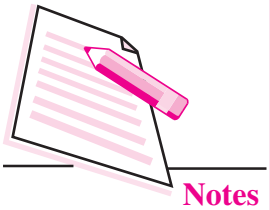

Notes

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16

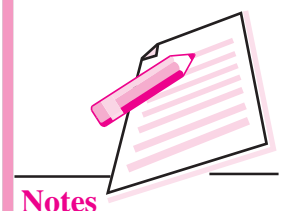
LOCOMOTION AND MOVEMENT

Movement is the temporary or permanent displacement of a body or its parts from its original position. Living beings and parts thereof move in response to stimulus from outside or from within the body. Locomotion, on the other hand, is the displacement of the entire body from one place to another. It is a characteristic feature of all animals, Protoctista and zoospores and zoogametes of lower plants.

OBJECTIVES

After studying this lesson, the learner will be able to

- assert that movement is an important feature of all living beings.
- emphasize that locomotion is a characteristic of the Protoctista, gametes and spores of some lower plants, and animals.
- differentiate between movement and locomotion with the help of examples.
- explain the functions of cilia and flagella as organelles for movement and locomotion in Protoctista and animals.
- recognise skeleton and muscles as organs which help in locomotion in animals.
- describe the structure and working of muscles.
- describe the types of contractile proteins and their role in muscle contraction.
- explain the mechanism of muscle contraction.
- provide an outline of human skeletal system and mention functions of its parts.
- give a brief account of disorders related to muscular and skeletal systems such as Myaesthenia Gravis, Tetany, Muscular Dystrophy, Arthritis, Osteoporosis and Gout.



16.1 MOVEMENT AND LOCOMOTION

Consider the following examples

(i) Your arm stretches to pick up an apple or flexes to scratch the face.

(ii) Your tongue is in motion when you sing, the dog wags its tail, the frog's tongue is shot out to catch insects.

(iii) The gill cover of the fish flips up and down to draw in a current of water.

(iv) Cytoplasm streams within cells

The above examples signify movement, not locomotion. In locomotion, the entire body of an animal or a protozoan or an alga moves away from its original position. In the unicellular organisms like bacteria and Protoctists specific organelles like flagella and cilia cause locomotion. Recall the microscopic structure of these organelles from lesson 4 of your text book entitled Cell Structure and Function. Sperms, the male gametes have a flagellar tail by which they move about. Among the multicelled animals, molluscs locomote with a muscular foot and the starfish with the help of tube feet. Birds fly using muscles and other animals use muscles to walk or run.

INTEXT QUESTIONS

What would you call the following as – movement (M) or locomotion (L) ?

- The elephant uses its trunks to pick up sticks ( )
- The cow uses its tail to drive away flies ( )
- A mouse runs into a hole. ( )
- The bees leave their hive in search of pollen ( )
- Johan kicks the football into the goal ( )
- The cat jumps on to the window ( )

16.2 TYPES OF MOVEMENTS FOR LOCOMOTION

16.2.1 Ciliary Movements

Cilia are minute hair like processes which are motile and extend from cell surfaces. In smaller organisms like the ciliate protozoa, cilia help in locomotion from one place to another. In animals, the cilia help to propel fluids and materials.

Cilia beat in a pattern which is different from that of the flagellum although their internal structure is the same. Ciliary beat begins with fast stroke ahead in one direction called effective stroke and then it bends back and returns to its original position. This second stroke is called recovery stroke. (Fig 15a.1a & b). During ciliary beat, water is propelled parallel to ciliated surface.

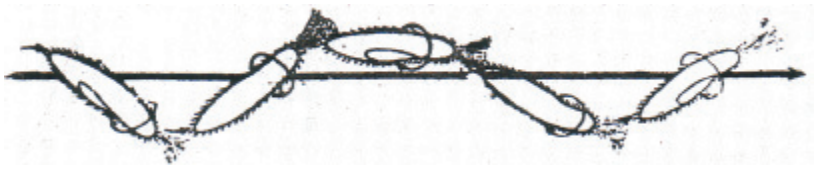


Fig. 16.1(a) Locomotion in *Paramecium*. Solid line represents the general direction;

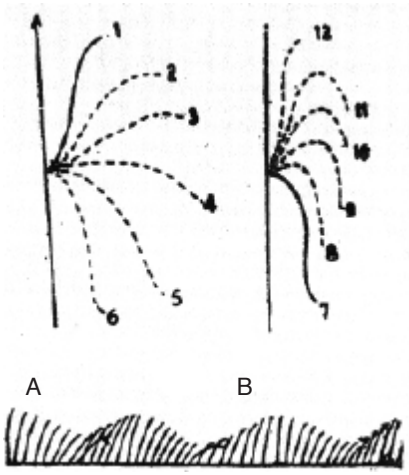


Fig. 16.1(b) A – Effective stroke of a cilium, B – Recovery stroke of a cilium, C – Metachronous wavy movement of a row of cilia.

16.2.2 Flagellar movement

A flagellum is a long, whip like structure. While cilia cover the entire surface, flagellum is mostly present singly or in a small number at one end of a cell. Flagella occur in flagellate protozoan like *Euglena* or an alga like *Chlamydomonas* and in animal sperms. A flagellum beats symmetrically in a snake like manner and propels the water parallel to long axis of flagellum. See figure of flagellum of *Euglena* and *Chlamydomonas* in Module 1, lesson 2, unit 2.2.2 of your text book.

INTEXT QUESTIONS

1. State the similarity in internal structure between a cilium and a flagellum as learnt in lesson 4 of your text book?
2. What is an effective stroke ? Which stroke is called the recovery stroke as depicted during ciliary movement ?
3. State the difference between flagella and cilia with regard to location and number.

16.3 MUSCULAR MOVEMENT IN ANIMALS

16.3.1 Structure of muscle

You have already learnt about muscular tissue in lesson 5, Module 1, unit 5.3.3. Go back to the lesson and revise the structure of striated muscle fibres. Stuated muscles are also called skeletal muscles as they are attached to bones and are responsible for movements of the limbs.

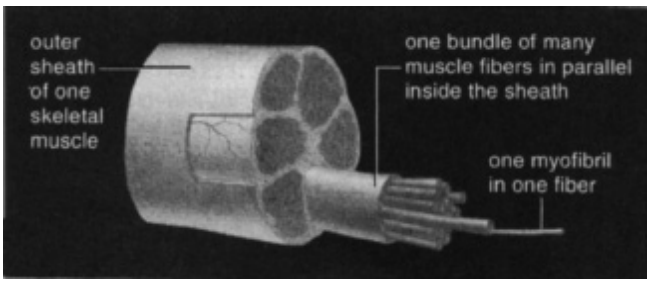


Fig. 16.2 The skeletal muscle

Striated muscle fibres are packed into bundles enclosed in a tough connective tissue. These bundles are grouped to form a muscle. Every skeletal muscle is also enclosed in a thin connective tissue as shown in the above figure.

The ends of muscles connect to bones through another kind of connective tissue called **tendon**. So, tendon joins a bone to a muscle.

16.3.2 Myofilaments

The muscle cell, also called muscle fibre because of its long shape, is multinucleated and contains myofibrils made of myofilaments. Myofilaments are proteins which are of two types:

(i) thick filaments made of myosin protein and

(ii) thin filaments made of actin protein.

Myosin and actin proteins are contractile proteins and responsible for muscular contraction.

The functional unit of the myofibril is called sarcomere. It lies between two successive dense linear structure called Z lines.

The thin filaments also contain two other proteins, tropomyosin and troponin Troponin is the switch, which in the presence of calcium ions controls muscle contraction.

Study the figure below to understand the structure of myofilaments:

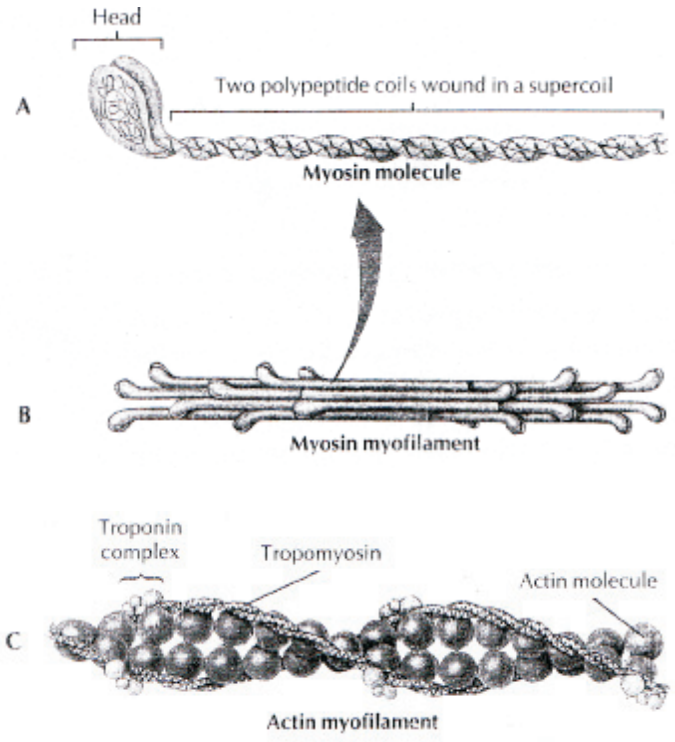


Fig. 16.3 Molecular structure of thick and thin myofilaments of a skeletal muscle. A. the myosin molecule is with coiled expanded ends forming a globular head. B. The thick myofilament is composed of a bundle of myosin molecules with their globular heads extended outward. C. The thin myofilament consists of a double strand of actin surrounded by two tropomysoin strands. A globular protein complex, troponin, occurs in pairs on actin.

16.3.3 The sliding model of muscle contraction

Striated muscle contraction is explained by **Sliding Filament Theory**. This theory can be explained through the following steps:

(i) The thick and thin filaments myosin and actin are linked by crossbridges of troponin and tropomyosin.

(ii) These crossbridges, on contraction, pull the thin filaments back over thick filaments.

(iii) As a result, the thin filaments slide over the thick filaments. Calcium and ATP are required for attaching and releasing Troponin.

(iv) Because of this sliding action, Z lines come closer (Fig 16.4) and sarcomere shortens.

(v) All sarcomeres shorten together so the entire muscle contracts.

(vi) The muscle relaxes when crossbridges relax and sarcomere regains original position.

See figure given below

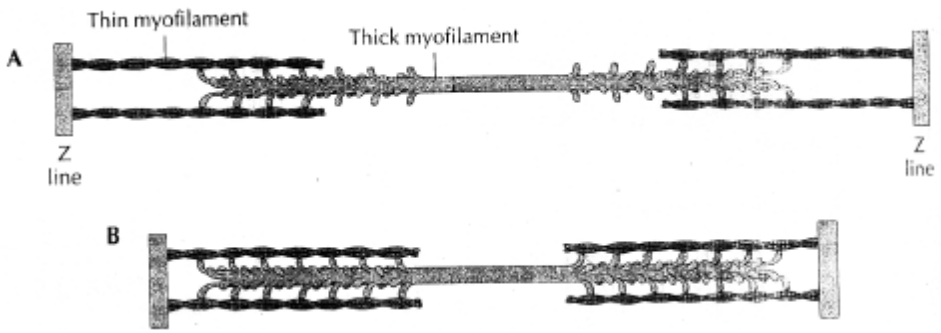
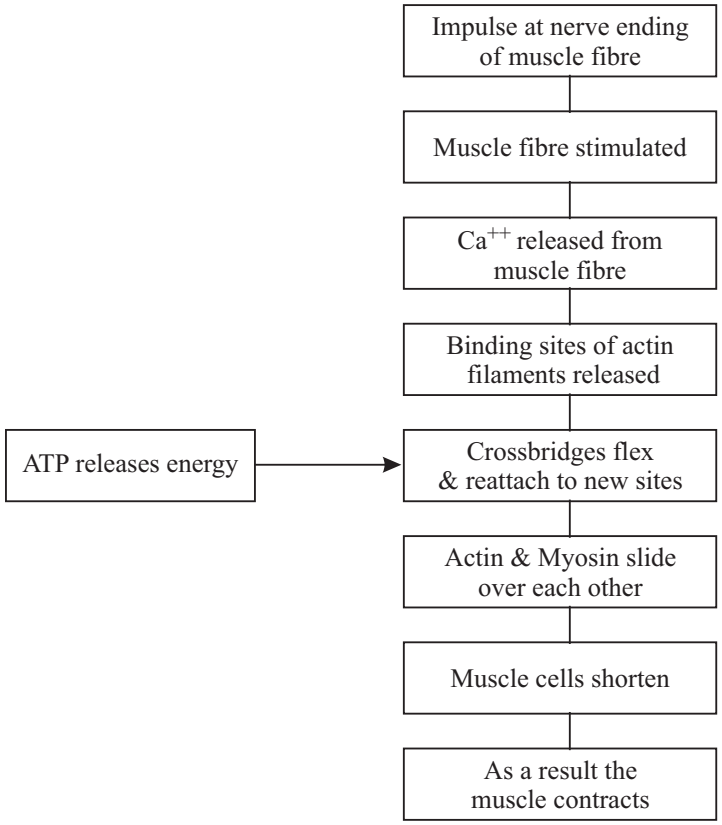


Fig. 16.4 Sliding myofilament model, showing how thick and thin myofilaments interact during contraction, A. Muscle relaxed. B. Muscle contracted.

Stimulation of muscle contraction

Muscles cannot contract on their own unless stimulated by a nerve. The nerve branches on a muscle and this area of the muscle fibre is called **myoneural junction** (myo: muscle; neuro: nerve).

Summary of events of muscle contraction



INTEXT QUESTION 16.3

1. Name the structure that connects (i) a bone to another bone (ii) muscle to bone. Which type of tissue are these ?
2. Why is the muscle cell also called muscle fibre ?
3. Why is the mechanism of muscle contraction called 'sliding movement'?
4. What is the chemical composition of myofilaments.
5. In a muscle, where can you find the following ? myofilaments, muscle fibres.

16.3.4 Energy for muscle contraction

The biological energy, ATP or Adenosine triphosphate is required for muscle contraction. Muscle also has a reservoir of high energy phosphate called creatine phosphate which can be converted to ATP.

16.4 THE SKELETAL SYSTEM

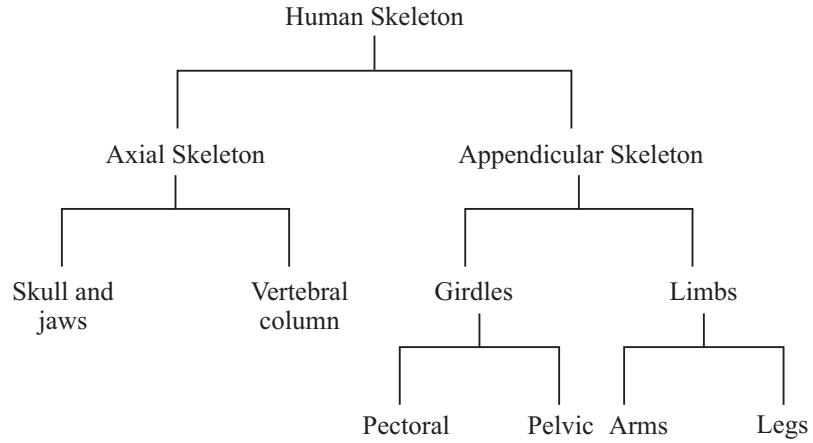
16.4.1 The types of skeleton.

Skeleton supports the body, gives rigidity to body, provides surface for attachment of muscles, and protects soft internal organs like the brain, heart, lungs etc.

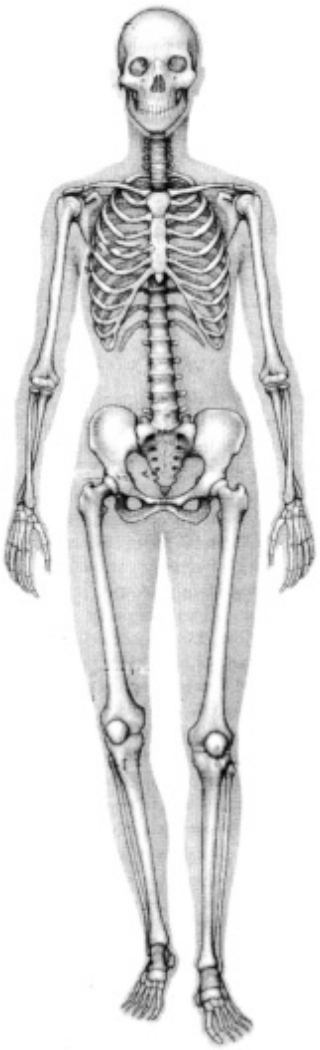
In the vertebrates, skeleton is made of bone and cartilage about which you have studied in the lesson on tissues. It is located inside the body and hence termed endoskeleton. Another rigid skeleton is the exoskeleton in the form of hard, calcareous shells in molluscs and the covering of chitin (a carbohydrate) in insects and other arthropods. Many invertebrates, such as the earthworm use their muscles, which are not attached to any rigid skeletal elements, by contracting against fluid in their body cavity. Coelomic (Coelom = body cavity) fluid within limited space acts as skeleton for muscle movement and is hence termed hydrostatic skeleton.

16.4.2 The human skeleton

The human skeleton is divided into following parts:



See the figure given below and locate the rib cage, the skull and the girdles.



16.5 MUSCULAR AND SKELETAL DISORDERS

You have all seen some people who are wheel chair bound. They are unable to move on their own. You have just learnt that muscle contracts only when stimulated by nerves. If nerve supply to muscle get severed, muscle gradually weakens or **atrophies**.

The old may limp because of calcium deficiency or deficiency of vitamin D_3 which is responsible for calcium absorption.

Injury to limb or girdle bones also hamper locomotion. But, these apart, some muscular and skeletal disorders are **hereditary** e.g. **Myaesthenia gravis** and **Muscular dystrophy**. **Arthritis** and **Rheumatoid arthritis** may or may not be hereditary. **Osteoporosis** and **Gout** are due to nutritional deficiency and **metabolic errors**. Let us learn a little about them.

Myaesthenia gravis is because of a gene on X chromosome and so is hereditary. The muscles slowly waste away and the patient gradually becomes immobile and in the last stages even the jaw muscles do not work and patient is unable to eat.

Muscular dystrophy is an autosomal dominant disorder. In this hereditary disorder, muscles waste away and person becomes immobile.

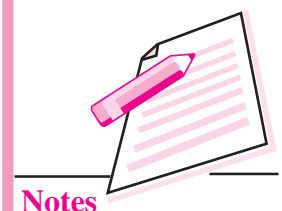
Arthritis and Rheumatoid arthritis are disorders of bones especially joints. There is constant joint pain in Rheumatoid arthritis which is a crippling disease. Hands and feet become crooked due to inflammation in the joints.

Osteoporosis is the softening of bones due to calcium deficiency. You know that calcium absorption is dependent on availability of Vitamin D. So it is important to expose oneself to the sun every day for atleast half an hour. You have aleady learnt that sunlight helps to generate Vitamin D. Women, post menopause are prone to osteoporosis. Estrogen, the female hormone mobilises calcium and sends it to bones. In the absence of estrogen, bones tend to crack and break.

Gout results in painful inflammation of joints due to elevated level of uric acid in blood. Uric acid is a product of protein metabolism. Gout can be cured.

INTEXT QUESTION 16.4

1. Name an animal with endoskeleton and one with exoskeleton.
2. Name main parts of skeleton and mention their functions.
3. Name any two disorders of the musculo–skeletal system which are hereditary.



4. What causes osteoporesis and gout ?
5. Which limbs are supported by which girdles and which kind of muscles are attached to the limb skeleton ?

16.6 MOVEMENTS IN PLANTS

Plants are rooted to the soil, hence they are unable to undertake locomotion. But plants show movements in response to external stimuli like light, water, gravity, called TROPIC MOVEMENTS. When a plant part, such as the root or stem, move towards the source of stimulus, it is termed positively tropic e.g. shoot moves and grows towards sunlight, it is positively phototropic. Root moves away from light, it is negatively phototropic. Similarly there are movements in response to stimuli which are given in the table below.

Stimulus	Term for Response
Touch/Contact	Thigmotropism
Gravity	Geotropism
Water	Hydrotropism

In tropic movements, plants are fixed but their parts e.g. a branch or a flower move in the direction of stimulus. Turgor movements are due to difference in water potential in different parts of plant. Examples are given below

- Leaf closes in the insectivorous plant Venus fly trap when an insect enters.
- *Mimosa pudica* called 'chhui mui ' in Hindi, droops when touched.
- Guard cells cause opening and closing of stomata due to changes in tugor pressure.

NASTIC MOVEMENTS are induced by certain stimuli like contact, change in day length, temperature etc. Unlike tropic movements in nastic movements the plant parts do not move in the direction of stimulus e.g. flowers of *Portulaca*, bloom in the day. But when light fails at sunset, the petals close in response to darkness and lowered temperature. In other words, direction of movement of an organ is fixed but the stimulus may come from any direction.

WHAT YOU HAVE LEARNT

- Movement is an important feature of all living beings and locomotion is characteristic of protoctista and animalia.
- While in movement, an organ or organelle may shift from its original position and come back to it, in locomotion, the entire body of the animal or the protoctist moves away and is displaced from its original location
- Ciliate protozoa or alga carry out locomotion by means of cilia, organelles made of microtubules. Ciliary beating begins with fast stroke and ends in a recovery stroke.
- Flagellum is long and whip like organelle made of microtubules. While cilia are many, flagella may be one or two.
- Muscles and bones help the vertebrates to locomote from one place to another, muscles are joined to bone by ligaments and one muscle is joined to the other by a tendon.
- Muscles are a tissue made of muscle cells, also called muscle fibres. Muscle fibres are made of thick and thin myofilaments made of myosin and actin protein molecules respectively.
- Muscles contract and relax to cause movement. Muscle contraction is explained by sliding filament theory of muscle contraction.
- Ca and ATP are required for muscle contraction.
- Vertebrate skeleton is made of bone and cartilage
- Axial skeleton is made of skull and vertebral column and appendicular skeleton is made of girdles and limbs.
- Hereditary muscular and skeletal disorders are myaesthenia gravis and muscular dystrophy. Arthitis and Rheumatism are bone disorders. Osteoporosis to softening is the bones due to Ca and Vitamin D deficiency. Gout results from increase in level of uric acid in blood.

  Plant movements may be tropic movements or nastic movements.
- Movement is a characteristic of living beings. It means a temporary or permanent displacements of the body or its parts.
- Locomotion is the displacement of the entire body from one place to another. It is a characteristic of protoctists and animals.
- Cilia and flagella are organslles which help in movement. Ciliary protozoa Locomote with the help of cilia. Human sperms, certain algae like *Chlamydomonas* move from one place to another with the help of flagella.

- Cilia are many and move together causing a wavy motion. Flagella may be one or two and with whip like strokes help in Locomotion.
- Most animals carry out Locomotion with the help of muscles.
- Muscles are made of muscle fibres. Muscle fibres have protein filaments called myofilaments.
- Actin and myosin filaments in a muscle fibre (muscle cell) slide over each other to cause Locomotion.
- Hence the muscle is said to contract through sliding of these two kinds of myofilaments and this is termed sliding model of muscle contraction.
- Apart from actin and myosin protein molecules, two other protein molecules named Troponin and Tropomyosin participate in muscle movement.
- The unit of contraction is termed a sarcomere and it contains both the myofilaments which slide between Z lines.
- Nerve impulse stimulates muscle movement.
- Human skeleton is divided into axial skeleton which includes skull and vertebral column and appendicular skeleton comprised of bones of girdles and limbs.
- Bones are connective tissues made of ossein and cartilage which are also part of human skeleton. Bones are joined to each other by ligaments & to muscles by tendons.
- Muscular & Skeletal disorders include Muscular dystrophy, arthritis, Myaesthenia graive, Osteoporosis and gout.

TERMINAL EXERCISES

1. Distinguish between the following pairs of terms:
   (i) movement and locomotion
   (ii) thick and thin myofilaments
   (iii) tendon and ligament
   (iv) cilia and flagella
   (v) tropic and nastic movement
2. Enlist the steps in muscle contraction as explained by sliding filament theory.
3. How does *Paramecium* swim in water?
4. Answer in one word or sentence

(i) What is the shape of actin molecule?

(ii) What is the chemical nature of troponin and tropomyosin?

(iii) What is meant by recovery stroke of cilia?

(iv) Give an example each of geotropism and phototropism.

(v) Why do we say that vertebrate muscle contraction is energy dependent?

ANSWER TO INTEXT QUESTIONS

16.1

M, M, L, L, M, L

16.2

1. Both made of microtubules arranged in a similar manner.
2. Fast stroke – cilium beats to move ahead

   Recovery stroke – cilium bends back to original position
3. Location – cilia all over body, flagella at anterior or posterior end

   Number – cilia many, flagella 1 or 2

16.3

1. Ligament; tendon; connective tissue
2. because of its elongated structure
3. because thick and thin myofilaments slide over each other to cause muscle contraction.
4. Protein
5. myofilaments in muscle fibre

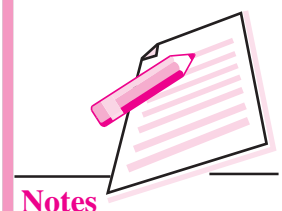
   muscle fibres in muscle tissue

16.4

1. any vertebrate named

   any insect/mollusc named
2. axial, appendicular

   support, protection to interanl organs; locomotion and movement; blood cells manufactured in bone marrow gives shape to body



3. Myaesthenia gravis; muscular dystrophy
4. Osteoporosis – lack of Ca

   Gout – High level of uric acid in blood
5. Pectoral – fore limbs; Pelvic – hind limb; Striped or striated