BIOLOGY

Chapter 17: Locomotion and Movement

LOCOMOTION AND MOVEMENT

Locomotion and Movement

Movement is defined as the movement of living organisms from one place to another; if the movement causes a change in location or position, it is called locomotion; such as walking, climbing, running, etc.

Kinds of Movement

There are three kinds of movement which are ciliary, amoeboid, and muscular.

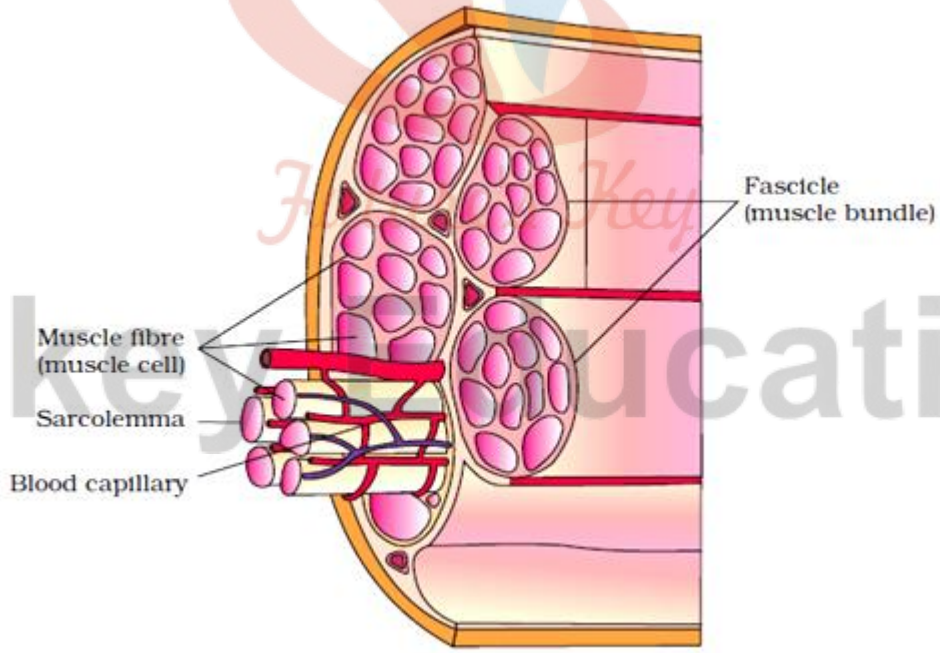
- **Ciliary Movement:** This type of movement occurs in those organs which are covered with ciliated epithelium. It helps to capture dust particles that are inhaled during breathing and also helps to move the egg from the fallopian tube into the uterus.
- **Amoeboid Movement:** This type of movement can be seen in some immune cells, such as macrophages and white blood cells. It can also be seen in amoeba moving through pseudopods.
- **Muscular Movement:** Muscle movement is seen in the tongue, chin, limbs, etc. The muscles, bones, and nervous system are all involved in locomotion.

Muscles

Muscles are specialized tissues of mesodermal origin. They have property like excitability, contractility, extensibility and elasticity.

There are three types of muscles:

- **Skeletal muscle:** These are closely associated with the skeletal components of the body having a striped appearance when viewed under a microscope hence known as striated muscles. Primarily, these muscles are involved in the locomotory actions and the changes of the body posture.
- **Visceral muscle:** These are situated in the inner walls of the hollow visceral structures of the body such as the reproductive tract, alimentary canal etc and show no striations. As they appear smooth, they are referred to as smooth muscles. These involuntary muscles enable the transportation of food through the digestive tract and the movement of gametes through the genital tract.
- **Cardiac muscle:** These are the muscles of the heart, where the cells arrange in a branching pattern forming cardiac muscles. These are striated and involuntary in nature.
- **Fascia:** Skeletal Muscle is made up of muscles bundles (fascicles), held together by collagenous connective tissue called fascia.

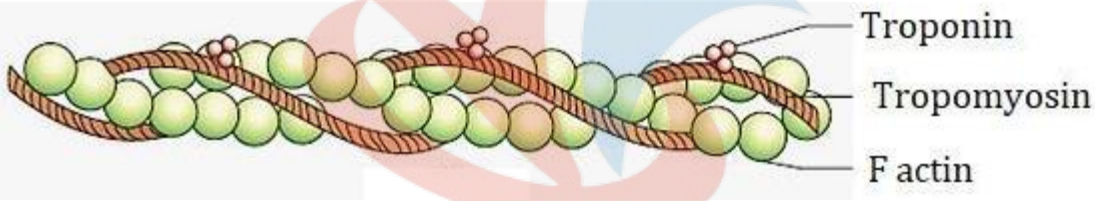


- Each muscle bundle contains a number of muscle fibres. Each muscle fibre is lined by plasma membrane called sarcolemma enclosing sarcoplasm. Partially arranged myofibrils are present in muscle bundle having alternate light and dark bands due to presence of protein- actin and myosin

- Light bands contain actin and is called I-band (isotropic band) and dark band contains myosin, called A-band (anisotropic band). Both bands are present parallel to each other in longitudinal fashion.
- In center of each I-band is elastic fiber called 'Z' line. In the middle of A-band is thin fibrous 'M' line. The portion of myofibrils between two successive 'Z' lines is the functional unit of contraction called a sarcomere.
- At resting stage thin filament overlaps the thick filament. The part of thick filament not overlapped is called 'H' Zone.

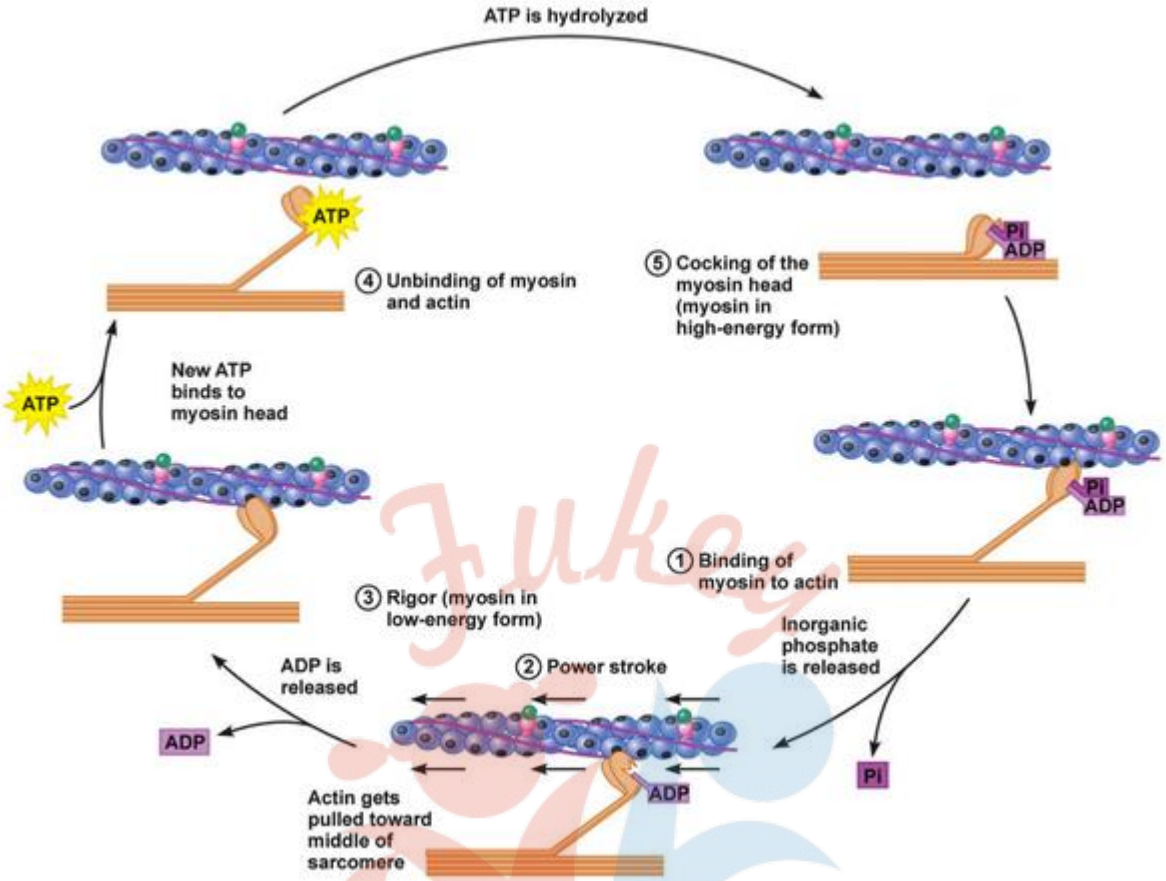
Structure of contractile Protein

- Each thin filament (actin) is made of two 'F' actins helically wounded to each other. Two filaments of another protein, tropomyosin runs close to it. A complex protein Troponin is distributed at regular intervals on the tropomyosin.
- Each myosin filament is made of many monomeric proteins called Meromyosins. Each meromyosin has globular head with short arm and tails. Globular head has ATP binding sites.



Mechanism of muscle contraction

- The mechanism of muscle contraction is explained by sliding mechanism theory in which thin filament slide over thick filament.
- Muscle contraction start with signal sent by CNS via motor neuron. Neural signal release neurotransmitter (Acetyl choline) to generate action potential in the sarcolemma.
- This causes the release of Ca^{++} from sarcoplasmic reticulum.
- Ca^{++} activates actin which binds to the myosin head to form a cross bridge.
- These cross bridges pull the actin filaments causing them to slide over the myosin filaments and thereby causing contraction.
- Ca^{++} are then returned to sarcoplasmic reticulum which inactivate the actin. Cross bridges are broken, and the muscles relax.

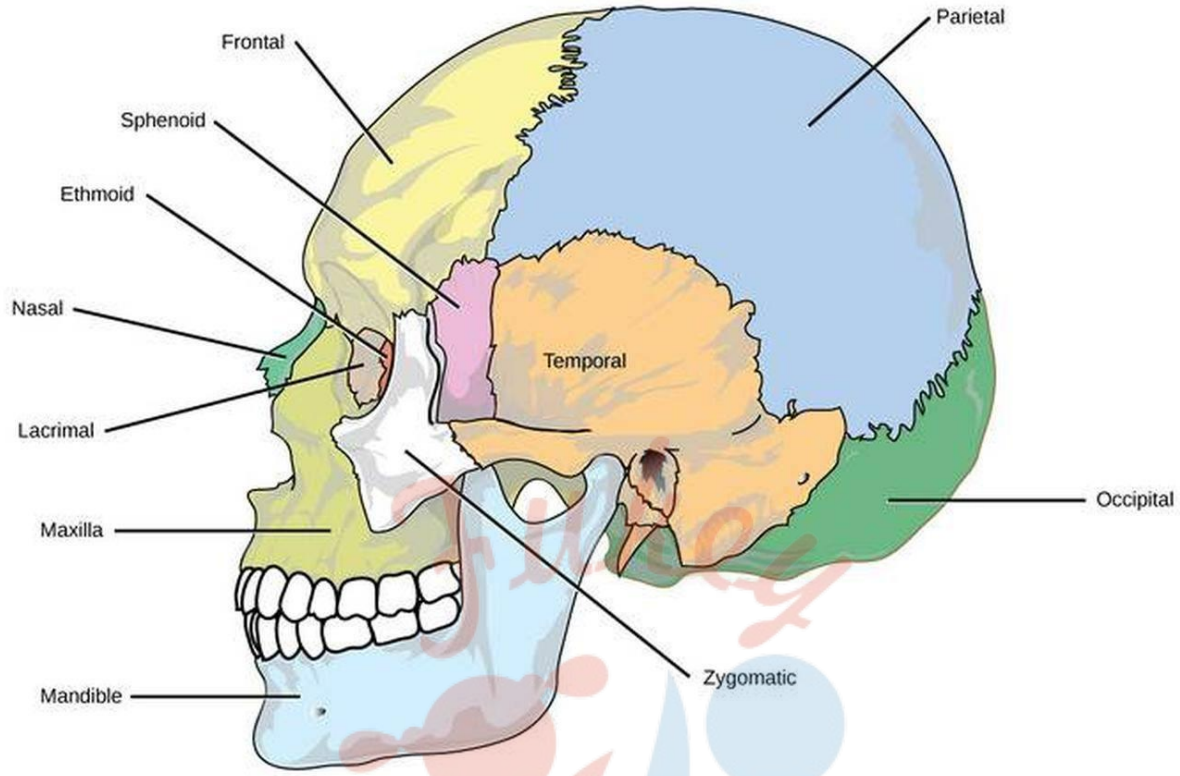


Muscles are classified as

- **Red fibres:** Red fibres (aerobic muscles-) contain myoglobin that has plenty of mitochondria to use large amount of oxygen stored in them.
- **White fibres:** White fibres the muscle fibres containing less number of myoglobin are called white fibres.

Skeletal System

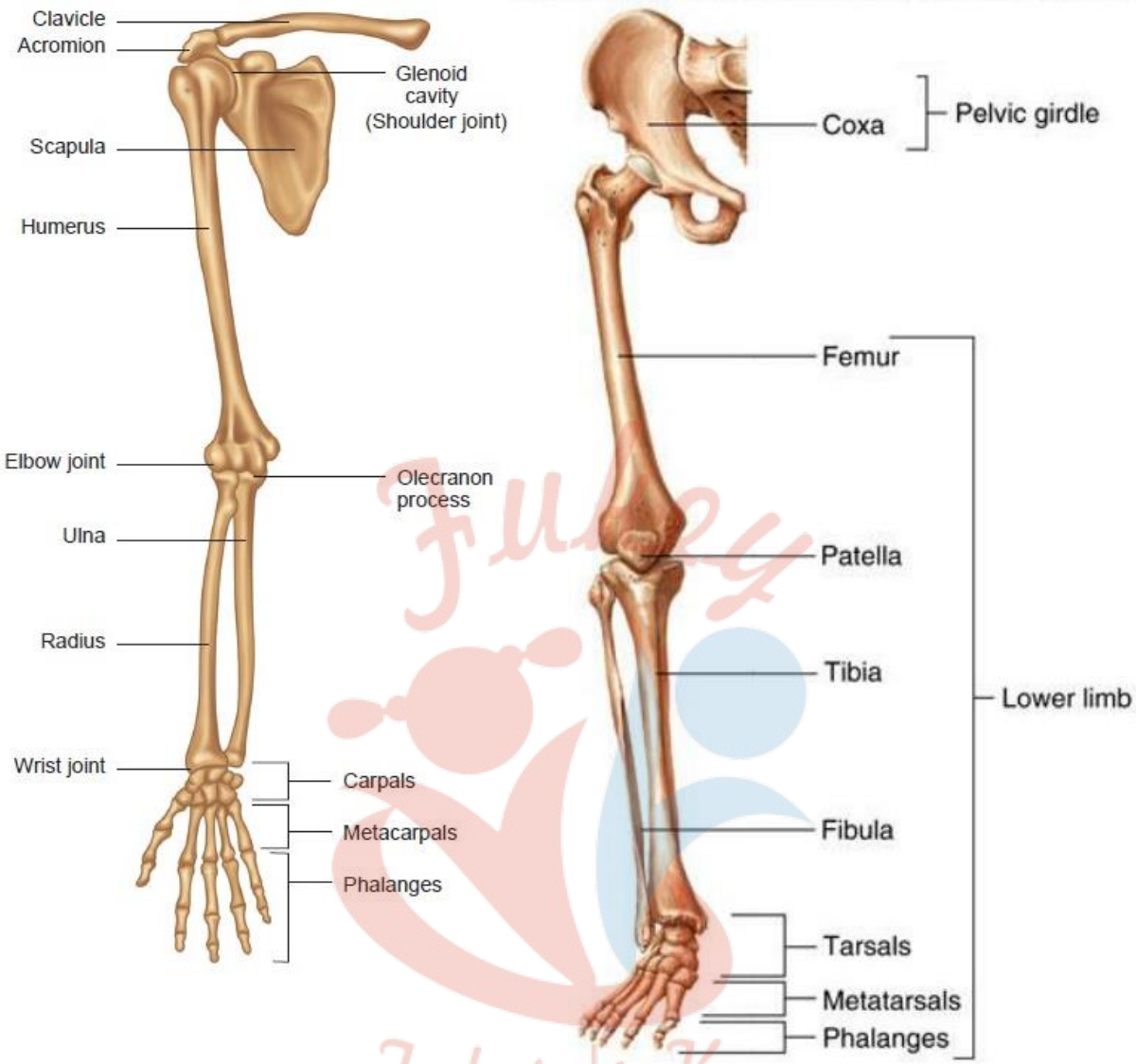
- Framework of bones and cartilage forms the skeletal system. In human beings, it consists of 206 bones and some cartilages.
- The two principle division of skeletal system are:
- Axial Skeleton (80 bones) includes skull, vertebral column, sternum and ribs constitute axial system.



- The skull (22 bones) is composed of cranial and facial bones. Cranial (8 bones) forms protective covering for brain (cranium). The facial region consists of 14 skeletal systems that form front part of skull. Hyoid bone (U-shaped) forms the base of buccal cavity.
- The middle ear bone (Malleus, Incus and Stapes) collectively called Ear Ossicles. Skull joins with vertebral column with two occipital condyle.
- Vertebral column consists of 26 serially arranged vertebrae. First vertebra is atlas that combines with occipital condyle. Other includes Cervical -7, thoracic -12, lumbar -5, sacral -1 coccoygeal -1.
- 12 pairs of ribs connected dorsally to vertebral column and ventrally to sternum. 11th and 12th rib bones are not connected with sternum and are called floating ribs.

Appendicular Skeleton

Appendicular Skeleton includes bones of limbs and girdles. Each limb contains 30 bones.

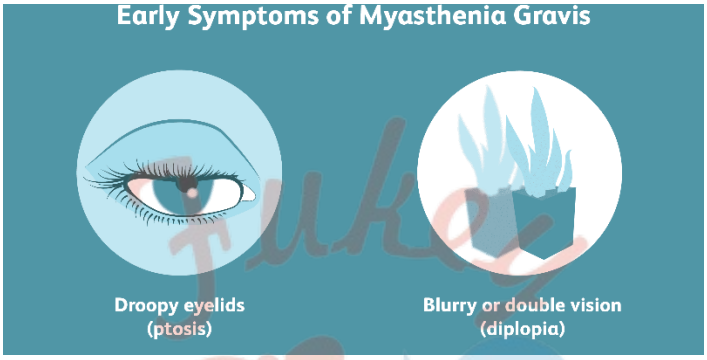


- **Upper Arm:** Humerus, radius and ulna, 8-carpels, 5-metacarpels, 14-phalanges,
- **Lower Limb:** Femur, tibia and fibula, 7-tarsals, 5-metatarsals, 14-phalanges, cup shaped patella cover the knee.
- **Pectoral and Pelvic girdle bones:** Pectoral and Pelvic girdle bones help in the articulation of the upper and the lower limbs respectively with the axial skeleton. Pectoral girdle consists of a clavicle and a scapula. Pelvic girdle consists of two coxal bones. Each coxal bone is formed by the fusion of three bones – ilium, ischium and pubis.
- **Joints:** Are points of contact between bones, or between bones and cartilage.
- **Fibrous joints:** Do not allow any movements. Present in flat skull bones to form cranium.
- **Cartilaginous joints:** Bones are held together with the help of cartilage present in vertebrae. Permits limited movements.

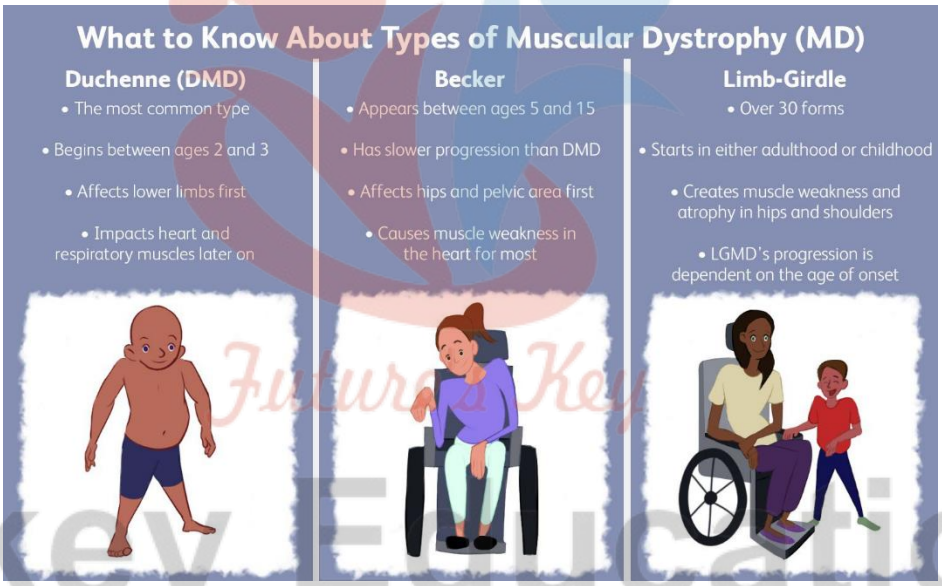
- **Synovial joints:** Fluid filled synovial cavity, provide considerable movements. Ball and socket joint, hinge joints, pivot joints, gliding joints etc.

Disorders of Muscular and Skeletal System

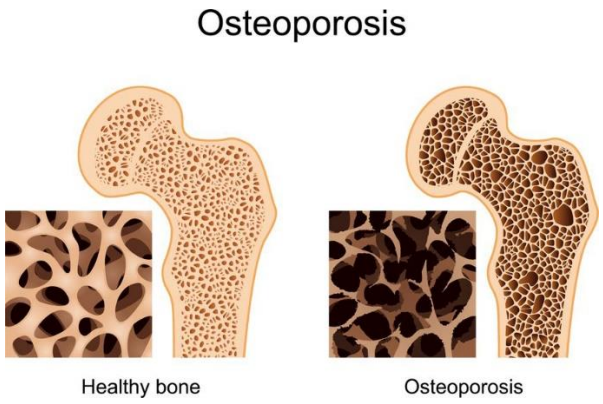
- **Myasthenia gravis:** Auto immune disorder affecting neuromuscular junction causing fatigue, weakening and paralysis of skeletal system.



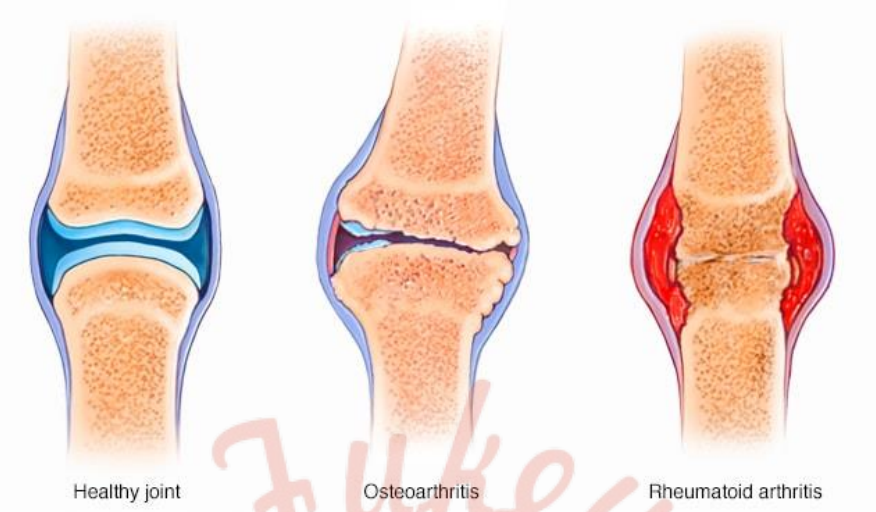
- **Muscular Dystrophy:** Degeneration of skeletal muscles due to genetic disorder.



- **Osteoporosis:** Decreased bone mass in old age leading to chance of fracture due to decreased estrogen.



- **Arthritis:** inflammation of joints.



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

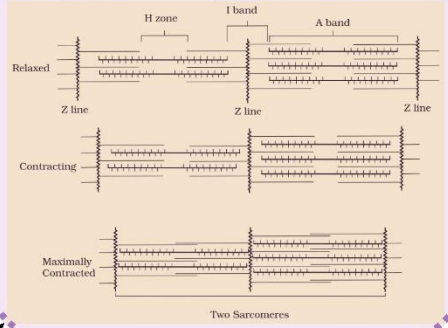
- **Tetany:** Rapid spasms in muscle due to low Ca^{++} in body fluid.

Class : 11th Biology
Chapter- 20 : Locomotion and Movement

Properties of muscle fibers
- Excitability
- Contractility
- Extensibility
- Elasticity

Types of muscles
- Skeletal
- Visceral
- Cardiac

Sliding filament theory of Muscle Contraction



Types of Movement
- Amoeboid
- Ciliary
- Muscular

Disorders of muscular and skeletal System
- Myasthenia gravis
- Muscular dystrophy
- Tetany
- Arthrithis
- Osteoporosis
- Gout

Cartilaginous (Slightly movable)

Fibrous (Immovable)

Joints

Synovial (movable)
- Ball and socket joint
- Hinge joint
- Pivot joint
- Gliding joint
- Saddle joint

Locomotion and Movement

Skeletal System

Axial (80 bones)

Appendicular (126)

Skull (40 bones)

Sternum (1)

Vertebral column

Ribs (12 pairs)

- Cervical (5)
- Thoracic (12)
- Lumbar (5)
- Sacral (1 fused)
- Coccygeal (1 fused)

Limb bones

Girdles

Bones of hindlimbs (30 x 2 = 60)

Bones of forelimbs (30 x 2 = 60)

Pectoral girdle (2 x 2 = 4)

Pelvic girdle (2)

Important Questions

➢ Multiple Choice Questions:

Question 1. Human skull is

(a) Tricondylic

(b) Acondvlic

(c) Dicondylic

(d) Monocondylic

Question 2. Cranium of man is formed of bones

(a) 8

(b) 6

(c) 2

(d) 4

Question 3. Face of skull is formed of bones

(a) 28

(b) 10

(c) 8

(d) 14

Question 4. Curves in the vertebral column are

(a) 8

(b) 4

(c) 2

(d) 1

Question 5. Which vertebra is commonly called yesbone?

(a) Thoracic

(b) Axis

(c) Atlas

(d) Typical carvical.

Question 6. Axis vertebra is characterised by the presence of

(a) Transverse

(b) Odontoid process

(c) Neural spine

(d) Pre and post zygapophysis.

Question 7. Total number of cervical vertebrae in human vertebral column are

(a) 3

(b) 12

(c) 7

(d) 5.

Question 8. Total number of thoracic vertebrae in human vertebral column are

(a) 3

(b) 12

(c) 5

(d) 7

Question 9. Total number of lambar vertebrae in human vertebral column are

(a) 3

(b) 12

(c) 5

(d) 7

Question 10. Xiphoid process is the lowest part of

(a) Pectoral girdle

(b) Pelvic girdle

(c) Lumbar vertebrae

(d) Sternum.

Question 11. Trochlea is a part of

(a) Pectoral girdle

(b) Pelvic girdle

(c) Femur

(d) Humerus bone.

Question 12. Sigmoid notch is a part of

(a) Ulna bone

(b) Humerus bone

(c) Tibia bone

(d) Radius bone.

Question 13. Innominate bone is also known as

(a) Pelvic girdle

(b) Pectoral girdle

(c) Clavicle

(d) Sternum

Question 14. Acetabulum is a part of

(a) Humerus bone

(b) Pelvic girdle

(c) Femur bone

(d) Pectoral girdle

Question 15. The obturator foramen is a part of

(a) Skull

(b) Spinal cord

(c) Pelvic girdle

(d)Vertebral column.

➢ Fill In the Blanks:

1. Human beings can move ……., ……., ……., ……. etc. Such voluntary movements are called locomotion.
2. Cells of the human body exhibit three main types of movements, namely, ……., ……. and …….
3. Based on their location, three types of muscles are identified, (i) …… (ii) …… and (iii) …….
4. ……. are the muscles of heart. Based on appearance, cardiac muscles are …….
5. Muscle fibre is a ……. as the sarcoplasm contains many nuclei.
6. Each myofibril has alternate ……. and …… bands on it.

➢ True or False:

1. First seven pairs of ribs are called true ribs.
2. The 8th, 9th and 10th pairs of ribs do not articulate directly with the help of hyaline cartilage. These are called vertebrochondral ribs.

3. The bones of the limbs along with their girdles constitute the appendicular skeletion. Each limb is made of 30 bones.
4. The fore limb (hand) bones are humerus, radius and ulna, carpals (wrist bones-8 in number), meta carpals (palm bones – 5 in number) and phalanges (digits- 14 in number).
5. A cup shaped bone called patella cover the knee ventrally (knee cap).
6. Joints are essential for all types of movements involving the bony parts of the body.

➢ Very Short Question:

1. What is a tendon?
2. What are antagonistic muscles?
3. What is tetanus?
4. What is threshold stimulus?
5. What is a muscle twitch?
6. What is sarcomere?
7. How many bones are present in the human skeleton?
8. What are synovial joints?
9. What is locomotion?
10. What is rigour mortis?

➢ Short Questions:

1. List the mechanical function of the skeleton.
2. List some biological function of the skeleton.
3. List different modes of locomotion and movement in hydra.
4. What are the different molecules present in muscles?
5. A red muscles fibre works for a prolonged period, whereas a white muscle fibre gets fatigued, why?
6. What are the advantages of the movement of body parts?
7. What are the advantages of locomotion?
8. Draw a labelled diagram of the joint found between the pelvic girdle and femur. Also, write the type of this joint.

➢ Long Questions:

1. (a) During muscular contraction what are the chemical changes that take place. Describe in a listed form.

(b) What are the main groups of vertebrae in the vertebral column of man?

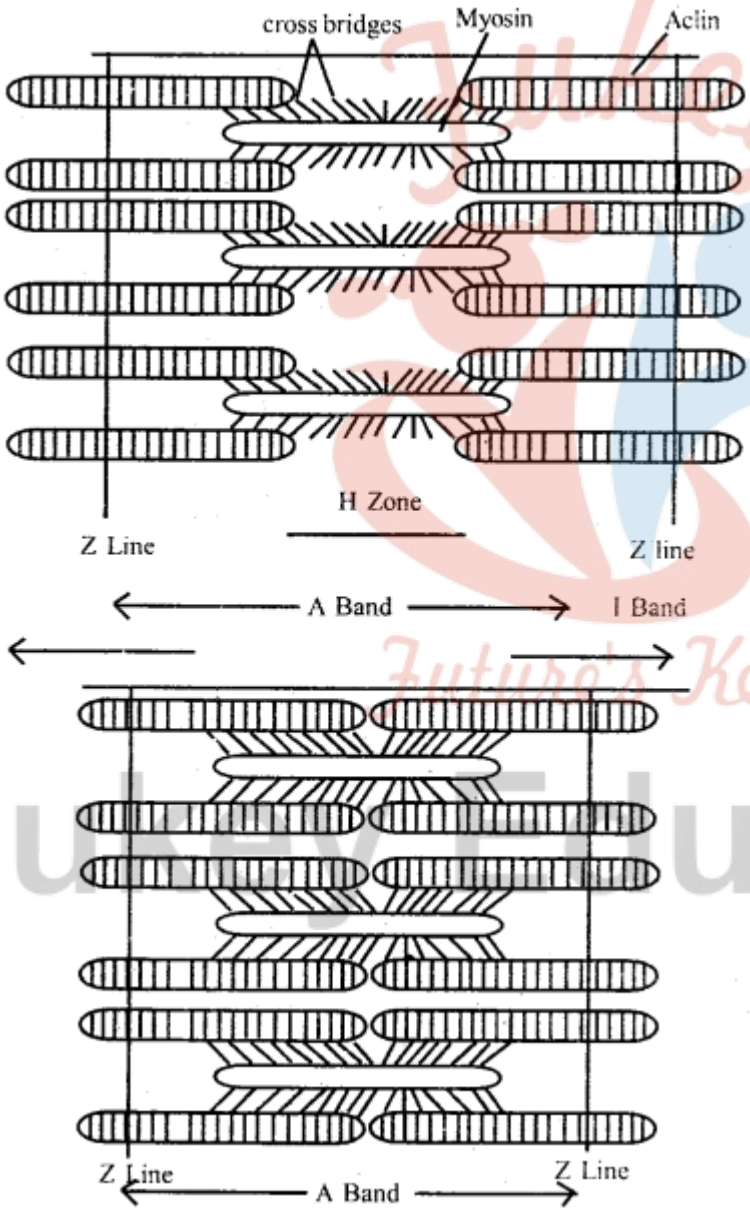
2. (a) What purposes does movement of external body parts in relation to body axis serve in animals?

   (b) What are fibrous joint and cartilaginous joints and their biological function?

   (c) Explain Antagonistic muscles.

   (d) Distinguish between muscles twitch and tetanus or explain muscle twitch and tetanus.

3. How thick and thin filaments are arranged in a muscle fibre?



relationship between actin and myosin filaments in stretched and contracted states

Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: There are similarities between the locomotion of unicellular organisms and multicellular animals.

   Reason: Ciliary, flagellar and amoeboid movements occur in unicellular organisms.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   Assertion: Muscle fibre is a syncitium.

   Reason: Muscle fibre has a large number of parallelly arranged myofilaments in the sarcoplasm.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (c) Dicondylic.
2. (a) 8.
3. (d) 14.
4. (b) 4.
5. (c) Atlas.
6. (b) Odontoid process.
7. (c) 7.
8. (b) 12.

9. (c) 5.
10. (d) Sternum.
11. (d) Humerus bone.
12. (d) Radius bone.
13. (a) Pelvic girdle.
14. (b) Pelvic girdle.
15. (c) Pelvic girdle.

➢ Fill In the Blanks:

1. limbs, jaws, eyelids, tongue
2. amoeboid, ciliary, muscular
3. Skeletal, Visceral, Cardiac
4. Cardiac muscles, striated
5. syncitium
6. dark, light

➢ True or False:

1. True
2. True
3. True
4. True
5. True
6. True

➢ Very Short Answers:

1. Answer: The dense connective tissue joins bone and skeletal muscle.
2. Answer: The. pair of muscles which at a joint produce opposite movements.
3. Answer: The continued state of muscular contraction is called tetanus.
4. Answer: The stimulus of minimum strength which is required to bring about muscular contraction is called the threshold stimulus.
5. Answer: The single contraction of muscle upon receiving the stimulus is called muscle twitch. (Contraction is followed by relaxation).
6. Answer: The functional unit of myofibril contracts and causes the shortening of muscle

fibre.

7. Answer: The human skeleton contains 206 bones.
8. Answer: These are freely movable joints due to the presence of synovial fluid in the synovial cavity.
9. Answer: The bodily movement in animals from one place to the other is called locomotion.
10. Answer: Stiffening of muscle after death.

➢ Short Answer:

1. Answer:

   i. It provides a rigid framework of the body and definite shape to organs.

   ii. It supports the weight of the body.

   iii. It protects the internal organs.

   iv. Its long bones function as a lever.

   v. Skeletal muscles with flexible connective tissue bands called tendons in association with endoskeleton and joints give locomotion and movements to different body parts.

2. Answer:

   i. Provides attachment surface to muscles.

   ii. Serves as storage depot of calcium and phosphate minerals.

   iii. Act in erythropoiesis.

   iv. Ear ossicles help in sound wave propagation.

   v. Redbone marrow present inside the marrow cavity of long bones such as femur, humerus and in interstices of spongy bones of vertebrae, sternum, scapula etc. help in the formation of RBCs, WBCs and platelets of the blood. This process is known as Haemopoiesis.

3. Answer:

   i. Contraction and expansion

   ii. Bending and swaying

   iii. Looping

   iv. Somersaulting.

   v. Floating

   vi. Gliding

   vii. Swimming

viii. Walking.

4. Answer:

   i. Contractile proteins viz. actin, myosin and tropomyosin.

   ii. Enzymes and other proteins like troponin.

   iii. Carbohydrate as a substrate for energy.

   iv. Energy carries viz. ATP, ADP, AMP and CP.

   v. Ions viz. Na^+, K^+, Mg^{++}, Ca^+, Cl^+.

5. Answer: Red muscle fibres contain oxygen storing pigment myoglobin and a large number of mitochondria, so they can have O_2 supply for aerobic respiration and release of energy for a longer period.

   White muscles fibres do not have myoglobin pigment. They face a short supply of O_2 and much depends on anaerobic respiration, so they get fatigued soon.

6. Answer: The movement has the following advantages:

   i. With change in body posture and limb movement, equilibrium of the body is maintained.

   ii. Limb movement causes locomotion.

   iii. Food is captured by movement of tentacles, limbs, jaw, tongue etc. in different animals.

   iv. Changes in environment surrounding can be sensed by the movement of the eyeball, pinna etc.

   v. Blood circulation is possible by heart movement.

   vii. Movement of the diaphragm causes inhales and exhale (breathing).

7. Answer: The bodily movements or locomotion has the following advantages:

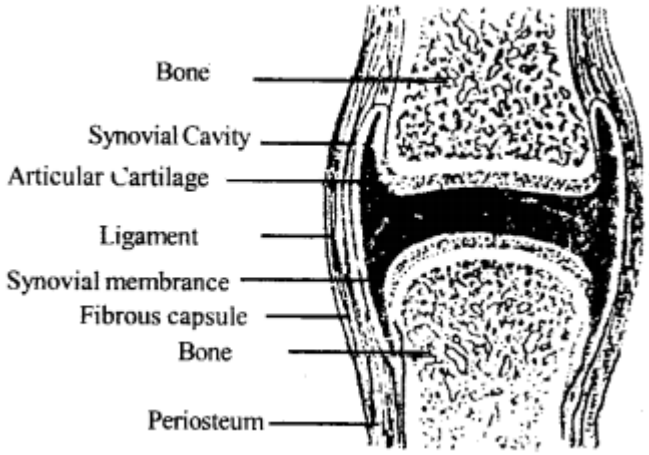
   i. It enables the body to shift it entirely from one place to the other.

   ii. It protects the organism from predation.

   iii. It helps the animals to make the search for their food and other nutritional requirements.

   iv. It helps the animal to seek a mate for reproduction.

8. Answer: Type of the joint: The joint between pelvic and femur bones is a ball and socket synovial joint.



Synovial ball and socket joint between pelvic and femur

➢ Long Answer:

1. (a) Answer: The main chemical events that happen during muscular contraction described by Albert Szent Gyorgi are

   i. Acetylcholine is released from vesicles at the neuromuscular junction. It stimulates the muscle.

   ii. Hydrolysis of ATP in the presence of Ca++ and Mg++ Energy used up in muscle contraction.

   iii. ADP is charged again by taking phosphate from creatine phosphate (CP).

   ADP+CP ⟶ ATP +C
   Creating Phosphate Creating

   iv. During relaxation, creatine is phosphorylated, energy being provided by anaerobic conversion of muscle glycogen into lactic acid.

   Creatine + ATP— Creating-phosphate + ADP

   v. Energy released by hydrolysis of ATP causes rotation of myosin heads and bring near the actin filaments, actomyosin complex is formed, eventually, sarcomere shortens.

   vi. Ca++ are actively transported to the sarcoplasmic reticulum, no more Ca++ available for ATP breakdown, no further energy available for further contraction of the sarcomere.

   vii. Part of the energy is utilized by breaking of cross-bridges and the muscle relaxes.

   (b) Answer: There are 5 groups of vertebrae namely cervical, thoracic, lumbar, sacral and coccygeal vertebral.

   (The vertebral formula is C7, T12, L5, C3-5 = 32 – 34).

2. Answer:

i. The movement of limbs, appendages, head and trunk serves to change the body posture to maintain equilibrium against gravity.

ii. Limb movements are prerequisites for carrying out locomotion.

iii. Prehension of food involves movement of tongue, jaws, snout, tentacles, limbs and appendages in different animals.

iv. Movement of eyeballs and pinna of ear help to collect information from the external environment.

(b) Answer:

i. Fibrous joint: The articulating bones are firmly held together by the dense bands of tough, inextensible white fibrous tissues. They provide strength and support for the body or protection of delicate structures which cannot withstand any kind of deformation.

ii. Cartilaginous joints: In cartilaginous joints, a dense disc of white fibrocartilage joins the opposing surfaces of the articulating bones to each other. This allows a limited movement at the joints.

(c) Answer: Antagonistic muscles: Antagonistic muscles are those which contract to produce opposite movements at the same joint. When a muscle contract to produce a movement, its antagonistic must relax to allow that movement to take place, e.g., the bicep is a FLEXER for the elbow joint and the tricep is it's antagonistic and an EXTENSOR for that joint.

During flexion at the elbow, the biceps contract and the tricep relax, during extension at the same joint the tricep contracts and the biceps relaxes.

(d) Answer: A single isolated contraction caused by a single nerve impulse or electric shock is called a muscle twitch. Immediately after the brief twitch, the muscle fibres relax.

Tetanus is a continued state of concentration caused by many repeated stimuli. Much higher tension is developed in tetanus than in an isolated twitch. Almost all our daily activities are carried out by tetanic contractions of muscles.

3. Answer: Each striated muscle contains thin actin and thick myosin filaments. These filaments are longitudinally arranged inside light I bands and dark A bands respectively. The actin and myosin filaments remain cross-linked with each other in the myofibril. Sarcomeres are the rows of functional unit in each myofibril, each extending from the dark Z- line of the next I band. Each sarcomere thus comprises of A band in the middle with 2 half I band on its two sides.

From each Z line, the actin filaments through half of the I band intermingles with the ends of myosin filaments in the A band. The myofibril is surrounded at each I band by

the tubules and cisternae of sarcoplasmic reticulum and at each junction of A and I bands by a TI tubule communicating with the cell exterior, which is shown in the figure. The relationship between actin (thin filament) and myosin (thick filament).

Assertion Reason Answer-

1. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: Main movement found in unicellular organisms are ciliary, flagellar and amoeboid movements. In multicellular animals also, phagocytes migrate through tissues by amoeboid movements. Ciliary movement of cells lining the upper respiratory tract, fallopian tubes and vasa efferentia of testes transport, respectively dust particles, ova and sperms in specific direction in those organs. Mammalian sperms move into the female reproductive tract by flagellar movements.

2. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: Muscle fibre is a syncitium as the sarcoplasm contains many nuclei. A characteristic feature of the muscle fibre is the presence of a large number of parallelly arranged filaments in the sarcoplasm called myofilaments or myofibrils. Each myofibril has alternate dark and light bands on it.