalated discs support synchronised contraction of cardiac tissue.

6. Muscular dystrophy

7. *Hydra* can use its tentacles for the capturing its prey besides locomotion.

8. The two important contractile proteins of muscles are myosin and actin.

9. The filament of sarcomere comprises of three proteins; actin, troponin and tropomyosin.

10. Tetany is caused due to low Ca^{2+} in body fluid. This results in rapid spasms or wild contractions in muscles.

11. Locomotion occurs generally for the search of food, shelter, mate, suitable breeding locations and favourable climatic conditions. Animals also move to escape from predators.

12. Muscle is a specialised tissue of mesodermal origin that constitutes about 40-50 percent of the body weight of a human adult. Special properties of muscle tissue are excitability, contractility, extensibility and elasticity.

13. (a) On the basis of their presence at different locations, muscles can be classified as:

(i) Skeletal muscles – muscles present in limbs, pharynx, etc.

(ii) Visceral muscles – muscles found in stomach, lung, etc.

(iii) Cardiac muscles – muscles in wall of heart.

(b) Based on their appearance, muscles are of following types :

(i) Striated or striped muscles – skeletal and cardiac muscles.

(ii) Non striated or unstriped muscles – visceral (smooth) muscles.

(c) Action of muscles are regulated differently, hence they are classified as :

(i) Voluntary muscles – Skeletal muscles.

(ii) Involuntary muscles – Visceral muscles and cardiac muscles.

14. Visceral or smooth muscles are involuntary muscles. These are involuntary in nature as their activity is controlled by the autonomic nervous system and are not under the control of the animal's will. Involuntary muscles are present in urinary bladder, iris of an eye, blood vessels, etc.

15. The differences between actin and myosin filaments are as follows :

	Actin filaments	Myosin filaments
(i)	These are found in I-band and also project in A-band.	These are found in A-band only.
(ii)	These are thin, having size of 50 Å.	These are thick, having size of 100 Å.
(iii)	Consist of 3 proteins: actin, tropomyosin and troponin.	Consist of 2 proteins: myosin and meromyosin.
(iv)	Slide into H-zone during muscle contraction.	Do not slide during muscle contraction.
(v)	Cross bridges (heads) are absent.	Cross bridges (heads) are present.

16. Release of calcium ions from sarcoplasmic reticulum trigger the muscle contraction process.

The calcium ions result in movement of troponin and tropomyosin on their thin filaments, and this enables the myosin molecule heads to 'grab and swivel' their way along the thin filament, this is the driving force of muscle contraction.

Energy for contraction of muscle fibre is provided by ATP which is produced by creatine phosphate and respiratory breakdown of glycogen or glucose.

17. As a muscle contracts, following changes occur in sarcomere:

(i) the thin myofilaments slide inward towards the H-zone

(ii) the Z lines come closer together

(iii) the width of the I bands decreases

(iv) the width of the H zones decreases

(v) there is no change in the width of the A band.

18. The sarcomere is the functional unit of myofibril. A myofibril has dark and light bands. The dark bands are called A-bands and light bands are called I-bands. At centre of A-band, less dark zone, H-zone is present. Each I-band has at its centre a dark membrane called Z-line. The part of myofibril between two successive Z-lines is called sarcomere.

19. Movement is one of the significant features of living organisms. This is observed in both animals and plants. Plants do not move from one place to another because they do not show locomotion. They show movements of various parts such as leaves, stem, flower, etc., in response to external conditions but not locomotion.

20. Following are the differences between skeletal and visceral muscles :

	Skeletal muscles	Visceral muscles
(i)	They are closely associated with skeletal component of body.	They are located in the inner wall of hollow visceral organs of the body.
(ii)	Striations are prominent.	Striations are absent.
(iii)	These are voluntary muscles.	These are involuntary muscles.
(iv)	Cells are multinucleated.	Cells are uninucleated.

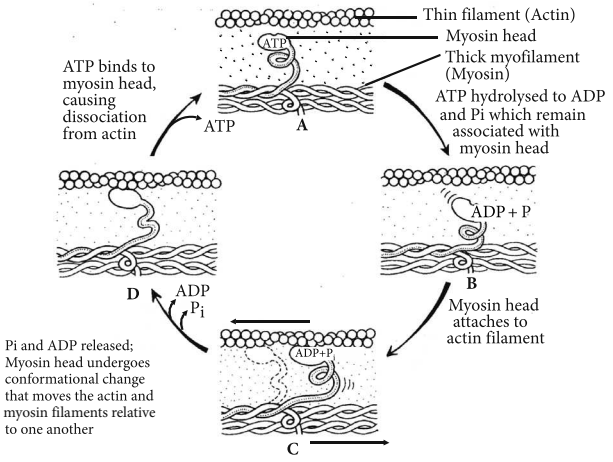
21. Plants and animals exhibit a wide range of movements such as cytoplasmic streaming, movement of cilia, flagella, limbs, eyelids, tongue, etc. Some movements that result in a change of place or location are called locomotion, *e.g.*, walking, climbing, flying, etc. Every movement does not change the location of organism but an organism can change its location only by the movements of certain structures. Hence, all locomotions are movements but all movements are not locomotions.

22. Differences between skeletal and cardiac muscles are as follows :

	Skeletal muscles	Cardiac muscles
(i)	They are associated with bones.	They are not associated with bones.
(ii)	They are voluntary in nature.	They are involuntary in nature.
(iii)	Skeletal muscle fibres are syncytial (multinucleated).	Cardiac muscle fibres are uninucleated.
(iv)	Fibres are unbranched.	Fibres are branched.
(v)	It soon gets fatigued.	It never gets fatigued.

(vi)	Oblique bridges and intercalated discs absent.	Oblique bridges and intercalated discs present.

23. Stages of crossbridge formation between actin and myosin during muscle contraction.



24. (a) On receiving a stimulus from motor neuron, the sarcoplasmic reticulum releases the stored Ca^{2+}. Calcium binds with the specific sites present on the troponin of thin filament, induces conformational changes that lead to exposure of active sites present on F-actin molecule. Now these sites bind myosin head to form cross-bridges and eventually causes sliding of thin myofilament along thick myofilament with the help of Mg^{2+} dependent ATPase activity. During the relaxation, Ca^{2+} is pumped back into sarcoplasmic reticulum.

Release of Ca^{2+} from troponin makes troponin available to mask active site at myosin head and cessation of interaction between actin and myosin occurs.

(b) Enzyme myosin ATPase takes part in muscle contraction.

25. Human cells exhibit three main types of movements, namely, amoeboid, ciliary and muscular.

(i) Amoeboid movement : Certain specialised cells, *e.g.*, macrophages and leucocytes exhibit amoeboid movement which occurs with the help of pseudopodia formed due to the streaming of protoplasm. Cytoskeletal elements, *e.g.*, microfilaments are also involved in amoeboid movement.

(ii) Ciliary movement : Large number of internal tubular organs in man are lined by ciliated epithelium. For instance, the cilia of the cells lining the trachea, oviducts and vasa efferentia propel dust particles, eggs and sperms respectively by their coordinated movements in specific directions in these organs.

(iii) Muscular movement : Movement of limbs, jaws, tongue, etc., require the muscular movement. The universal property of alternate contraction and relaxation of muscles are effectively used for locomotion and movement in human beings.

26. Movements of internal organs make many vital activities possible. For example :

(i) Movement of muscle of heart circulate blood in the body.

(ii) Peristalsis of alimentary canal propels food through it.

(iii) Movements of diaphragm assist the chest in the flow of air through the respiratory tract.

(iv) Movements of genital tract affect egg laying and delivery of the baby.

(v) Visceral movements are also responsible for sound production, defecation and micturition.

27. The muscle gets its energy for contraction from ATP. During muscular contraction, ATP is hydrolysed to ADP and inorganic phosphate by myosin ATPase.

$$ATP + H_2O \longrightarrow ADP + P_i$$

After that, ATP is soon replenished in the muscle fibres. For this, muscles contain another energy compound called creatine phosphate (CP). It helps in the conversion of ADP to ATP. This happens at the end of muscular contraction.

$$ADP + CP \rightleftharpoons ATP + Creatine$$

28. The following flow chart describes the steps of muscle contraction :

Discharge of motor neuron
↓
Release of transmitter (acetylcholine) at motor end plate
↓
Binding of acetylcholine to end plate of motor receptors
↓
Increased Na^+ and K^+ conductance in end-plate membrane
↓
Generation of end-plate potential
↓
Generation of action potential in muscle fibres
↓
Inward spread of depolarisation along T tubules
↓
Release of Ca^{2+} from terminal cisternae of sarcoplasmic reticulum and diffusion to thick and thin filaments
↓
Binding of Ca^{2+} to troponin C, uncovering myosin - binding sites on actin
↓
Formation of cross-linkages between actin and myosin and sliding of thin on thick filaments, causing contraction of muscle

29. (a) Some specialised cells in our body like macrophages and leucocytes in blood exhibit amoeboid movement which

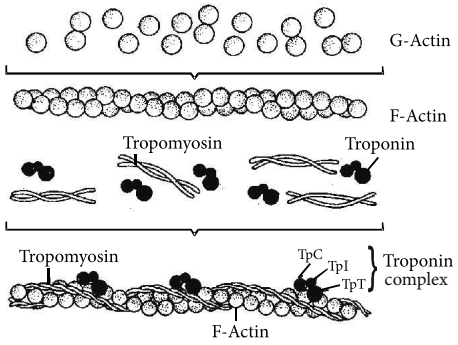
occurs with the help of pseudopodia formed by the streaming of protoplasm. Cytoskeletal elements like microfilaments are also involved in amoeboid movement.

(b) Cilia of the upper respiratory tract of humans keeps the invading microbes and dust particles out whereas, the cilia of the Fallopian tubes (oviducts) of human females transport ova.

(c) Human sperms (a flagellated cell) exhibit the flagellar movement. The flagellum provides propulsion for the movement of sperm towards the ovum. This propulsion is brought about by the whip-like movement of the tail and the middle piece of the sperm.

30. (a) Antagonistic muscles are the pair of muscles that act opposite to each other, *e.g.*, biceps (flexor) and triceps (extensor) are antagonist for the elbow joint. During flexion at the elbow, biceps contract and triceps relax, while triceps contract and biceps relax during extension.

(b) Structure of thin myofilament:



31. (a) Oxygen debt is the requirement of extra oxygen during recovery phase of muscle after vigorous exercise. During strenuous exercise, muscles do not get sufficient oxygen to meet its energy need immediately; so it contracts anaerobically and accumulates lactic acid produced by anaerobic gylcolysis. The increased oxygen consumption of muscle during recovery is called oxygen debt. The extra oxygen required during recovery phase is for regeneration of oxymyoglobin, restoration of depleted ATPs and creatine phosphate and oxidation of lactic acid.

(b) Muscle twitch or muscle fasciculations are fine movements of small area of muscle, caused by minor muscle contractions in the area, or uncontrollable twitching of muscle group served by single motor nerve fibre, *e.g.*, flittering eye lids.

(c) Rigor mortis is a condition that sets few hours after the death. In this, muscles and joints become rigid, *i.e.*, can neither contract nor stretch as cellular processes come to halt. Rigor mortis subsides about 15-24 hours after death.

32. Sliding filament theory of muscle contraction was proposed by A.F. Huxley and H.E. Huxley in 1954. The smallest unit of muscle contraction is a sarcomere. According to the theory, following are the steps involved in muscle contraction :

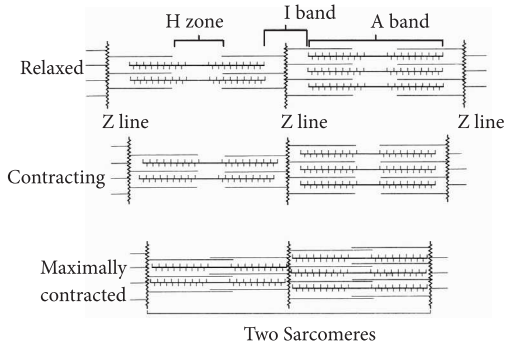
(i) During muscle contraction, the thin myofilaments slide inward towards the H-zone.

(ii) The sarcomere shortens, but the lengths of thin and thick myofilaments do not change.

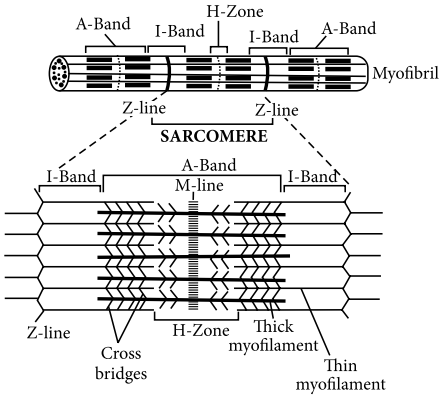
(iii) The crossbridges of the thick myofilaments connect with portions of actin of the thin myofilaments. The myosin cross bridges move on the surface of the thin myofilaments and the thin and thick myofilaments slide past each other.

(iv) As the thin myofilaments move past the thick myofilaments, the H zone narrows and even disappears when the thin myofilaments meet at the centre of the sarcomere. Thus, the length of the sarcomere decreases during contraction. Size of I band also decreases.

(v) The lengths of the thick and thin myofilaments do not change during muscle contraction.



33. (a) Structure of a myofibril showing sarcomere.



(b) Differences between A-band and I-band are :

	A-band	I-band
(i)	It is formed of myosin and actin filaments and is anisotropic.	It is formed of only actin filaments and is isotropic.
(ii)	It gives dark appearance.	It gives light appearance.
(iii)	In the central zone, it has light Hensen's line or H-zone.	In the central zone, it has dark Krause's membrane or Z-line.
(iv)	Its length remains unchanged during muscle contraction.	It shortens during muscle contraction.

34. Electrical and biochemical events of muscle contraction are summarised as follows :

(i) As a nerve impulse reaches the terminal end of the axon, small sacs called synaptic vesicles fuse with the axon membrane and release a chemical transmitter, acetylcholine. Acetylcholine diffuses across the synaptic cleft (the space between the axon membrane and the motor end plate) and binds to receptor sites of the motor end plate. When depolarisation of the motor end plate reaches a certain level, it creates an action potential. After this, an enzyme cholinesterase present along with receptor sites for acetylcholine, breaks down acetylcholine into acetate and choline. A portion of the choline diffuses back to the axon and is reused to synthesise more acetylcholine for transmission of subsequent impulses.

(ii) At the opening of each transverse tubule onto the muscle fibre surface, the action potential spreads inside the muscle fibre.

(iii) At each point where a transverse tubule touches part of the sarcoplasmic reticulum, it causes the sarcoplasmic reticulum to release Ca^{++} ions.

(iv) The calcium ions bind to troponin causing a change in its shape and position. This in turn alters shape and the position of tropomyosin, to which troponin binds. This shift exposes the active sites on the F - actin molecules.

(v) The heads of myosin molecules project laterally from thick myofilaments towards the surrounding thin myofilaments.

(vi) These heads are called crossbridges. The head of each myosin molecule contains an enzyme myosin ATPase. In the presence of myosin ATPase, Ca^{++} and Mg^{++} ions, ATP breaks down into ADP and inorganic phosphate, releasing energy in the head.

$$ATP \xrightarrow[Ca^{++},\ Mg^{++}]{\text{Myosin ATPase}} ADP + Pi + Energy$$

(vii) Energy from ATP causes energised myosin crossbridges to bind to actin.

(viii) The energised cross-bridges move, causing thin myofilament to slide along the thick myofilaments.

35. Sarcomere comprises of number of parallely arranged filaments called myofilaments. A myofilament has alternate dark and light bands. The dark band corresponds to 'A-band', made up of protein myosin and light band is 'I-band', comprising of protein actin. Each myosin (thick) filament is a polymerised protein made of many monomeric proteins called meromyosins. Each meromyosin has two important parts - a globular head with a short arm, termed as heavy meromyosin (HMM) and a tail; called light meromyosin (LMM). The HMM component projects outwards at an angle from a polymerised myosin filament at regular distance, and popularly known as cross arms.

The globular head is an active ATPase enzyme which has sites for attachment with ATP and actin. Each actin filament is made of two 'F' actins helically wound to each other. Each 'F' actin is a polymer of monomeric G-actins. Actin also contains two filaments of another protein, tropomyosin, running close to F-actins throughout the length and troponin distributed at regular intervals on the tropomyosin.