XI
20

LOCOMOTION AND MOVEMENT

SYLLABUS

Types of movement-amoeboid, ciliary, muscular; Skeletal muscle- contractile proteins and muscle contraction;
Skeletal system and its functions (To be dealt with the relevant practical of Practical syllabus); Joints; Disorders of muscular and skeletal system- Myasthenia gravis, Tetany, Muscular dystrophy, Arthritis, Osteoporosis, Gout.

KEY CONCEPTS

INTRODUCTION

* In Paramoecium, cilia helps in the movement of food through cytopharynx and in locomotion as well.
* Hydra can use its tentacles for capturing its prey and also use them for locomotion.
* All locomotions are movements but all movements are not locomotions.

TYPES OF MOVEMENT

* Cells of the human body exhibit three main types of movements, namely, amoeboid, ciliary and muscular.
* Some specialised cells in our body like macrophages and leucocytes in blood exhibit **amoeboid movement.**
* It is effected by pseudopodia formed by the streaming of protoplasm (as in Amoeba). Cytoskeletal elements like microfilaments are also involved in amoeboid movement.
* Ciliary movement occurs in most of our internal tubular organs which are lined by ciliated epithelium.
* The coordinated movements of cilia in the trachea help us in removing dust particles and some of the foreign substances inhaled alongwith the atmospheric air.
* Passage of ova through the female reproductive tract is also facilitated by the **ciliary movement.**
* Movement of our limbs, jaws, tongue, etc, require **muscular movement.** The contractile property of muscles are effectively used for locomotion and other movements by human beings and majority of multicellular organisms.
* Locomotion requires a perfect coordinated activity of muscular, skeletal and neural systems.

TYPES OF LOCOMOTION

* Locomotion takes several forms such as walking (man), creeping (earthworm, lizard), cursorial (Horse, flightless birds), hopping (frog, rabbit), running (dog, horse), flying (insects, birds) and swimming (fish, whale).
* Animals have suitable adaptations for their specific mode of locomotion.
* Adaptations for running, hopping, swimming and flying are respectively called cursorial, saltatorials, natatorial, and volant adaptations.
* Morphogenetic movement, i.e., the streaming of cells in the early embryo to form tissues or organs, may be considered a form of locomotion.

* **Locomotion in different animals :**

(i) **Locomotion in Protozoa :** Locomotion in protozoans by the help of cilia, flagella and pseudopodia.

(ii) **Locomotion in Porifera :** Sponges are sedentary or fixed animals which are always attached to some substratum. Hence locomotion never takes place.

(iii) **Locomotion in Coelentrates :** Locomotion in coelentrates is largely due to the contraction of the epidermal muscle fibres following type of movements take place in coelentrates

(a) Swimming (b) Floating
(c) Surfacing (d) Climbing
(e) Walking (f) Gliding
(g) Somersaulting (h) Looping
(i) Bending swaying movement.

(iv) **Locomotion in Helminths:** In helminths (platyhelminthes and aschelminthes) locomotion not required by adult due to parasitic adaptations. However in miracidia (a larva) locomotion by cilia, in cercaria larva by tail. In Ascaris 15% locomotion by cuticle fiber. In planaria locomotion by cilia and muscles.

(v) **Locomotion in Annelids :** Leech, Earthworm and Nereis have well developed circular and longitudinal muscles in the body wall that help these animals to move about. Parapodia and setae helpful for locomotion in nereis. In earthworm also locomotion by setae.

(vi) **Locomotion in Arthropods :** In arthropods locomotion takes place with the help of jointed legs, and a pair of wings. Cockroaches, housefly etc., move from one place to another by legs (walking) as by wings (flight) both. Palaemon or prawn crawls at bottom by pairs of walking legs. Palamnaeus or Indian scorpion used 4 pairs of walking legs. All insects used 3 pair of walking legs for locomotion.

(vii) **Locomotion in Mollusca :** In all the molluscs, the locomotory organ is a thick walled, muscular, broad or laterally compressed foot. In some molluscs, the foot is modified into eight or ten arms (e.g., *Sepia, Loligo, Ocotopus* etc). Foot is chiefly a locomotory organ in unio and pila both. In Neopilina also locomotion by foot. In *sepia, loligo* locomotion by fins mainly.

(viii) **Locomotion in Echinodermata :**
In echinoderms such as starfish, the locomotory organs are tubefeet and locomotion takes place by water vascular system, which set up a hydraulic pressure. The tubefeet are associated with this system intimately. At the time of locomotion, one or two arms of a side work as main structures.

(ix) **Locomotion in vertebrates :** In vertebrates, locomotion takes place with the help of skeletal muscles, and skeleton. The locomotory organs are a pair of legs.

MUSCLE

* Muscle is a specialised tissue of mesodermal origin.
* The muscular tissue is made up of specialised cells called myocytes.
* About 40-50 per cent of the body weight of a human adult is contributed by muscles. They have special properties like excitability, contractility, extensibility and elasticity.
* The muscles that act together to produce a movement are called **synergists** and the muscle that act in opposition to each other are **antagonists**. The muscles that act most powerfully during any given movements are called prime movers.
* Muscles have been classified using different criteria, namely location, appearance and nature of regulation of their activities.
* Based on their location, three types of muscles are identified :
(i) Skeletal (ii) Visceral and (iii) Cardiac.
* **Skeletal muscles** are closely associated with the skeletal components of the body. They have a striped appearance under the microscope and hence are called **striated muscles**. As their activities are under the voluntary control of the nervous system, they are known as **voluntary muscles** too. They are primarily involved in locomotory actions and changes of body postures.
* **Visceral muscles** are located in the inner walls of hollow visceral organs of the body like the alimentary canal, reproductive tract, etc.

They do not exhibit any striation and are smooth in appearance. Hence, they are called **smooth muscles (nonstriated muscle)**. Their activities are not under the voluntary control of the nervous system and are therefore known as **involuntary muscles**. They assist, for example, in the transportation of food through the digestive tract and gametes through the genital tract.

* **Cardiac muscles** are the muscles of heart. Many cardiac muscle cells assemble in a branching pattern to form a cardiac muscle. Based on appearance, cardiac muscles are **striated**. They are **involuntary** in nature as the nervous system does not control their activities directly.

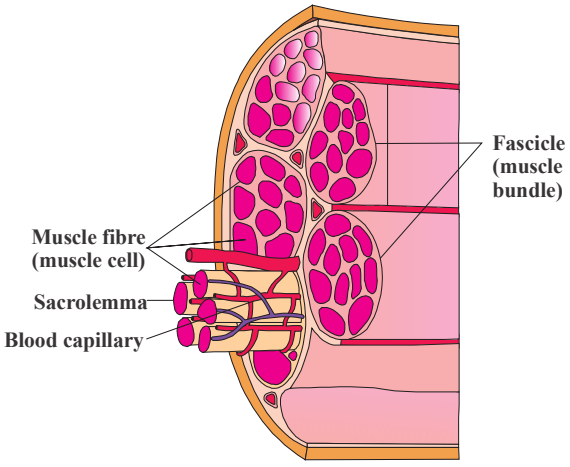


Figure : Diagrammatic cross sectional view of a muscle showing muscle bundles and muscle fibres

* Each organised skeletal muscle in our body is made of a number of muscle bundles or fascicles held together by a common collagenous connective tissue layer called **fascia**. Each muscle bundle contains a number of muscle fibres. Each muscle fibre is lined by the plasma membrane called **sarcolemma** enclosing the **sarcoplasm**. Muscle fibre is a syncitium as the sarcoplasm contains many nuclei. The endoplasmic reticulum, i.e., sarcoplasmic reticulum of the muscle fibres is the store house of calcium ions.
* 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. A detailed study of the myofibril has established that the striated appearance is due to the distribution pattern of two important proteins – **Actin and Myosin**.
* The light bands contain actin and is called **I-band or Isotropic band**, whereas the dark band called **'A' or Anisotropic band** contains myosin. Both the proteins are arranged as rod-like structures, parallel to each other and also to the longitudinal axis of the myofibrils.
* Actin filaments are thinner as compared to the myosin filaments, hence are commonly called thin and thick filaments respectively.
* In the centre of each 'I' band is an elastic fibre called 'Z' line which bisects it.
* The thin filaments are firmly attached to the 'Z' line.
* The thick filaments in the 'A' band are also held together in the middle of this band by a thin fibrous membrane called 'M' line.
* The 'A' and 'I' bands are arranged alternately throughout the length of the myofibrils.
* The portion of the myofibril between two successive 'Z' lines is considered as the functional unit of contraction and is called a sarcomere.
* In a resting state, the edges of thin filaments on either side of the thick filaments partially overlap the free ends of the thick filaments leaving the central part of the thick filaments. This central part of thick filament, not overlapped by thin filaments is called the 'H' zone.

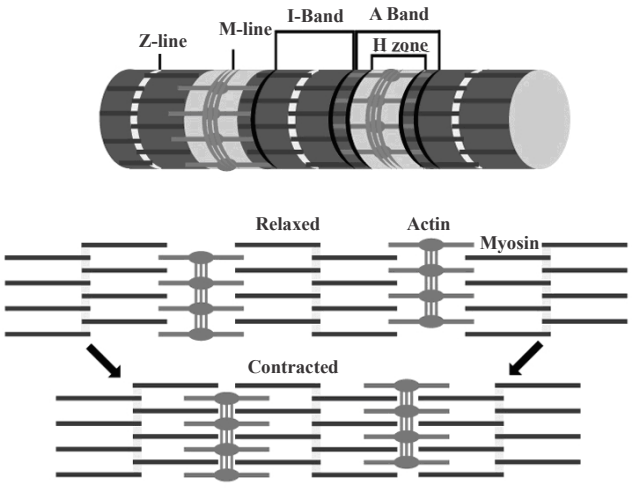


Figure : Anatomy of muscle fibre showing a sarcomere

STRUCTURE OF CONTRACTILE PROTEINS

* Each actin (thin) filament is made of two 'F' (filamentous) actins helically wound to each other. Each 'F' actin is a polymer of monomeric 'G' (Globular) actins. 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.
* Each myosin (thick) filament is also a polymerised protein.
* Myosin molecule has an ATP binding site.
* Many monomeric proteins called **Meromyosins** constitute one thick filament.
* 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).**
* The HMM component, i.e.; the head and short arm projects outwards at regular distance and angle from each other from the surface of a polymerised myosin filament and is known as **cross arm**. The globular head is an active ATPase enzyme and has binding sites for ATP and active sites for actin.

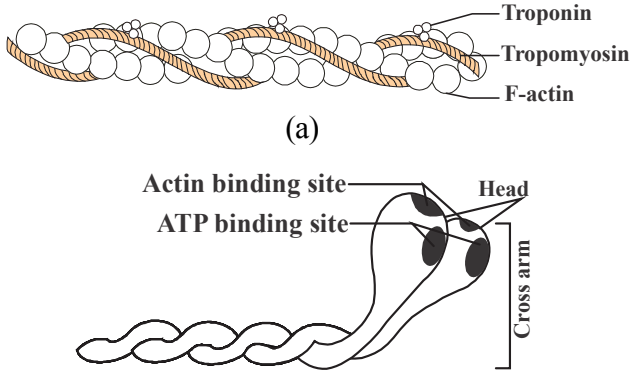


Figure : (a) An actin (thin) filament (b) Myosin monomer (Meromyosin)

MECHANISM OF MUSCLE CONTRACTION

* Mechanism of muscle contraction is best explained by the **sliding filament** theory which states that contraction of a muscle fibre takes place by the sliding of the thin filaments over the thick filaments.
* This theory was proposed by two group of workers (Andrew Hutley and Ralph Niedergerke, Hugh Huxley and Jean Hanson).
* Muscle contraction is initiated by a signal sent by the central nervous system (CNS) via a motor neuron.
* A motor neuron alongwith the muscle fibres connected to it constitute a motor unit.
* The junction between a motor neuron and the sarcolemma of the muscle fibre is called the neuromuscular junction or motor-end plate.
* A neural signal reaching this junction releases a neurotransmitter (Acetyl choline) which generates an action potential in the sarcolemma.
* This spreads through the muscle fibre and causes the release of calcium ions into the sarcoplasm.
* Increase in Ca^{++} level leads to the binding of calcium with a subunit of troponin on actin filaments and thereby remove the masking of active sites for myosin.
* Utilising the energy from ATP hydrolysis, the myosin head now binds to the exposed active sites on actin to form a cross bridge.

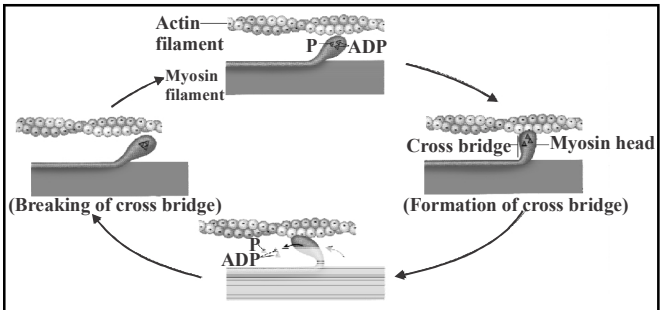


Figure : Stages in cross bridge formation, rotation of head and breaking of cross bridge

* This pulls the attached actin filaments towards the centre of 'A' band.
* The 'Z' line attached to these actins are also

pulled inwards thereby causing a shortening of the sarcomere, i.e., contraction.

* During shortening of the muscle, i.e., contraction, the 'I' bands get reduced, whereas the 'A' bands retain the length.
* The myosin, releasing the ADP and P goes back to its relaxed state. A new ATP binds and the cross-bridge is broken.
* The ATP is again hydrolysed by the myosin head and the cycle of cross bridge formation and breakage is repeated causing further sliding.
* The process continues till the Ca^{++} ions are pumped back to the sarcoplasmic cisternae resulting in the masking of actin filaments. This causes the return of 'Z' lines back to their original position, i.e., relaxation.
* Repeated activation of the muscles can lead to the accumulation of lactic acid due to anaerobic breakdown of glycogen in them, causing fatigue.

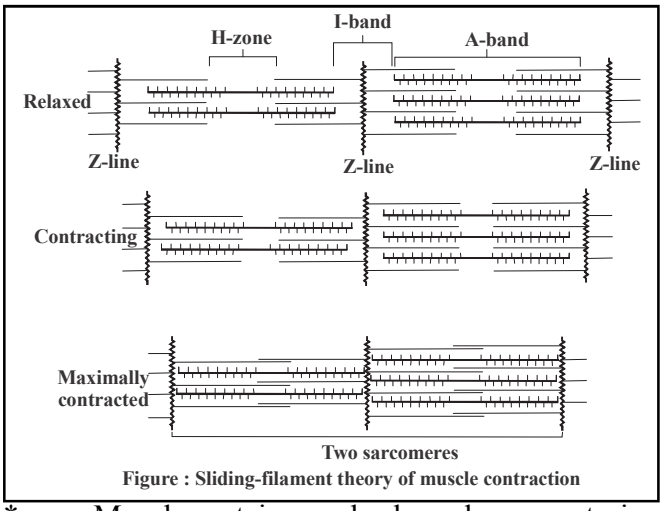


Figure : Sliding-filament theory of muscle contraction

* Muscle contains a red coloured oxygen storing pigment called **myoglobin**. Myoglobin content is high in some of the muscles which gives a reddish appearance. Such muscles are called the **Red fibres**. These muscles also contain plenty of mitochondria which can utilise the large amount of oxygen stored in them for ATP production. These muscles, therefore, can also be called aerobic muscles.
* Some of the muscles possess very less quantity of myoglobin and therefore, appear pale or whitish. These are the **White fibres**. Number of mitochondria are also few in them, but the amount of sarcoplasmic reticulum is high. They depend on anaerobic process for energy.

SKELETAL SYSTEM

* Skeletal system consists of a framework of bones and a few cartilages.
* Bone and cartilage are specialised connective tissues. The former has a very hard matrix due to calcium salts in it and the latter has slightly pliable matrix due to chondroitin salts. In human beings, this system is made up of 206 bones and a few cartilages. It is grouped into two principal divisions – the **axial** and the **appendicular skeleton**.
* The axial skeleton runs along the middle longitudinal axis of the body.
* The appendicular skeleton system includes the skeleton of the limbs, the pectoral and pelvic girdle which support and suspend the skeleton of limbs from the vertebral column.

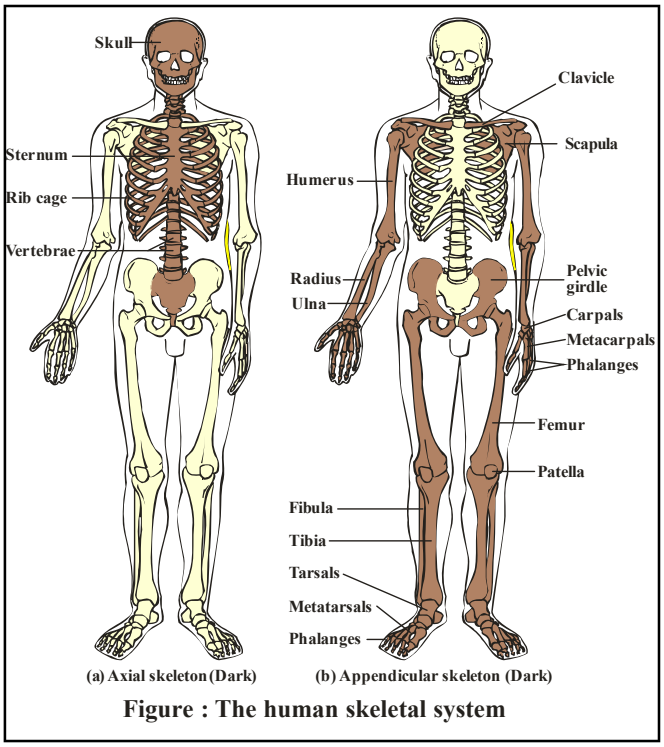


Figure : The human skeletal system

(I) Axial skeleton :

* It comprises 80 bones distributed along the main axis of the body. The skull, vertebral column, sternum and ribs constitute axial skeleton.
* The skull is composed of two sets of bones – cranial and facial, that totals to 22 bones. Cranial bones are 8 in number.

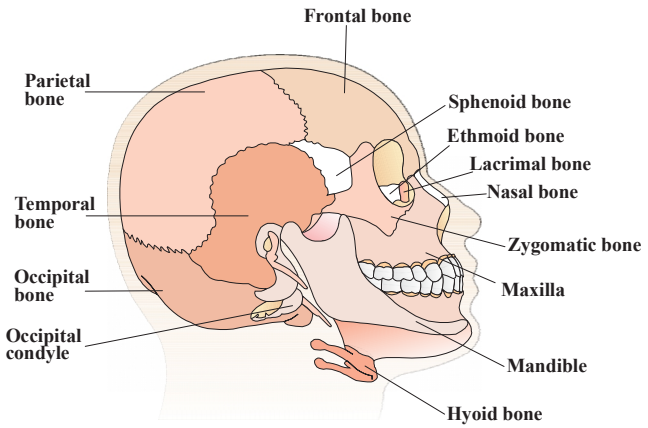


Figure : Diagrammatic view of human skull

* They form the hard protective outer covering, cranium for the brain.
* The facial region is made up of 14 skeletal elements which form the front part of the skull.
* A single U-shaped bone called hyoid is present at the base of the buccal cavity and it is also included in the skull.
* Each middle ear contains three tiny bones – Malleus, Incus and Stapes, collectively called **Ear Ossicles.**
* The skull region articulates with the superior region of the vertebral column with the help of two occipital condyles (dicondylic skull).

Vertebral column :

* Our vertebral column is formed by 26 serially arranged units called vertebrae and is dorsally placed.
* It extends from the base of the skull and constitutes the main framework of the trunk. Each vertebra has a central hollow portion (neural canal) through which the spinal cord passes.
* First vertebra is the atlas and it articulates with the occipital condyles.
* The vertebral column is differentiated into cervical (7), thoracic (12), lumbar (5), sacral (1-fused) and coccygeal (1-fused) regions starting from the skull.
* The number of cervical vertebrae are seven in almost all mammals including human beings.

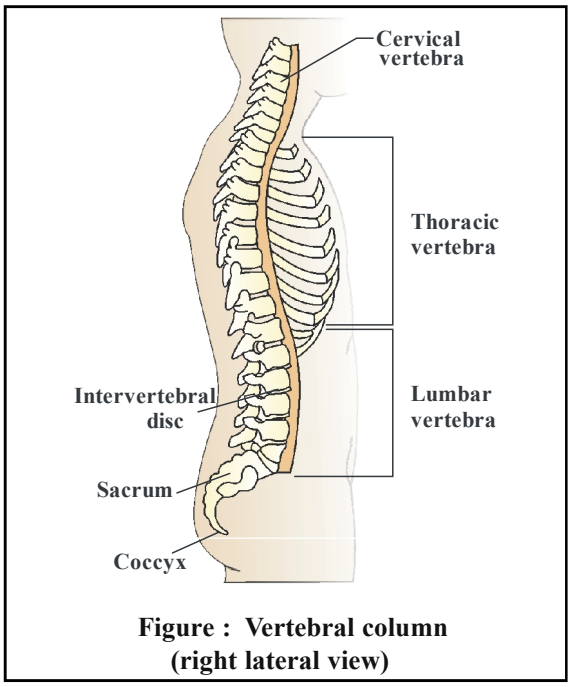


Figure : Vertebral column (right lateral view)

* The vertebral column protects the spinal cord, supports the head and serves as the point of attachment for the ribs and musculature of the back.

Sternum :

* Sternum is a flat bone on the ventral midline of thorax.
* It is present just under the skin in the middle of the chest.
* The sternum forms protective covering which protects the internal organs present in the thoracic region.
* It provides a surface where muscles attach and help in the respiratory mechanism.

Ribs :

* There are 12 pairs of ribs. Each rib is a thin flat bone connected dorsally to the vertebral column and ventrally to the sternum.
* It has two articulation surfaces on its dorsal end and is hence called **bicephalic**.
* First seven pairs of ribs are called **true ribs.**
* Dorsally, they are attached to the thoracic vertebrae and ventrally connected to the sternum with the help of hyaline cartilage.
* The 8th, 9th and 10th pairs of ribs do not articulate directly with the sternum but join the seventh rib with the help of hyaline cartilage.

These are called vertebrochondral **(false) ribs.**

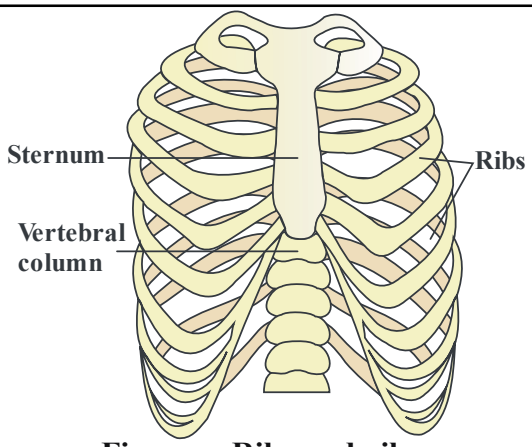


Figure : Ribs and rib cage

* Last 2 pairs (11th and 12th) of ribs are not connected ventrally and are therefore, called **floating ribs**.
* Thoracic vertebrae, ribs and sternum together form the rib cage.
* The ribs serve three important functions -

(i) They protect the heart, large blood vessels and lungs.

(ii) They bear respiratory muscle (external and internal intercostal muscle).

(iii) Lower two pair of ribs protect the kidney. (11th & 12th)

(II) Appendicular skeleton :

* The bones of the limbs alongwith their girdles constitute the **appendicular skeleton**. Each limb is made of 30 bones.
* The bones of the hand (fore limb) are humerus, radius and ulna, carpals (wrist bones-8 in number), metacarpals (palm bones-5 in number) and phalanges (digits-14 in number).
* Femur (thigh bone-the longest bone), tibia and fibula, tarsals (ankle bones-7 in number), metatarsals (5 in number) and phalanges (digits -14 in number) are the bones of the legs (hind limb).
* A cup shaped bone called patella cover the knee ventrally (knee cap).

Pectoral and Pelvic girdle bones :

* It help in the articulation of the upper and the lower limbs respectively with the axial skeleton.
* Each girdle is formed of two halves.
* Each half of pectoral girdle consists of a clavicle and a scapula.
* Scapula is a large triangular flat bone situated in the dorsal part of the thorax between the second and the seventh ribs.
* The dorsal, flat, triangular body of scapula has a slightly elevated ridge called the **spine** which projects as a flat, expanded process called the **acromion**.
* The clavicle articulates with this. Below the acromion is a depression called the **glenoid cavity** which articulates with the head of the humerus to form the shoulder joint.
* Each clavicle is a long slender bone with two curvatures. This bone is commonly called the **collar bone.**

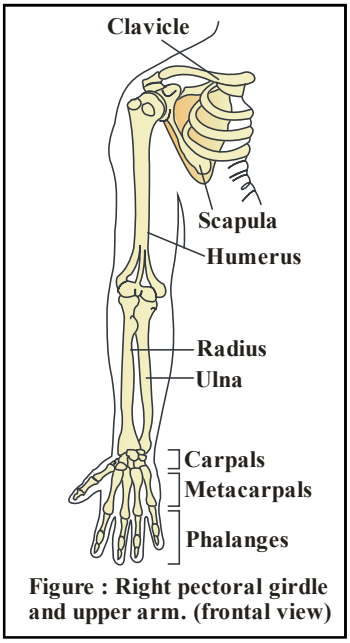


Figure : Right pectoral girdle and upper arm. (frontal view)

* Pelvic girdle consists of two coxal bones. Each coxal bone is formed by the fusion of three bones – ilium, ischium and pubis.
* At the point of fusion of the above bones is a cavity called **acetabulum** to which the thigh bone articulates.
* The two halves of the pelvic girdle meet ventrally to form the pubic symphysis containing fibrous cartilage.

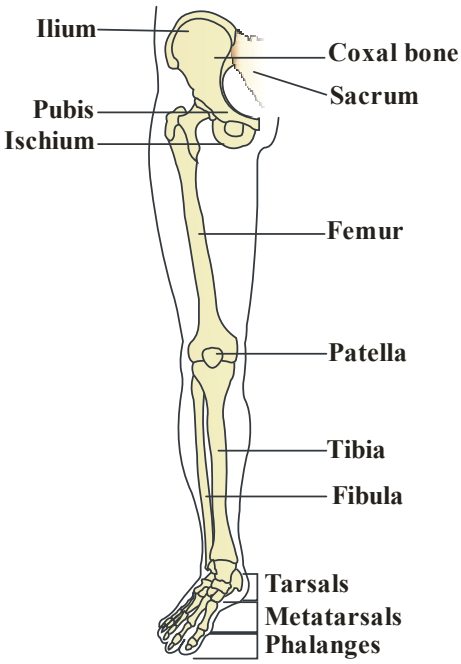


Figure : Right pelvic girdle and lower limb bones (frontal view)

Limb bones : Limb are two types fore limb and hind limb.

* **Bones of fore limbs**

(i) Humerus or arm bone or bone of upper arm, is longest and largest bone of upper limb.

(ii) It articulates proximally with scapula and distally at the elbow with both ulna and radius.

(iii) Humerus proximal end with greater and lesser tuberosity tubercle.

(iv) Both radius and ulna with nutrient foramina.

(v) Radius present towards thumb side.

(vi) Ulna present towards little finger side.

(vii) It includes Humerus + Radius & ulna + Carpals + Meta carpals + Phalanges.

(viii) Humerus is characterised by presence of deltoid tuberocity for the attachment of muscles.

(ix) Distal end of humerus at the elbow joint is like pully and called trochlea. Its groove is called olecranon fossa whose basal part is marked by a supratrochlear foramen for the passage of brachial artery and nerve.

(x) Humerus is characterised by arterial foramen.

(xi) Head of the humerus articulate with glenoid cavity of pectoral girdle.

(xii) Radius is smaller and ulna is larger.

(xiii) Styloid process is present in distal end of ulna and radius both.

(xiv) Olecranon process is present in ulna. Proximally, which forms prominence of elbow.

(xv) Trochlear notch is formed by ulna which is also known as sigmoid notch.

(xvi) Carpals or wrist bone are eight in number, joined to one another by ligaments. Carpals are arranged in 2 rows, with 4 bones in each row.

(xvii) Metacarpals are five in number, and phalanges are - fourteen, phalanges formula = 2, 3, 3, 3, 3.

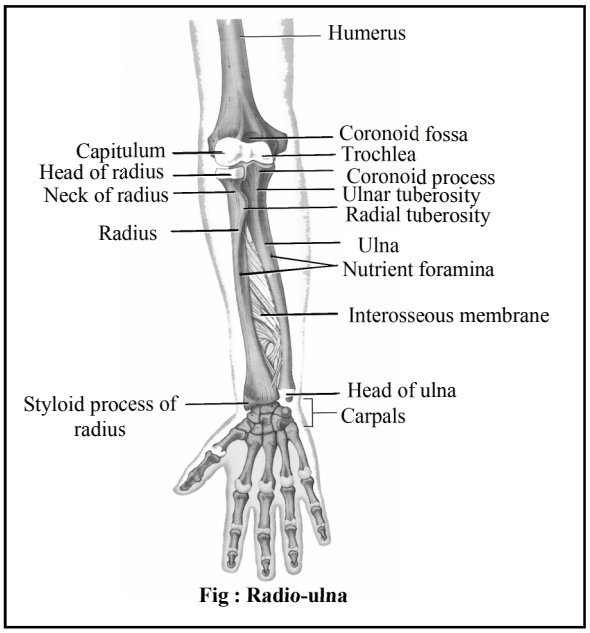


Fig : Radio-ulna

* **Bones of hind limbs**

(i) It includes Femur + Tibia and Fibula + Tarsals + Metatarsals + Phalanges

(ii) Fovea capitis is depression in head of femur.

(iii) Femur is longest and strongest bone of body.

(iv) Femur is known as bone of thigh

(v) Greater trochenter, lesser trochenter 3rd trochonter are present in femur, of thigh and buttock muscles.

(vi) Patellar groove in found in distal end of femur.

(vii) Fibula is smaller and associated with knee joint.

(viii) Tibia is larger, also called shin bone. It bears a weight of body.

(ix) Tarsal bones are seven.

(x) Metatarsals are five.

(xi) Phalanges are fourteen.

(xii) Phalanges formula = 2, 3, 3, 3, 3

(xiii) Patella form knee cap.

(xiv) Patella is formed by sesamoid bone. Fabella also example of sesamoid bone.

(xv) Thumb of foot is called hallux.

(xvi) Ankle bones have 7 tarsals and arranged in two rows then Ist row have talus and calcaneus, second row with cuboid, Navicular, and I, II, III cuneiform.

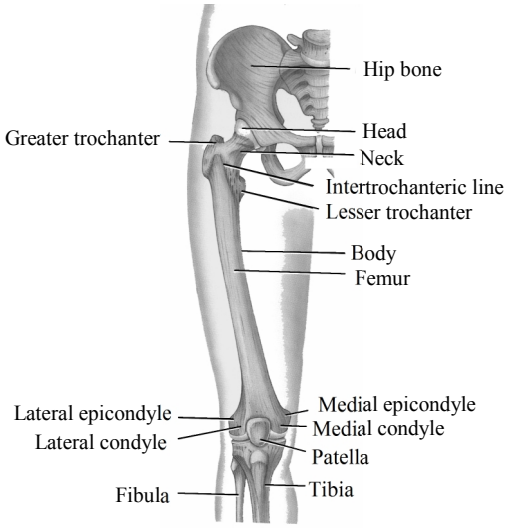


Fig : Femur (Anterior view)

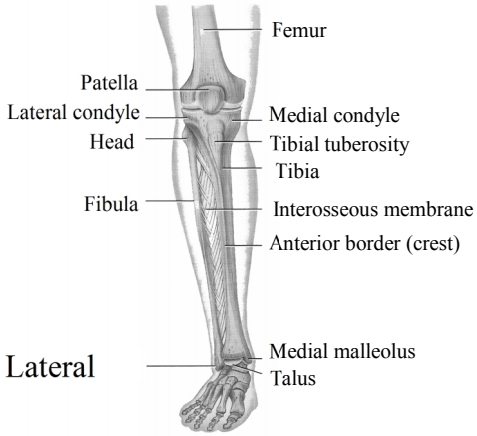


Fig : Tibia-fibula

JOINTS

* 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.
* The movability at these joints vary depending on different factors. Joints have been classified into three major structural forms, namely, fibrous, cartilaginous and synovial.
* Fibrous joints do not allow any movement. This type of joint is shown by the flat skull bones which fuse end-to-end with the help of dense fibrous connective tissues in the form of sutures, to form the cranium.
* In cartilaginous joints, the bones involved are joined together with the help of cartilages. The joint between the adjacent vertebrae in the vertebral column is of this pattern and it permits limited movements.
* Synovial joints are characterised by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones. Such an arragement allows considerable movement. These joints help in locomotion and many other movements. Ball and socket joint (between humerus and pectoral girdle), Hinge joint (knee joint), Pivot joint (between atlas and axis), Gliding joint (between the carpals) and Saddle joint (between carpal and metacarpal of thumb) are some examples.

1. **Ball and socket joint :** Ball and socket joint is the most free joint of all joints.It shows movements in different directions. The articulate end of one bone is in the shape of a ball whereas the end of the other bone is in the shape of a cup. The ball of one bone is fitted into the socket of the other bone e.g., shoulder joint and hip joint.
2. **Hinge joint :** Hinge joint is a joint which allows movement only in one plane. In a hinge joint, the end of one bone is deep convex in shape and the end of other bone is deep concave in shape. The convex end of the bone articulates with the concave end of the other bone and allow movement only in one plane e.g., elbow joint, knee joint.
3. **Pivot joint :** The pivot joint allows movement in one one plane. The primary movement at the pivot joint is rotation. Two bones articulate with each other where end of one bone is rounded or pointed which fits into a shallow depression of the other bone. The rounded end of the bone is fixed or stationary whereas the other bone rotates

over it e.g., joint between the radius and ulna just below the elbow.

4. **Gliding joint :** It is the simplest of synovial joint. The articulate ends of both the bones are flat or slightly curved so that the bones can easily glide or slide over each other. This joint allows movement only in one direction i.e. side to side movement, no twisting or rotational movement is possible because the bones are packed closely or held in place by ligaments e.g., wrist, tarsal etc.
5. **Saddle joint :** Saddle joint is a joint in which one ball or convex head of one bone fixes into saddle-like depression of the other bone. It is a type of ball and socket joint and hence allows movement in many direction e.g., between carpals and metacarpals of human thumb.
6. **Angular or condyloid or ellipsoid joint :** It is a type of joint in which articulate end of one bone is oval and convex and the articulate end of the other is elliptical and concave. The oval or convex end fits into the elliptical or concave end and causes movement only in two directions i.e., back and forth or side to side.

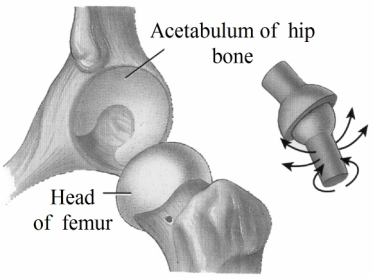


Fig : Ball-and-socket joint between head of the femur and acetabulum of the hip bone

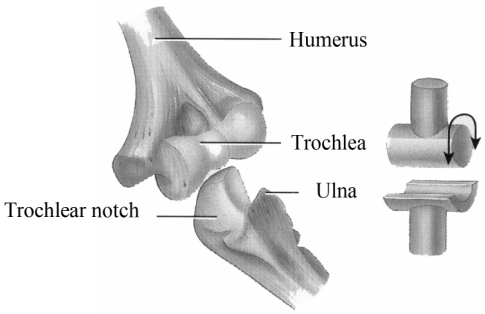


Fig : Hinge joint between trochlea of humerus and trochlear notch of ulna at the elbow

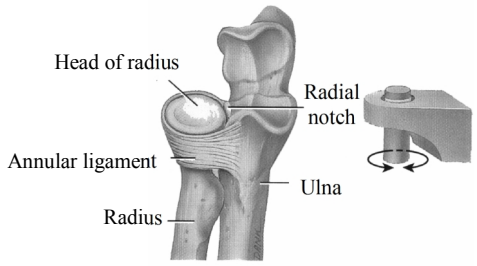


Fig : Pivot joint between head of radius and radial notch of ulna

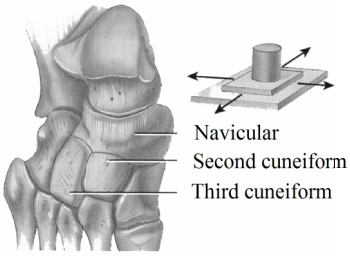


Fig Gliding joint between the navicular and second and third cuneiforms of the tarsus in the foot

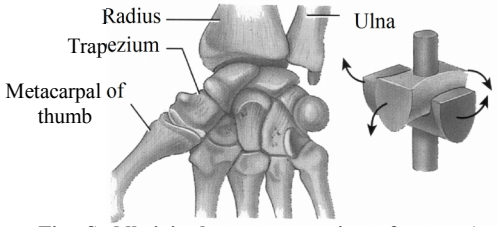


Fig : Saddle joint between trapezium of carpus (wrist) and metacarpal of thumb

DISORDERS OF MUSCULAR AND SKELETAL SYSTEM

* **Myasthenia gravis:** Auto immune disorder affecting neuromuscular junction leading to fatigue, weakening and paralysis of skeletal muscle.
* **Muscular dystrophy:** Progressive degeneration of skeletal muscle mostly due to genetic disorder.
* **Tetany:** Rapid spasms (wild contractions) in muscle due to low Ca^{++} in body fluid.
* **Arthritis:** Inflammation of joints.
* **Osteoporosis:** Age-related disorder characterised by decreased bone mass and increased chances of fractures. Decreased levels of estrogen is a common cause.

* **Gout:** Inflammation of joints due to accumulation of uric acid crystals.
* **Sprain :** Sprain refers to injury to a joint capsule, typically involving a stretching or tearing of tendons or ligaments. Unfortunately, both these structures have much poorer regenerative power than bone, and once stretched often remain weak. Sprain is often considered a minor disorder, but it may become chronic.
* **Fracture :** Fracture is a break of a bone. Fracture occurs rarely in children. The bones of children have a large quantity of organic matter and are, therefore, very flexible and less likely to break. With advancing age, mineral matter (calcium phosphate) is deposited in the bones. This decreases the organic matter, making the bones hard and brittle. Thus, old people are more liable to fracture of bones.

CONCEPT REVIEW

* **Muscle tissue** consists of cells specialized to contract. Each cell is an elongated muscle fiber containing many contractile units called **myofibrils**.
* **Skeletal muscle** is striated and under voluntary control. Each elongated, cylindrical muscle fiber has several nuclei.
* **Cardiac muscle** is striated; its contraction is involuntary. Its elongated, cylindrical fibers branch and fuse; each fiber has one or two central nuclei.
* **Smooth muscle** contracts involuntarily. Its elongated, spindle shaped fibers lack striations. Each fiber has a single central nucleus. Smooth muscle is responsible for movement of food through the digestive tract and for movement of other body organs.
* **The sequence of events in muscle contraction :**

(1) Acetylcholine (released from motor neuron) combines with receptors on muscle fiber causing depolarization and an action potential.

(2) The action potential spreads through T tubules, triggering Ca^{2+} release from sarcoplasmic reticulum.

(3) When troponin binds Ca^{2+} it undergoes a conformational change that causes active sites on actin filaments to be exposed.

(4) ATP (attached to myosin) is split and the energized myosin head is cocked; it binds to active site on actin filament, forming a cross bridge.

(5) P_i is released from myosin head, triggering the power stroke.

(6) The power stroke occurs as the actin filament is pulled toward center of sarcomere; and ADP is released.

(6) The myosin head binds ATP and detaches from actin. If sufficient Ca^{2+} is present, the sequence repeats from step (4).

* The **skeletal system** supports and protects the body, and transmits mechanical forces generated by muscles.
* Many soft-bodied invertebrates, including cnidarians, flatworms, and annelids, have a **hydrostatic skeleton** in which fluid in a closed body compartment is used to transmit forces generated by contractile cells or muscle.
* **Exoskeletons** are characteristic of mollusks and arthropods. The arthropod skeleton, composed partly of **chitin**, is jointed for flexibility, and adapted for many lifestyles. This nonliving skeleton does not grow, making it necessary for arthropods to molt periodically.
* The **endoskeletons** of echinoderms and chordates consist of living tissue and therefore can grow.
* The vertebrate skeleton consists of an **axial skeleton** and an **appendicular skeleton.**
* The axial skeleton consists of **skull, vertebral column, ribs,** and **sternum.**
* The appendicular skeleton consists of bones of the **limbs, pectoral girdle,** and **pelvic girdle.**
* A typical long bone consists of a thin outer shell of **compact bone** surrounding the inner spongy bone and a central cavity that contains bone marrow.
* Long bones develop from cartilage templates during **endochondral bone** formation. Other bones, such as the flat bones of the skull, develop from a noncartilage connective tissue model by intramembranous bone development.

* Osteoblasts, cells that produce bone, and osteoclasts, cells that break down bone, work together to shape and remodel bone.
* Joints are junctions of two or more bones. **Ligaments** are connective tissue bands that connect bones and limit movement at the joint.
* The sutures of the skull are immovable joints. Joints between vertebrae are slightly movable joints.
* A freely movable joint is enclosed by a joint capsule lined with a membrane that secretes **synovial fluid**.
* A skeletal muscle such as the biceps is an organ made up of hundreds of **muscle fibers**. Each fiber consists of thread like **myofibrils** composed of smaller **myofilaments,** or simply filaments.
* The striations of skeletal muscle fibers reflect the overlapping of their **actin filaments** and **myosin filaments**. A sarcomereis a contractile unit of actin (thin) and myosin (thick) filaments.
* **Acetylcholine** released by a motor neuron combines with receptors on the surface of a muscle fiber. This may cause depolarization of the sarcolemma and transmission of an action potential.
* The action potential spreads through the T tubules, releasing calcium ions from the **sarcoplasmic reticulum.**
* Calcium ions bind to troponin in the actin filaments, causing the troponin to change shape. Troponin pushes **tropomyosin** away from the active sites on the actin filaments.
* ATP binds to myosin; ATP is split, putting the myosin head in a high-energy state (it is "cocked"). Energized myosin heads bind to the exposed active sites on the actin filaments, forming **cross bridges** linking the myosin and actin filaments.
* After myosin attaches to the actin filament, phosphate is released, flexing the cross bridge. The actin filament is pulled toward the center of the sarcomere. This is tile power stroke. ADP is released.
* The myosin head binds a new ATP, which lets the myosin head detach from the actin. As long as the calcium ion concentration remains elevated, the new ATP is split, and the sequence repeats. The myosin reattaches to new active sites so that the filaments are pulled past one another, and the muscle continues to shorten.
* During muscle contraction, the myosin filaments pull the actin filaments toward the center of the myofibril. This movement requires energy.
* ATP is the immediate source of energy for muscle contraction. The energy from ATP hydrolysis provides the energy to "cock" the myosin.
* Muscle tissue has an intermediate energy storage compound, **creatine phosphate.**
* **Glycogen** is the fuel stored in muscle fibers.
* Muscles pull on **tendons**, connective tissue cords that attach muscles to bones. When a muscle contracts, it pulls a bone toward or away from the bone with which it articulates. Muscle tone is the state of partial contraction characteristic of muscles.
* Muscles act **antagonistically** to one another. The muscle that produces a particular action is the agonist; the antagonist produces the opposite movement.
* When activated by a brief electrical stimulus, skeletal muscle responds with a **simple twitch**. Typically skeletal muscle is stimulated with a series of separate stimuli timed close together and responds with a smooth, sustained contraction called **tetanus**.

IMPORTANT POINTS

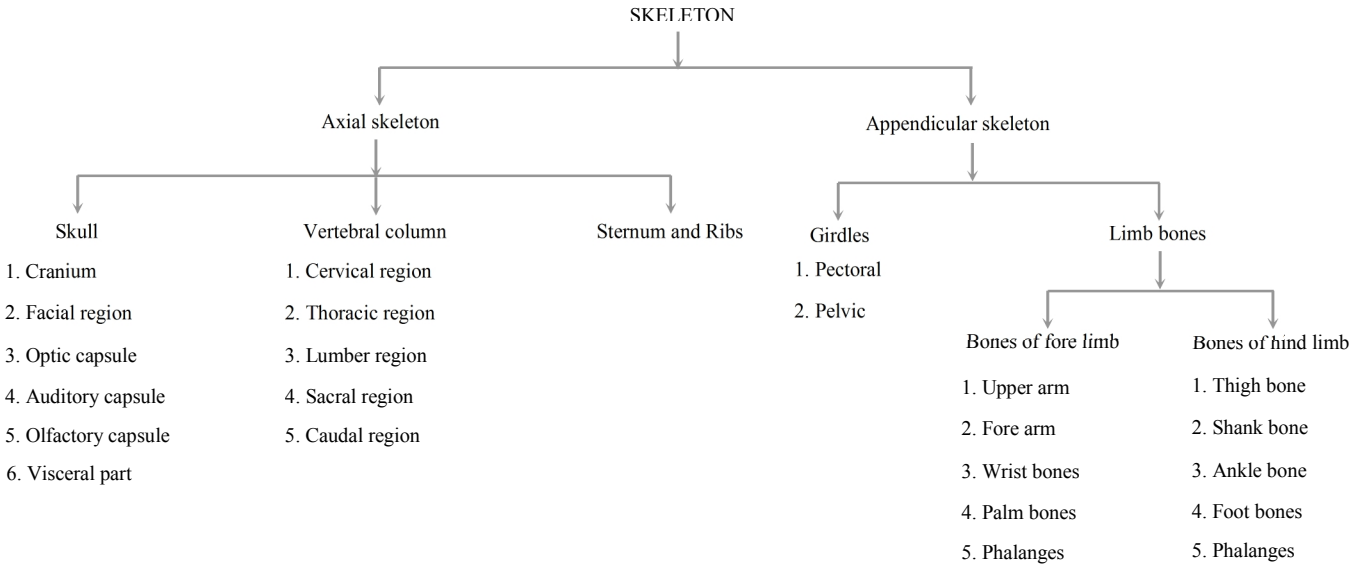
* Number of vertebrae in human skeleton is 33.
* Number of bonds present in human cranium is 8.
* Each half of pelvic girdle is made of ischium, ilium, pubis.
* Part of pelvic girdle joined by transverse process is ilium.
* Substance that accumulates in a fatigued muscle is lactic acid.
* Longest visceral muscle occurs in abdomen.
* Longest bone is that of femur.
* A muscle bends a part over another. It is flexor.
* Sesamoid bone is derived from tendon.
* Sacromere is distance between two Z-lines.
* Joint of sternum and ribs is cartilaginous.
* Muscular and nervous excitability is reduced by K^+.

* Joints of hip and shoulder are ball and socket joints.
* Synovial joint is ball and socket joint, pivot joint, hinge joint.
* Tendon connects muscle with bone.
* Bones of fore and hind limb is an example of appendicular skeleton.
* True joints are synovial joints.
* A bands are dark and contain myosin.
* I-bands are light and contain actin.
* Ball and socket joint = Humerus and pectoral girdle
  Hinge joint = Knee, Pivot joint = Atlas and axis
  Saddle = Carpal and metacarpal of thumb.
* Actin is a thin filament and is made up of two F-actins.
* Human skeleton
  (i) Skull is dicondylic.
  (ii) Metacarpals are five in numbers.
  (iii) The pelvic girdle has two coxal bones.
* Human vertebra is acoelous.
* Bones of upper limb (Fore limbs) of Man
  (a) Arm - Brachium - Humerus = 1 bone
  (b) Fore arm -Antibrachium - Radius + Ulna = 2 bone
  (c) Wrist-Carpus = 4 + 4 carpals = 8 bone
  (d) Palm - Metacarpals - 5 metacarpals = 5 bone
  (e) Fingers - Phalangeal formula - 2 3 3 3 3 = 14 bone
  Total = 30 bone
* Bones of lower limb - (Hind limbs) of man
  (i) Thigh - Femur = 1 bone
  (ii) Knee - Knee cap - patella = 1 bone
  (iii) Leg - Tibia + Fibula = 2 bone
  (iv) Ankle - 7 tarsals = 7 bone
  (v) Sole - 5 Meta tarsals = 5 bone
  (vi) Phalangial formula - 2 3 3 3 3 = 14 bone
  Total = 30 bone
* Bone of lower jaw - Mandible.
* Strongest bone of axial skeleton = Mandible (Lower jaw)
* Neurocranium - A part of skull having brain and sensory capsules.
* Sella turcica - Depression in sphenoid of skull that lodges pituitary body.
* Wish bone - It is V-shaped bone formed by the fusion of clavicle and interclavicle in bird. It is also named as Merry thought bone.)
* Largest foramen - Foramen of magnum at the base of cranium from where brain enters into spinal cord.
* Weberian Ossicles - Small bones developed from 1st four vertebrae of bony fishes like carp and cat fish. These connect air bladder to internal ear and act as a barometer)
* Smallest bone - Stapes
* Longest bone - Femur
* Movable joints are called synovial joints.
* Synovial joints have a synovial or joint cavity, a space between articulating bones.
* Articular cartilage covers the surface of articulating bones.
* Articular cartilage of synovial joints is hyaline cartilage.
* Synovial joints are surrounded by a tubular articular capsule.
* The articular capsule consists of two layers, outer fibrous capsule and inner synovial membrane.
* The synovial membrane secretes synovial fluid which lubricates and provides nourishment to articular cartilage.
* In old age, stiffness of joints is due to the decrease in synovial fluid.
* Structural arrangement of a perfect joint permits considerable movement of articulating bones without danger of friction.
* Due to the elasticity of the ligaments of the wall of joint capsule, articulating bones automatically return back to their normal positions after movements.
* Sprain is caused by excessive stretching of ligament at the joint. It causes pain and swelling.
* Dislocation between two bones may occur when ligament ruptures or it is torned and the bones are displaced.

* Table : Muscle Tissues

	Skeletal	Cardiac	Smooth
Location	Attached to skeleton	Walls of heart	Walls of stomach, intestines, etc.
Type of control	Voluntary	Involuntary	Involuntary
Shape of Fibers	Elongated, cylindrical, blunt ends	Elongated, cylindrical, fibers that branch and fuse	Elongated, spindle-shaped, pointed ends
Striation	Present	Present	Absent
Number of Nuclei per Fiber	Many	One or two	One
Position of Nuclei	Peripheral	Central	Central
Speed of Contraction	Most rapid	Intermediate (varies)	Slowest
Resistance to Fatigue (with repetitive contraction)	Least	Intermediate	Greatest

* Skeleton system



* In human vertebrae are grouped into five groups namely cervical, thoracic, lumber, sacrum, coccygeal

Category	Name of vertebrae	Number	Region	Curve
1.	Cervical	7 (1st atlas) (2nd Axis)	Neck	Cervical curves forward
2.	Thoracic	12	chest	Thoracic curves backward
3.	Lumbar	5	Abdomen	Lumbar curves forward
4.	Sacral	5 (fused to form a single sacrum)	Pelvis	Sacral curves backward
5.	Coccygeal	4 (fused to form a single coccyx	Vestigeal tail	Coccyx curves forward

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.
For Q.1-Q.7
Match the column I with column II.

Q.1

	Column I	Column II
(a)	HMM	(i) Head
(b)	LMM	(ii) Short arm
		(iii) Tail

(A) a-i, ii ; b-iii (B) a-iii ; b-i, ii
(C) a-i, iii ; b-ii (D) a-ii ; b-i, iii

Q.2

	Column I	Column II
(a)	Cervical	(i) 1
(b)	Thoracic	(ii) 7
(c)	Lumbar	(iii) 5
(d)	Sacral	(iv) 12

(A) a-ii, b-i, c-iii, d-iv (B) a-ii, b-iv, c-iii, d-i
(C) a-ii, b-i, c-iv, d-iii (D) a-iv, b-i, c-ii, d-iv

Q.3

	Column I	Column II
(a)	Ball and socket joint	(i) Between humerus and pectoral girdle
(b)	Hinge joint	(ii) Knee joint
(c)	Pivot joint	(iii) Between atlas and axis
(d)	Gliding joint	(iv) Between the carpals

(A) a-i, b-ii, c-iii, d-iv (B) a-iv, b-iii, c-i, d-ii
(C) a-ii, b-i, c-iv, d-iii (D) a-iv, b-i, c-ii, d-iv

Q.4

	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

(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

Q.5

	Column I	Column II
(a)	True ribs	(i) 11, 12 pairs
(b)	False ribs	(ii) 8, 9, 10 pairs
(c)	Floating ribs	(iii) First 7 pairs

(A) a-i ; b-ii ; c-iii (B) a-i ; b-iii ; c-ii
(C) a-iii ; b-ii ; c-i (D) a-iii ; b-i ; c-ii

Q.6

	Column I	Column II
a.	Sternum	i. Synovial fluid
b.	Glenoid Cavity	ii. Vertebrae
c.	Freely movable joint	iii. Pectoral girdle
d.	Cartilagenous joint	iv. Flat bones

(A) a-ii, b-i, c-iii, d-iv (B) a-iv, b-iii, c-i, d-ii
(C) a-ii, b-i, c-iv, d-iii (D) a-iv, b-i, c-ii, d-iv

Q.7

	Column I	Column II
(a)	Smooth muscle	(i) Myoglobin
(b)	Tropomyosin	(ii) Thin filament
(c)	Red muscle	(iii) Sutures
(d)	Skull	(iv) Involuntary

(A) a-iv, b-ii, c-i, d-iii (B) a-iv, b-iii, c-i, d-ii
(C) a-ii, b-i, c-iv, d-iii (D) a-iv, b-i, c-ii, d-iv

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.8 to Q.26 :
Choose one word for the given statement from the list.

Resting, Partially, Thick, H, Autoimmune, Neuromuscular, Skeletal, Stripped, Striated, Seven, 14, Troponin, Tropomyosin, Light, I, Dark, A, Myosin, Relaxed, Broken, Myosin, Vertebral column, Two, Dicondylic, Sacroplasmic reticulum, 11th, 12th, Eight, Red fibres; Uric acid crystals, White fibres

Q.8 Skeletal muscles are closely associated with the ____ components of the body. They have _____ appearance under the microscope and hence are called _____ muscles.

Q.9 The ____ releasing the ADP and Pi goes back to its ____ state. A new ATP binds and the cross bridge is ____. The ATP is again hydrolysed by the ____ head and cycle of cross bridge formation and breakage is repeated causing further sliding.

Q.10 In a _____ state, the edge of thin filaments on either side of thick filaments _____ overlap the free ends of _____ filaments leaving the central part of thick filaments. This central part of thick filament, not overlapped by thin filaments is called _____ zone.

Q.11 Skull region articulates with the superior region of ____ with the ___ occipital,condyles that's way human skull is called ____ skull.

Q.12 Aerobic muscles are called ____ and anaerobic muscles are called _____.

Q.13 Gout happens due to accumulation of ____ in joints

Q.14 Myasthenia gravis is a _____ disorder affecting _____ junction leading to fatigue weakening and paralysis of skeletal muscle.

Q.15 ____ band contains actin and is called ____band, whereas the ___ band called ___ band contains myosin.

Q.16 All mammals (except a few) have ___ cervical vertebra.

Q.17 The number of phalanges in each limb of human is _____.

Q.18 Thin filament of myofibril contains 2 'F' actins and two other proteins namely ____ and ___.

Q.19 In a muscle fibre Ca^{++} is stored in ____.

Q.20 ___ and ___ pairs of ribs are called floating ribs.

Q.21 The human cranium is made of ____ bones.

Q.22 Actin is present in thin filament. **[True / False]**

Q.23 H-zone of striated muscle fibre represents both thick and thin filaments. **[True / False]**

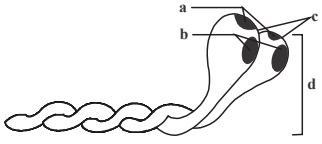
Q.24 Human skeleton has 206 bones. **[True / False]**

Q.25 There are 11 pairs of ribs in man. **[True / False]**

Q.26 Sternum is present on the ventral side of the body. **[True / False]**

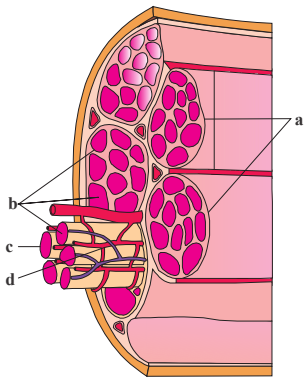
SECTION - 3 (ENHANCE DIAGRAM SKILLS)

Q.27 Identify a, b, c and d in the given diagram and choose the correct option.



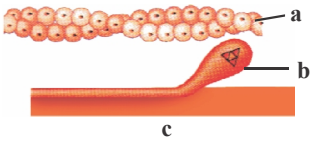
(A) a-Actin binding site, b-ATP binding site, c-Head, d-Cross arm
(B) a-Actin binding site, b-ATP binding site, c-Head, d-Side arm
(C) a-Actin binding site, b-ATP binding site, c-Head, d-Long arm
(D) a-Actin binding site, b-ATP binding site, c-Head, d-Short arm

Q.28 Identify a, b, c and d in the given diagram and choose the correct option.



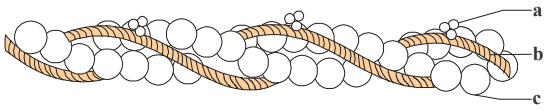
(A) a-Fascicle, b-Muscle fibre, c-Sarcolemma, d-Blood capillary
(B) a-Muscle fibre, b-Fascicle, c-Sarcolemma, d-Blood capillary
(C) a-Muscle fibre, b-Fascicle, c-Sarcoplasm, d-Blood capillary
(D) a-Muscle fibre, b-Endoplasmic reticulum, c-Sarcoplasm, d-Blood capillary

Q.29 Identify a, b and c in the given diagram. Choose the correct option.



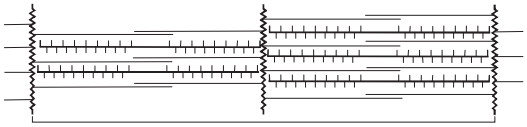
(A) a-Actin filament, b-Myosin filament, c-Breaking of cross bridge
(B) a-Myosin filament, b-Myosin filament, c-Breaking of cross bridge
(C) a-Myosin filament. b-Actin filament, c-Breaking of cross bridge
(D) a-Breaking of cross bridge b-Actin filament, c-Myosin filament.

Q.30 Identify a, b and c along the given diagram.



(A) a-Troponin, b- Tropomyosin, c- Factin
(B) a - Thick filament, b-Troponin, c - Tropomyosin
(C) a - Myosin filament, b - Troponin, c - Tropomyosin
(D) a - Meromyosin, b - Troponin, c - Tropomyosin

Q.31 Identify the state of two sarcomeres in the diagram given below.



(A) relaxed state
(B) contracting state
(C) fully contracted state
(D) maximally relaxed state

SECTION - 4 (ENHANCE PROBLEM SOLVING SKILLS)

Choose one correct response for each question.

PART - 1 : TYPES OF MOVEMENT

Q.32 Macrophages and leucocytes exhibit
(A) Ciliary movement (B) Flagellar movement
(C) Amoeboid movement (D) Gliding movement

Q.33 Cytoplasmic streaming movement is the characteristic of –
(A) prokaryotes (B) eukaryotes
(C) virus (D) All of these

Q.34 Movement of our limbs, jaws, tongue, etc. requires –
(A) cillary movement
(B) amoeboid movement
(C) muscular movement
(D) flagellar movement

Q.35 Main types of movement exhibited by the cells of human body are –
I. Amoeboid II. Ciliary
III. Muscular IV. Flagellar
(A) I and II (B) II and III
(C) III and IV (D) I, II and III

Q.36 Locomotion requires a perfect coordinated activity of –
(A) muscular system (B) skeletal system
(C) neural system (D) All of these

PART - 2 : MUSCLES

Q.37 Identify the muscle which represents the following characteristics and choose the correct Option accordingly.
I. Transportation of food through the digestive tract.
II. Transportation of gametes through the genital tract.

(A) Skeletal muscles (B) Visceral muscles
(C) Cardiac muscles (D) Striated muscles

Q.38 Muscle contraction is initiated by the signal sent by
(A) CNS (B) PNS
(C) ANS (D) Neutral transmitters

Q.39 Choose the correct statement about muscles.
(A) Muscles are the specialised tissues of mesodermal origin.
(B) About 40-50% of the body weight is contributed by muscles.
(C) Muscles have special properties like excitability, contractibility and extensibility
(D) All of the above

Q.40 Red fibres are the fibres containing high content of –
(A) myoglobin (B) globular protein
(C) glycogen (D) anthocyanin

Q.41 Myofilaments or myofibrils are
(A) obliquely arranged filaments of muscle fibre.
(B) parallely arranged filaments of muscle fibre.
(C) horizontally arranged filaments of muscle fibre
(D) radially arranged filaments of muscle fibre.

Q.42 In the centre of each I-band there is an elastic fibre called
(A) I-line (B) Z-line
(C) A-line (D) H-zone

Q.43 During muscles contraction
(A) Thick filaments slide over thin filaments.
(B) I-band gets reduced.
(C) Both (A) and (B).
(D) None of the above.

Q.44 Each actin (thin) filament is made up of
(A) two 'F' (filamentous) actins
(B) two filament of tropomyosin
(C) tropin
(D) All of the above

Q.45 Which of the following are the properties of cardiac muscles?
I. They are the muscles of the heart.
II. They are non-striated.
III. They are involuntary in their functions.
IV. They are made up of fascicles.
Select the correct option.
(A) I and III (B) II and IV
(C) I and IV (D) II and III

Q.46 Which one of the following statement is incorrect?
(A) Heart muscles are striated and involuntary.
(B) The muscles of hands and legs are striated and voluntary.
(C) The muscles located in the inner walls of alimentary canal are striated and involuntary.
(D) Muscles located in the reproductive tracts are unstriated and involuntary.

Q.47 F-actin is a polymer of
(A) G (molecular) actin (B) G (globular) actin
(C) G (meromyosin) actin (D) All of these

Q.48 ATPase of the muscle is located in
(A) Actinin (B) Troponin
(C) Myosin (D) Actin

Q.49 Contraction of the muscles takes place by the sliding of
(A) thick filament over thin filament.
(B) thin filament over thick filament.
(C) thin filament over thin filament.
(D) thick filament over thick filament.

Q.50 Muscles with characteristic striations and involuntary are
(A) Muscles in the wall of alimentary canal
(B) Muscles of the heart
(C) Muscles assisting locomotion
(D) Muscles of the eyelids

Q.51 Z-lines divides the myofibrils into
(A) sarcomere (B) sarcolemma
(C) sarcosome (D) sarcoplasm

Q.52 Muscle contains a red coloured oxygen containing pigment called
(A) haemoglobin (B) myoglobin
(C) haemocyanin (D) Both (A) and (B)

Q.53 Action potential in sarcolemma of muscles causes the release of
(A) Na^+ (B) Cl^-
(C) Ca^{2+} (D) HCO_3^-

Q.54 Contractile fibrils of the muscles are called
(A) neurofibrils (B) collagen fibres
(C) myofibrils (D) yellow fibres

Q.55 The store house of calcium ions in the muscle fibre is
(A) smooth endoplasmic reticulum
(B) Golgi body
(C) sarcoplasmic reticulum
(D) lysosomes

Q.56 For how long, contraction of the muscles continues in sliding filament theory?
(A) Till ATP binds to myosin head.
(B) Till ADP binds to myosin head.
(C) Till Ca^{2+} present in sarcoplasm.
(D) Till polymerisation of myosin head is going on.

Q.57 Cross arms of the myosin monomer consists of
(A) outward projection of G-actin filament.
(B) outward projection of the head region of meromyosin.
(C) outward projection of the tail region of meromyosin.
(D) Both (B) and (C).

Q.58 Action potential in the sarcolemma of muscles is generated by
(A) neuroinhibitors (B) acetylcholine
(C) methylcholine (D) ethylcholine

Q.59 Both proteins, actin and myosin are arranged in a rod-like structure in the muscles
(A) radially (B) parallely
(C) horizontally (D) obliquely

Q.60 Sliding filament theory was given by
(A) AF Huxley and T Huxley
(B) Leeuwenhoek and Hooke
(C) AF Huxley and HE Huxley
(D) HF Huxley and Robert Hooke

Q.61 Which ion binds with troponin during muscle contraction?
(A) HCO_3^- (B) Ca^{2+}
(C) Cl^- (D) Na^+

Q.62 Choose the incorrect statement about the skeletal muscles.
(A) Their activities are under the voluntary control of the nervous system.
(B) They are known as voluntary muscles.
(C) They are primarily involved in locomotory actions and changes of body postures.
(D) None of the above.

Q.63 A sarcomere in the myofibrils of muscle is found in between
(A) 2 M-lines (B) 2 Z-lines
(C) 2 H-zones (D) 2 A-bands

Q.64 Motor unit is a
(A) neuron
(B) muscle fibre
(C) motor neuron with muscle fibre
(D) All of the above

Q.65 Striated appearance of the myofibrils is due to
(A) actin proteins (B) myosin proteins
(C) Both (A) and (B) (D) None of these

Q.66 Head of myosin monomer consists of
I. actin binding sites II. ATP binding sites
III. ADP binding sites IV. AMP binding sites
Select the correct options.
(A) I and II (B) III and IV
(C) I and IV (D) II and IV

Q.67 Mechanism of muscle contraction is best explained by
(A) physical filament theory
(B) chemical filament theory
(C) sliding filament theory
(D) jumping filament theory

Q.68 Which of the following statements is true with reference to the structure of a muscle fibre?
(A) H-zone is present in the middle of A-band.
(B) A-band is present in the middle of sarcomere.
(C) M-line is present in the middle of H-zone.
(D) All of the above

Q.69 Based on their location in humans body or animals types of muscles are –
I. skeletal II. visceral
III. cardiac IV. non-visceral
The correct option is
(A) I and II (B) II and IV
(C) I, II and III (D) I, III and IV

Q.70 The region at the ends of the A-band of two adjoining sarcomeres is called
(A) H-zone (B) Z-line
(C) I-band (D) M-line

Q.71 Actin and myosin filaments of muscles are also called –
(A) thick and thin filaments respectively.
(B) thin and thick filaments respectively.
(C) black and white filaments respectively.
(D) white and black filaments respectively.

Q.72 Sarcomere is a
(A) functional unit of contraction.
(B) portion of myofibril present in between two M-lines.
(C) complete bundle of muscles.
(D) portion of myofibril present in between two A-bands.

Q.73 Fascicles in human/animal are the
(A) blood capillaries (B) muscle bundles
(C) intercalated discs (D) muscle cytoplasm

Q.74 Each myofibrils of muscles contains
(A) regular dark bands
(B) regular light bands
(C) Both (A) and (B)
(D) alternate dark and light bands

Q.75 I-bands of myofibrils are bisected by
(A) A-bands (B) H-zone
(C) Z-lines (D) M-lines

Q.76 Visceral muscles are also called
(A) smooth muscles (B) non-striated muscles
(C) involuntary muscles (D) All of these

Q.77 An individual sarcomere of myofibril consists of
(A) overlapping actin and myosin
(B) a stack of actin fibres
(C) a stack to myosin units
(D) overlapping actin and relaxin

Q.78 Fascicles are held together by the structure
(A) intercalated disc (B) connective fibres
(C) fascia (D) All of these

PART - 3 : SKELETAL SYSTEM

Q.79 Choose the wrongly matched option.
(A) Frontal bone-1 (B) Parietal bones-2
(C) Temporal bone-1 (D) Sphenoid bone-1

Q.80 Each human limb is made of
(A) 60 bones (B) 50 bones
(C) 40 bones (D) 30 bones

Q.81 Breast bone is also called
(A) sternum (B) true rib
(C) false rib (D) axis vertebrae

Q.82 Skeletal system consist of
(A) bones and cartilage (B) brain
(C) only bones (D) only cartilage

Q.83 Our vertebral column is formed by the
(A) 26 serially arranged units called vertebrae.
(B) 27 serially arranged units called vertebrae.
(C) 33 serially arranged units called vertebrae.
(D) 35 serially arranged units called vertebrae.

Q.84 Bones of the limbs along with their girdles constitutes the
(A) apendicular skeleton (B) axial skeleton
(C) apex skeleton (D) axis skeleton

Q.85 Intervertebral disc is found in the vertebral column of
(A) Birds (B) Reptiles
(C) Mammals (D) Amphibians

Q.86 Human skeletal system consists of
(A) 200 bones (B) 300 bones
(C) 206 bones (D) 250 bones

Q.87 First vertebrae in humans is called –
(A) axis (B) atlas
(C) lumbar (D) cervical

Q.88 Cartilage has slightly pliable matrix due to
(A) chondroitin salts (B) osteoblast
(C) chondroclast (D) osteoclast

Q.89 Bones of pectoral and pelvic girdle helps in the articulation of
(A) upper limbs (B) lower limbs
(C) Both (A) and (B) (D) None of these

Q.90 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

Q.91 Correct function of vertebral column in humans
(A) protects the spinal cord
(B) supports the head
(C) surface as an attachment for ribs and musculature of back.
(D) All of the above

Q.92 Ribs that are attached to the thoracic vertebrae and ventrally connected to the sternum with the help of hyaline cartilage are called
(A) true ribs (B) false rib
(C) floating ribs (D) rib cage

Q.93 Neural canal is
(A) solid portion of vertebrae through which the neural canal passes.
(B) hollow portion of vertebrae through which the neural canal passes.
(C) Both (A) and (B)
(D) None of the above

Q.94 Rib cage is formed by
(A) thoracic vertebrae (B) ribs
(C) sternum (D) All of these

Q.95 Which one of the following statements is true:
(A) Head of humerus bone articulates with acetabulum of pectoral girdle.
(B) Head of humerus bone articulates with glenoid cavity of pectoral girdle.
(C) Head of humerus bone articulates with a cavity called acetabulum of pelvic girdle.
(D) Head of humerus bone articulates with a glenoid cavity of pelvic girdle.

Q.96 Middle ear contains three tiny bones.
I. Maxillae II. Malleus III. Incus
IV. Stapes V. Vomer
(A) I, II and III (B) II, III and IV
(C) III, IV and V (D) I, II and V

Q.97 How many pairs of ribs are present in human skeleton?
(A) 10 pair (B) 12 pair
(C) 9 pair (D) 7 pair

Q.98 Ribs are attached to
(A) Scapula (B) Sternum
(C) Clavicle (D) Ilium

Q.99 Hardness of the bones is due to
(A) hard matrix made up of calcium salts.
(B) soft matrix made up of sodium salts.
(C) hard matrix made up of sodium salts.
(D) soft matrix made up of chondroitin salts.

PART - 4 : JOINTS

Q.100 Cartilaginous joints in humans
(A) permit any movement
(B) permit little movement
(C) permit no movement
(D) All of these

Q.101 Which of the following statements is correct?
(A) Movable skull bone is mandible.
(B) We move our hands, while walking for balancing.
(C) Cartilaginous joints have little mobility due to fibrocartilage disc between its articular ands, e.g., intervertebral disc between the centre of vertebrae.
(D) All of the above.

Q.102 What is the type of movable joint present between the atlas and axis?
(A) Pivot (B) Saddle
(C) Hinge (D) Gliding

Q.103 Which of the following statements about the joints of humans is false?
(A) Joints are essential for all types of movements involving bony parts.
(B) Joints are the contact between bones or between bones and cartilages.
(C) Fibrous joints are immovable.
(D) Cartilaginous joints permits great movement.

Q.104 Which one of the following options is incorrect?
(A) Hinge joint – between Humerus and Pectoral girdle
(B) Pivot joint – between atlas, axis and occipital condyle
(C) Gliding joint – between the carpals
(D) Saddle joint – between carpel and metacarpals of thumb

Q.105 Joints are the point of contact between
I. bones. II.cartilages and bones.
III. bones and muscles. IV. cartilage and muscles.
(A) I and II (B) II and III
(C) III and IV (D) IV and I

Q.106 Suturus of human skull is
(A) fibrous joint (B) hinge joint
(C) synovial joint (D) pivots joint

Q.107 Fibrous joints in humans
(A) allows any movement.
(B) allows little movement.
(C) don't allow any movement.
(D) None of the above

Q.108 Knee joint and elbow joints are examples of
(A) Saddle joint (B) Ball & socket joint
(C) Pivot joint (D) Hinge joint

Q.109 The joint of femur with pelvic girdle is
(A) hinge joint (B) pivot joint
(C) non-movable joint (D) ball & socket joint

Q.110 Where the saddle joints are presents in humans?
(A) between carpals and matacarpals.
(B) atlas and axis.
(C) radius and ulna.
(D) carpals and phallanges.

Q.111 Three major types of joints includes –
I. Fibrous joint II. Hinge joint
III. Cartilaginous joint IV. Pivot joint
V. Synovial joint
(A) I, III and V (B) II, III and IV
(C) I, II and III (D) III, IV and V

Q.112 Atlas and axis are joined by
(A) hinge joint (B) pivot joint
(C) seddle joint (D) None of these

Q.113 Synovial joints in humans are characterised by
(A) joining of two bones
(B) presence of fluid filled synovial cavity
(C) rare movement
(D) No movement at all

PART - 5 : DISORDERS OF MUSCULAR AND SKELETAL SYSTEM

Q.114 Low level of Ca^{2+} ions in muscles result in –
(A) rapid spasms (B) wild contractions
(C) Both (A) or (B) (D) None of the above

Q.115 Which one of the following is not a disorder of bone?
(A) Arthritis (B) Osteoporosis
(C) Rickets (D) Atherosclerosis

Q.116 A disease associated with joint is humans
(A) glaucoma (B) arthritis
(C) harnia (D) Horner's syndrome

Q.117 Muscular dystrophy in humans is a
(A) viral disease (B) bacterial disease
(C) genetic disease (D) fungal disease

Q.118 Osteoporosis is a
(A) age related disorder (B) gene related disorder
(C) viral disease (D) bacterial disease

Q.119 Arthritis is
(A) inflammation of liver (B) inflammation of joints
(C) degradation of joints (D) inflammation of heart

Q.120 In which of the following conditon, progressive degeneration of skeletal muscles happens?
(A) myasthenia gravis (B) muscular dystrophy
(C) tetany (D) arthritis

EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 The sliding filament mechanism states that __ .
(A) nebulin and titin filaments move relative to one another perpendicular to one another
(B) actin and myosin filaments become arranged perpendicular to one another.
(C) actin & myosin filaments move relative to one another.
(D) The two actin chains unwind and dissociate into G-actin.

Q.2 The number of vertebrae present in cervical, thoracic, lumbar, sacral and coccyx regions respectively are –
(A) 12, 7, 5, 1, 1 (B) 1, 7, 5, 12, 1
(C) 7, 5, 1, 12, 1 (D) 7, 12, 5, 1, 1

Q.3 The human skull is part of the –
(A) girdle (B) axial skeleton
(C) atlas (D) appendicular skeleton

Q.4 Facilitates the diffusion of oxygen into tissues from blood and stores oxygen in tissues.
(A) myoglobin (B) hemoglobin
(C) opsin (D) bilirubin

Q.5 Connective tissue that joins bones together on either side of a joint.
(A) periosteum (B) stratum corneum
(C) tendons (D) ligaments

Q.6 The vertebrate skin consists of –
(A) outer epidermis, inner hypodermis.
(B) outer epidermis, inner endoskeleton.
(C) outer endodermis, inner epidermis.
(D) outer epidermis, inner dermis.

Q.7 Gout is a disease that affects the joints and leads to arthritis. It is associated with an abnormality of –
(A) pyrimidine metabolism
(B) purine metabolism
(C) fat metabolism
(D) protein metabolism.

Q.8 An endoskeleton –
(A) is typically composed of dead tissue.
(B) is characterized by fluid in a closed compartment.
(C) is typical of echinoderms.
(D) is typical of arthropods.

Q.9 The thin outer shell of a long bone is made of
(A) compact bone (B) spongy bone
(C) epiphyses (D) cancellous bone

Q.10 Which of the following connects bones to one another?
(A) tendons (B) ligaments
(C) osteoclasts (D) synovial membranes

Q.11 In endochondral bone formation –
(A) osteoclasts produce bone
(B) joints connect fibers
(C) the skeleton consists of cartilage
(D) bones develop from cartilage templates

Q.12 The coxal bone of the pelvic girdle is formed by the fusion of –
(A) ilium, ischium and pubis
(B) scapula and clavicle
(C) ilium and scapula
(D) ilium, scapula and ischium.

Q.13 An energy storage compound that can be stockpiled in muscle cells for short-term use is –
(A) creatine phosphate (B) ADP
(C) troponin (D) myosin

Q.14 Myosin binds to actin, forming a cross bridge. What happens next?
(A) acetylcholine is released.
(B) calcium ions stimulate process that leads to exposure of active sites.
(C) filaments slide past each other, and the muscle fiber shortens.
(D) P_i is released, and the cross bridge flexes.

Q.15 Which of the following statements is incorrect?
(A) Smooth muscles are found in urinary bladder, alimentary canal and genital tract.
(B) A striated muscle is a syncytium i.e., a multinucleate structure.
(C) The cytoplasm of striated muscle is called endoplasm.
(D) The plasma membrane and ER of striated muscles are called sarcolemma and sarcoplasmic reticulum respectively.

Q.16 A hydrostatic skeleton –
(A) is characteristic of insects.
(B) has a cartilaginous framework.
(C) does not permit antagonistic muscle action.
(D) consists of fluid-filled body compartments.

Q.17 Glycogen is –
(A) produced by actin.
(B) depleted within 1 sec. of strenuous activity.
(C) a form of long-term energy storage.
(D) synthesized when cross bridges form.

Q.18 A cricket player is fast chasing a ball in the field. Which one of the following groups of bones are directly contributing in this movement?
(A) Femur, malleus, tibia, metatarsals.
(B) Pelvis, ulna, patella, tarsals.
(C) Sternum, femur, tibia, fibula.
(D) Tarsals, femur, metatarsals, tibia.

Q.19 The outer layer of a vertebrate's skin is the –
(A) epidermis (B) stratum basale
(C) stratum corneum (D) epithelium

Q.20 Neuromuscular junction is a junction between
(A) two neurons and muscles
(B) sensory neurons and muscles
(C) motor neurons and sarcolemma of muscles
(D) sensory neurons and sarcolemma of muscles

Q.21 Slow fibers –
(A) are also called white fibers
(B) do not depend on ATP
(C) have few mitochondria
(D) are rich in myoglobin

Q.22 Flat bone on the ventral midline of thorax is called
(A) coccyx (B) sternum
(C) sacrum (D) ribs

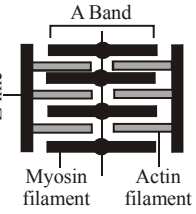
Q.23 Insect flight muscles –
(A) work best at low temperature.
(B) have a very high metabolic rate.
(C) do not create much lift.
(D) evolved after bird wings.

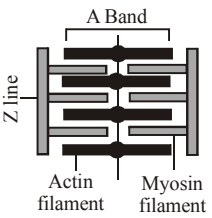
Q.24 Achilles tendon is associated with
(A) gluteus muscle
(B) hamstring muscle
(C) quadriceps muscle
(D) gastrocnemius muscle.

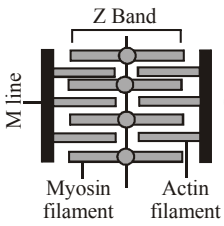
Q.25 Which of the following pairs of systems function together most closely?
(A) integumentary and skeletal
(B) integumentary and digestive
(C) muscular and epithelial
(D) skeletal and muscular

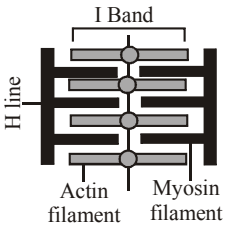
Q.26 The gliding joints are important for gliding movements. One example of such joint is between the –
(A) zygapophyses of adjacent vertebrae
(B) humerus and glenoid cavity
(C) occipital condyle and odontoid process
(D) femur and tibia fibula.

Q.27 Which of the following sarcomeres is labelled correctly?

(A)


(B)


(C)


(D)


Q.28 The tissue around bones that lays down new layers of bone is the –
(A) metaphysis (B) epiphysis
(C) marrow (D) periosteum

Q.29 Which are involved in muscle contraction-
(A) Ca^{2+} & Mg^{2+} (B) Ca^{2+} & Na^{+}
(C) Na^{+} & K^{+} (D) Mg^{2+} & K^{+}

Q.30 The functional unit of contractile system of a striated muscle is-
(A) Sarcomere (B) Z-band
(C) Cross bridge (D) Myofibril

Q.31 The contractile protein of muscle is-
(A) Tubulin (B) Myosin
(C) Tropomyosin (D) Actin

Q.32 Sharpey's fibres occur inside-
(A) Collagen (B) Muscle
(C) Bone (D) Skin

Q.33 Biceps is attached with-
(A) Radius (B) Scapula
(C) Femur (D) Both 1 and 2

Q.34 Joint between atlas and axis is-
(A) Pivot joint (B) Saddle joint
(C) Angular joint (D) Hinge joint

Q.35 Longest 'visceral' muscle occur in-
(A) vas deferens (B) Pregnant uterus
(C) Normal uterus (D) Abdomen

Q.36 Which ion is essential for muscle contraction-
(A) Na^{+} (B) K^{+}
(C) Ca^{++} (D) Cl^{-}

Q.37 Sutural joints are present between-
(A) Thumb and metatarsal
(B) Humerus and radio-ulna
(C) Parietals of skull
(D) Glenoid cavity and pectoral girdle

Q.38 Joint of sternum and ribs is-
(A) Cartilaginous (B) Fibrous joint
(C) Angular joint (D) Hinge joint

Q.39 Myoglobin occurs in –
(A) White muscle fibres (B) Red muscle fibres
(C) Involuntary muscles (D) All the above

Q.40 During strenuous exercise, glucose is converted into –
(A) Glycogen (B) Pyruvic acid
(C) Starch (D) Lactic acid

Q.41 We move our hand while walking for –
(A) Faster movement
(B) Balancing
(C) Increasing blood circulation
(D) Relieving tension

Q.42 Immediate source of energy for muscle contraction-
(A) Glucose (B) GTP
(C) Creatine phosphate (D) ATP

Q.43 Which one yields ATP required for muscle contraction
(A) Myoglobin (B) Creatine phosphate
(C) Creatinine phosphate (D) Myosin

Q.44 Synovial fluid is present in-
(A) Spinal cavity (B) Cranial cavity
(C) Freely movable joints (D) Fixed joints

Q.45 EDTA injected into muscles combines with Ca^{2+} and –
(A) Stops contraction
(B) Causes contraction
(C) Slows down contraction
(D) None of the above

Q.46 Fore-arm is rotated to turn palm downward or backward by muscle –
(A) Aductor (B) Abductor
(C) Promator (D) Extensor

Q.47 Joints of skull bones are –
(A) Synarthrous (B) Amphiarthrous
(C) Hemirthrous (D) Diarthrous

Q.48 Which one is a ball and socket joint –
(A) Knee joint
(B) Elbow joint
(C) Humerus and pectoral girdle
(D) Skull and atlas

Q.49 Largest synovial joint is –
(A) Hip joint (B) Knee joint
(C) Shoulder joint (D) Ankle joint

Q.50 Trochanters occur in –
(A) Humerus (B) Femur
(C) Radio-ulna (D) Tibia-fibula

Q.51 Acromion process is part of –
(A) Vertebral column (B) Pelvic girdle
(C) Femur (D) Pectoral girdle

Q.52 Part of the body having a single pair of bones is-
(A) Pelvic girdle (B) External ear
(C) Wrist (D) Lower jaw

Q.53 Comparative study of skulls is-
(A) Craniology (B) Conchology
(C) Malacology (D) Osteology

Q.54 I. Myoglobin in very less quantity.
II. Appear pale or whitish.
III. Mitochondria are very few.
IV. Sarcoplasmic reticulum in large quantity.
Given characteristics of muscles fibres belong to
(A) White fibres (B) Green fibres
(C) Red fibres (D) Pink fibres

Q.55 Haversian system is diagnostic feature of-
(A) Avian bones (B) Reptilian bones
(C) Mammalian bones (D) Bone of all animal

Q.56 Feeling of fatigue after running fast for some time is due to-
(A) Loss of energy
(B) Accumulation of lactic acid in muscle
(C) Formation of succinic acid
(D) Formation of biuret crystals

Q.57 In mammals the lower jaw is made of –
(A) Maxilla (B) Dentary
(C) Mandible (D) Ethmoid

Q.58 Choose the correct properties of muscle fibres.
I. Muscle fibre is lined by the plasma membrane called sarcolemma.
II. Cytoplasm of the muscle fibre is called protoplasm.
III. Sarcolemma of the muscle fibre encloses the sarcoplasm.
IV. Muscle fibre is syncitium.
(A) All except II (B) All except I
(C) All except III (D) All except IV

Q.59 Arrange the given steps of muscle contraction in the series of events from first to last.
I. Myosin head binds to the exposed active site on actin to form a cross bridge.
II. The Z-line attached to these actin are also pulled in wards there by causing shortening of sarcomere also called contraction.
III. This pulls the attached actin filaments towards the centre of A-band.
(A) I → II → III (B) III → II → I
(C) I → III → II (D) III → I → II

Q.60 Identify the synovial joints among the given articles.
I. Ball and socket II. Hinge joint
III. Pivot joints IV. Sutures of skull
V. Vertebral joints
(A) I, II, III and IV (B) I, III, IV and V
(C) II, III, IV and V (D) I, II and III

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 Myofilaments are composed of –
(i) fibers (ii) myofibrils
(iii) actin (iv) myosin
(v) sarcoplasmic reticulum
Choose the correct option –
(A) (i), (v) (B) (i), (iii)
(C) (iii), (iv) (D) (i), (ii)

Q.2 The human axial skeleton includes:
(i) ulna (ii) shoulder blades.
(iii) centrum. (iv) femur.
(v) sternum.
Choose the correct option –
(A) (i), (v) (B) (i), (iii)
(C) (iii), (v) (D) (i), (ii)

Q.3 Vertebrate appendages are connected to –
(i) the cervical complex
(ii) the atlas
(iii) the appendicular skeleton
(iv) the axial skeleton
(v) girdles
Choose the correct option –
(A) (iv), (v) (B) (i), (iii)
(C) (iii), (iv) (D) (i), (ii)

Q.4 Animal group in which the primary means of support is a hydrostatic skeleton.
(i) annelids (ii) cnidarians
(iii) flatworms (iv) echinoderms
(v) lobsters and cratfish
Choose the correct option –
(A) (i), (ii), (v) (B) (i), (iii), (v)
(C) (ii), (iii), (v) (D) (i), (ii), (iii)

Q.5 Internal skeletons are found in –
(i) annelids (ii) cnidarians
(iii) echinoderms (iv) lobsters and crayfish
(v) vertebrates
Choose the correct option –
(A) (i), (v) (B) (i), (iii)
(C) (iii), (iv) (D) (iii), (v)

Q.6 Calcium ions are released from the sarcoplasmic reticulum. What happens next?
(A) acetylcholine is released.
(B) active sites on the actin filaments are exposed.
(C) filaments slide past each other, and the muscle fiber shortens.
(D) myosin is activated.

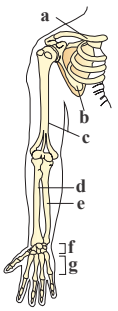
Q.7 Match the following and select the correct option.

	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

(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)

Q.8 When skeletal muscle is stimulated by a series of closely timed separate stimuli
(A) it responds with a smooth, sustained contraction called tetanus.
(B) a simple twitch occurs.
(C) white fibers respond.
(D) red fibers respond.

Q.9 Given diagram shows the right pectoral girdle and upper arm (frontal view) of human female. Identify a to g and choose the correct option.



(A) a - 1st vertebra, b - Scapula, c - Humerus, d-Radius, e - Ulna, f - Carpals, g - Metacarpals
(B) a - Scapula, b - Clavicle, c - Humerus, d - Radius, e-Ulna, f-Carpals, g - Metacarplals

(C) a - Ilium, b - Scapula, c - Humerus, d - Radius, e - Ulna, f - Carpals, g - Metacarpals.
(D) a - Clavicle, b - Scapula, c - Humerus, d - Radius, e - Ulna, f - Carpals, g - Metacarpals.

Q.10 Which is/are not correctly matched pairs?
(i) Ball and socket joint - Between humerus and pectoral girdle
(ii) Pivot joint - Between carpal and metacarpal
(iii) Saddle joint - Between atlas and axis
(iv) Gliding joint - Between the carpals
(v) Fibrous joint - In flat skull bones
(A) (ii) and (iii) (B) (i) and (iv)
(C) (v) only (D) (ii) only

Q.11 Correct statements regarding muscle proteins.
(i) Actin is a thin filament and is made up of two F-actins.
(ii) The complex protein, tropomyosin is distributed at regular intervals on the troponin.
(iii) Myosin is a thick filament which is also a polymerized protein.
(iv) The globular head of meromyosin consists of light meromyosin (LMM).
(A) (i), (ii) and (iii) are correct.
(B) (i), (ii) and (iv) are correct.
(C) (i) and (iii) are correct.
(D) (ii) and (iv) are correct.

Q.12 True statements with reference to human beings–
I. Vertebral column consists of 26 bones.
II. Vertebra is dorsally placed.
III. Neural canal in vertebra is the passage for spinal cord.
IV. Neural canal is ventrally placed.
The option with all correct statement is –
(A) II, III and IV (B) I, III and IV
(C) I, II and IV (D) I, II and III

Note (Q.13-Q.16) :
(A) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1
(B) Statement -1 is True, Statement -2 is True ; Statement-2 is NOT a correct explanation for Statement - 1
(C) Statement - 1 is True, Statement- 2 is False
(D) Statement -1 is False, Statement -2 is False.

Q.13 **Statement 1 :** Extra oxygen consumption in human body is known as oxygen debt.
Statement 2 : The extra oxygen is required by the body to oxidise the accumulated lactic acid produced during strenous exercise.

Q.14 **Statement 1 :** Arthritis or inflammation of a joint makes the joint painful.
Statement 2 : Some toxic substances are deposited at the joint.

Q.15 **Statement 1 :** There are similarities between the locomotion of unicellular organisms and multicellular animal.
Statement 2 : Ciliary, flagellar and amoeboid movement occur in unicellular organisms.

Q.16 **Statement 1 :** Skeleton helps in blood cell formation.
Statement 2 : Blood flows through skeleton.

Q.17 Choose the correct statements.
(A) Axial skeleton comprises 80 bones.
(B) Skull, vertebral column, sternum and ribs constitutes axial skeleton.
(C) Skull have total 22 bones.
(D) All of the above.

Q.18 There are seven cervical vertebrae in almost
(A) all vertebrate (B) all amphibian
(C) all reptile (D) all mammals

Q.19 Choose the correct statements.
(A) Synovial joints are freely movable.
(B) Ball and socket, and hinge joints are the synovial joints.
(C) Synovial joints are characterised by synovial cavity with fluid between the articulating surface of the two bones.
(D) All of the above

Q.20 Tick the wrong option regarding human beings.
(A) Cranial bones-12 (B) Facial bones-14
(C) Mandible bones-1 (D)Zygomatic bones-2

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

Q.1 Select the correct statement with respect to locomotion in humans – **[NEET 2013]**

(A) The joint between adjacent vertebrae is a fibrous joint

(B) A decreased level of progesterone causes osteoporosis in old people.

(C) Accumulation of uric acid crystals in joints causes their inflammation.

(D) The vertebral column has 10 thoracic vertebrae.

Q.2 The characteristics and an example of a synovial joint in humans is – **[NEET 2013]**

	Characteristics	Examples
(A)	lymph filled between two bones, limited movement	gliding joint between carpals
(B)	fluid cartilage between two bones, limited movements	Knee joint
(C)	fluid filled between two joints, provides cushion	skull bones
(D)	fluid filled synovial cavity between two bones	joint between atlas and axis

Q.3 The H-zone in the skeletal muscle fibre is due to **[NEET 2013]**

(A) extension of myosin filaments in the central portion of the A-band.

(B) the absence of myofibrils in the central portion of A-band.

(C) the central gap between myosin filaments in the A-band.

(D) the central gap between actin filaments extending through myosin filaments in the A band.

Q.4 Select the correct matching of the type of the joint with the example in human skeletal system : **[AIPMT 2014]**

Type of joint	Example
(A) Cartilaginous joint -	between frontal & parietal
(B) Pivot joint -	between third and fourth cervical vertebrae
(C) Hinge joint -	between humerus and pectoral girdle
(D) Gliding joint -	between carpals

Q.5 Stimulation of a muscle fiber by a motor neuron occurs at – **[AIPMT 2014]**

(A) The neuromuscular junction

(B) The transverse tubules

(C) The myofibril

(D) The sacroplasmic reticulum

Q.6 Sliding filament theory can be best explained as: **[AIPMT 2015]**

(A) Actin and Myosin filaments shorten and slide pass each other.

(B) Actin and Myosin filaments do not shorten but rather slide pass each other.

(C) When myofilaments slide pass other, Myosin filaments shorten while Actin filaments do not shorten.

(D) When myofilaments slide pass each other Actin filaments shorten while Myosin filament do not shorten.

Q.7 Glenoid cavity articulated : **[AIPMT 2015]**

(A) scapula with acromion

(B) clavicle with scapula

(C) humerus with scapula

(D) clavicle with acromion

Q.8 Which of the following is not a function of the skeletal system? **[RE-AIPMT 2015]**

(A) Storage of minerals

(B) Production of body heat

(C) Locomotion

(D) Production of erythrocytes

Q.9 Which of the following joints would allow no movement? **[RE-AIPMT 2015]**

(A) Cartilaginous joint (B) Synovial joint

(C) Ball and Socket joint (D) Fibrous joint

Q.10 Lack of relaxation between successive stimuli in sustained muscle contraction is known as **[NEET 2016 PHASE 1]**

(A) Spasm (B) Fatigue
(C) Tetanus (D) Tonus

Q.11 Name the ion responsible for unmasking of active sites for myosin for cross-bridge activity during muscle contraction. **[NEET 2016 PHASE 2]**

(A) Calcium (B) Magnesium
(C) Sodium (D) Potassium

Q.12 Osteoporosis, an age-related disease of skeletal system, may occur due to– **[NEET 2016 PHASE 2]**

(A) Immune disorder affecting neuromuscular junction leading to fatigue.
(B) High concentration of Ca^{++} and Na^{+}.
(C) Decreased level of estrogen.
(D) Accumulation of uric acid leading to inflammation of joints.

Q.13 The pivot joint between atlas and axis is a type of **[NEET 2017]**

(A) Fibrous joint (B) Cartilaginous joint
(C) Synovial joint (D) Saddle joint

Q.14 Out of 'X' pairs of ribs in humans only 'Y' pairs are true ribs. Select the option that correctly represents values of X and Y and provides their explanation : **[NEET 2017]**

(A) X = 12, Y = 7 True ribs are attached dorsally to vertebral column and ventrally to the sternum.
(B) X = 12, Y = 5 True ribs are attached dorsally to vertebral column and sternum on the two ends.
(C) X = 24, Y = 7 True ribs are dorsally attached to vertebral column but are free on ventral side.
(D) X = 24, Y = 12 True ribs are dorsally attached to vertebral column but are free on ventral side.

Q.15 Calcium is important in skeletal muscle contraction because it **[NEET 2018]**

(A) Detaches the myosin head from the actin filament.
(B) Activates the myosin ATPase by binding to it.
(C) Binds to troponin to remove the masking of active sites on actin for myosin.
(D) Prevents the formation of bonds between the myosin cross bridges and the actin filament.

Q.16 Select the correct option. **[NEET 2019]**

(A) 8^{th}, 9^{th} and 10^{th} pairs of ribs articulate directly with the sternum.
(B) 11^{th} and 12^{th} pairs of ribs are connected to the sternum with the help of hyaline cartilage.
(C) Each rib is a flat thin bone and all the ribs are connected dorsally to the thoracic vertebrae and ventrally to the sternum.
(D) There are seven pairs of vertebrosternal, three pairs of vertebrochondral and two pairs of vertebral ribs.

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (A) **(2)** (B) **(3)** (A) **(4)** (C)
(5) (C) **(6)** (B) **(7)** (A)
(8) Skeletal, stripped, striated
(9) Myosin, relaxed, broken, myosin
(10) Resting, partially, thick, H
(11) Vertebral column, two, dicondylic
(12) Red fibres; white fibres **(13)** Uric acid crystals
(14) Autoimmune, neuromuscular
(15) Light, I, dark, A **(16)** Seven
(17) 14
(18) Troponin, tropomyosin
(19) Sacroplasmic reticulum
(20) 11^{th}, 12^{th} **(21)** Eight
(22) True **(23)** False
(24) True **(25)** False
(26) True

EXERCISE - 1 [SECTION-3 & 4]

Q	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
A	A	A	A	A	D	C	B	C	D	D	B	A	D	A	B	B	B	A	A	C	B	C	B	B	A
Q	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
A	B	C	C	C	C	B	B	B	C	B	D	B	C	C	A	C	D	C	B	B	A	B	D	C	D
Q	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
A	A	C	C	D	A	A	A	A	C	C	B	A	C	D	D	A	B	D	B	B	B	B	A	B	D
Q	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120						
A	A	D	A	A	A	C	D	D	A	A	B	B	C	D	B	C	A	B	B						

EXERCISE - 2

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	C	D	B	A	D	D	B	C	A	B	D	A	A	D	C	D	C	D	A	C	D	B	B	D	D
Q	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
A	A	A	D	A	A	D	C	D	A	B	C	C	C	B	D	B	D	B	C	A	C	A	C	B	B
Q	51	52	53	54	55	56	57	58	59	60															
A	B	A	A	A	C	B	C	A	C	D															

EXERCISE - 3

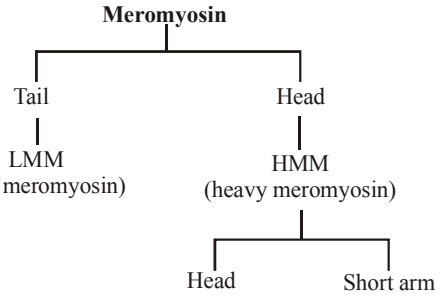
Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	C	C	A	D	D	B	C	A	D	A	C	D	B	C	B	C	D	D	D	A

EXERCISE - 4

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	C	D	D	D	A	B	C	B	D	C	A	C	C	A	C	D

SOLUTIONS

EXERCISE-1



(1) **(A).** Head and short arm projects outwards at regular distance and angle from each other from the surface of polymerised myosin filament is known as cross arm.

(2) **(B).** Vertebral Column

Types	No. of bones (Human)	Location
Cervical	7	Neck
Thoracic	12	Chest (thorax)
Lumbar	5	Abdomen
Sacral	Infant-5, adult-1	Hip
Caudal	Infant-4/5, adult-1	Tail

(3) **(A). Synovial joints are following types**

(i) **Ball and Socket :** The head of the bone fitting with the socket of other bone allowing movement in all plane. e.g., shoulder and hip joints.

(ii) **Hinge Joints** allows the movement in one plane. In this, articular end of one bone is deeper convex and the other is deeper concave. e.g., elbow joint and knee joint.

(iii) **Pivot Joints (rotatory) :** One of the two bone gets fixed and other one rotate on the fixed one. e.g., atlas.

(iv) **Saddle Joints :** Similar to ball and socket joints but both ball and socket are poorly developed and movement is comparatively less free, e.g., metacarpal and carpal.

(v) **Gliding joints :** The joints which permits the sliding of the articulating bones on each other. e.g., joint between the radio-ulna and carpel.

(vi) **Angular or ellipsoidal joints :** These joints allows the movements in two directions, i.e., side to side and back and front. e.g., wrist joints.

(4) (C)

(5) **(C).** True ribs : First 7 pairs
False ribs : 8, 9, 10 pairs
Floating ribs : 11, 12 pairs

(6) (B) **(7)** (A)

(8) Skeletal, stripped, striated

(9) Myosin, relaxed, broken, myosin

(10) Resting, partially, thick, H

(11) Vertebral column, two, dicondylic

(12) **Red fibres; white fibres.** Muscle contains a red coloured oxygen storing pigment called myoglobin. Myoglobin content is high in some of the muscles which gives them a reddish appearance. Such muscles are called the red fibres. These muscles, also contains plenty of mitochondria, which can utilise the large amount of oxygen stored in them for ATP production. These muscles therefore, can also be called aerobic muscles.

(13) **Uric acid crystals.** Gout is generally a old age disorder in which inflammation of joints accurs due to the line accumulation of uric acid crystals.

(14) Autoimmune, neuromuscular

(15) Light, I, dark, A

(16) Seven **(17)** 14

(18) Troponin, tropomyosin

(19) Sacroplasmic reticulum

(20) 11^{th}, 12^{th} **(21)** Eight

(22) True

(23) False, H-zone represents thick filaments

(24) True

(25) False, There are 12 pairs of ribs in man

(26) True

(27) (A) **(28)** (A) **(29)** (A)

(30) (A) **(31)** (D)

(32) **(C).** Macrophages and leucocytes exhibit amoeboid movement which is effected by pseudopodia due to the streaming of protoplasm.

(33) **(B).** Cytoplasmic streaming movement is also called cyclosis. Cyclosis helps in the circulation of material in the cells (inside eukaryotic cells).

(34) **(C).** The contractile property of the muscles is effectively used for locomotion and other movements by human beings and majority of multicellular organisms. Locomotion requires a perfect coordinated activity of muscular, skeletal and neural systems.

(35) **(D).** Cell of human body exhibits three main types of movement, i.e. amoeboid, ciliary and muscular.

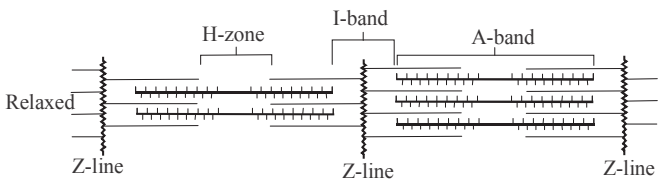
(36) (D) **(37)** (B)

(38) **(A).** Muscle contraction is initiated by a signal sent by Central Nervous System (CNS), via motor neurons. A motor neuron along with the muscle fibres connected to it constitutes a motor unit.

(39) **(D).** Muscle is a specialised tissue of the mesodermal origin. About 40-50% of the body weight of human adult is contributed by muscles. They have special properties like excitability, contractibility, extensibility and elasticity.

(40) (A) **(41)** (B)

(42) **(B).** The thick filaments lies parallel to one another and thin filaments are present in orderly array between the thick filaments. In the centre of the I-band, there is a band of amorphous material called Z-line. In the middle of the A-band a comparatively less dark zone called H-zone or band is present. The area between the two Z-lines is called sarcomere. M-line is present, in the middle of H-zone.



Sarcomere in relaxed state

(43) **(B).** During shortening of the muscles, i.e., contraction, the I-bands get reduced, whereas the A-bands retains the length.

(44) **(A).**

(45) **(A).** Cardiac muscle as the name suggests, are the muscles of heart. Many cardiac muscle cells assemble in a branching pattern to from a cardiac muscle. Based on appearance, they are striated. They are involuntary in nature as the nervous system does not control their activities directly.

(46) **(C).** Skeletal or striated or voluntary muscles are found in the limbs, body wall, tongue, pharynx and begining of oesophagus. These are under the control of animals will. Smooth or nonstriated or involuntary muscles are found in the posterior part of the oesophagus, stomach, intestine, lungs, urinogenital tract, etc. Action of these muscles is controlled by autonomic nervous system and they are not under the control of animals will. Cardiac muscles are found in the wall of the heart and in the wall of large veins. There fibres show the characters of both unstriped and striped muscle fibre and are involuntary.

(47) **(B).** Each actin (thin) filament is made up of two 'F' (filamentous) actins which are helically wound to each other. Each F-actin is a polymer of monomeric G (globular) actins. 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 sub-unit of troponin masks the active binding sites for myosin on the actin filaments.

(48) **(C).** The head of each myosin molecule contains an enzyme myosin ATPase. In the presence of myosin ATPase, Ca^{2+} and Mg^{2+} ions, ATP breaks down into ADP and inorganic phosphate, releasing energy in the head.

$$ATP \xrightarrow[Ca^{2+},\, Mg^{2+}]{\text{Myosin ATpase}} ADP + Pi + Energy$$

(49) (B) **(50)** (B) **(51)** (A)

(52) **(B).** Muscle contains red coloured oxygen containing pigment called the myoglobin. It is generally found in the red muscle in more quantity than other (white fibre).

(53) **(C).** The action potential in the sarcolemma causes the release of calcium ions in the sarcoplasm. Increase in the Ca^{++} level leads to the binding of calcium with a subunit of troponin on the actin filaments and thereby removes the masking of actin sites for myosin.

(54) **(C).** Myofibrils are parallely arranged contractile muscle fibres in the sarcoplasm of fascicle.

(55) **(C).**

(56) **(C).** Sliding of actin and myosin filaments continues till the Ca^{2+} ions are pumped back to the sarcoplasmic cisternae, resulting in masking the actin filaments. This causes the return of Z-lines back to their original position, i.e., relaxation.

(57) (B) **(58)** (B)

(59) **(B).** Both proteins, i.e., actin and myosin are arranged as rod-like structures, parallel to each other and also to the longitudinal axis of the myofibrils. Actin filaments are thinner as compared to myosin filaments, hence they are commonly called thin and thick filaments respectively..

(60) **(C).** Sliding filament was proposed by AF Huxley and HE Huxley in 1954. It is also called Rachek power stroke mechanism which explains the physical events involved in muscle contraction.

(61) **(B).**

(62) **(D).** Skeletal muscles are closely associated with the skeletal components of the body. They have a stripped appearance under the microscope and hence are called striated muscles. As their activities are under the voluntary control they are also called voluntary muscles too. They are primarily involved in locomotory actions and changes of body postures.

(63) **(B).**

(64) **(C).** Motor unit is a motor neuron with muscle fibre.

(65) **(C).** Each myofibril has an alternate dark and light bands on it. A detailed study of the myofibril has established that the striated appearance is due to the distribution pattern of two important proteins, .i.e., actin and myosin.

(66) **(A).** Each myosin (thick filament) is a polymerised protein. Many monomeric proteins called meromyosin constitutes one thick filament. Each meromyosin has two important parts, a globular head with a short arm and a tail, the former being called heavy meromyosin and the later is called light meromyosin.
The HMM component, i.e., the head and short arm projects outwards at regular distance and angle from each other from the surface of polymerised myosin filament and is called cross arm. The globular head is an active ATPase enzyme and has binding sites for ATP and active sites for actin.

(67) **(C).** Mechanism of muscle contraction is best explained by sliding and filament theory, which states that the contraction of a muscle fibre takes place by the sliding of the thin filaments over thick filaments.

(68) **(D).**

(69) **(C).** Muscle have been classified using different criteria, i.e., location, appearance and nature of regulation of their activities. Based on their location three types of muscles are identified(i)Skeletal (ii) Visceral (iii) Cardiac.

(70) **(B).** In the centre of each I-band is an elastic fibre called Z-line which bisects it. The thin filaments are firmly attached to the Z-line. The thick filaments in the A-band are also held together in the middle of this band by thin fibrous membrane called M-line. The A and I-band are arranged alternately throughout the length of myofibrils. The portion of the myofibrils between two successive Z-lines is considered as the functional unit of contraction called sarcomere.

(71) **(B).**

(72) **(A).** Functional unit of contraction is called sarcomere. It is present between the two Z-lines.

(73) **(B).** Each organised skeletal muscle in our body is made of a number of muscle bundles or fascicles held together by a common collagenous connective tissue layer called fascia. Each muscle bundle contains a number of muscle fibres.

(74) **(D).** Each myofibrils contains alternate dark and light bands. Light bands contains actin and is called I-band or isotropic band, whereas the dark bands are called A or anisotropic bands containing myosin.

(75) **(C).** I-band or anisotropic band contains the actin filaments that's why they are thinner than myosin filament. They are bisected by Z-line into two.

(76) **(D).** Visceral muscles are located in the inner wall of hollow visceral organs of the body like the alimentary canal, reproductive tract, etc. They don't exhibit any striation and are smooth in appearance hence they are called smooth muscles (non-striated muscles). Their activities are not under the voluntary control of the nervous system and are therefore, called involuntary muscles. They assist, for example, in the transportation of food through the digestive tract and gametes through the genital tract.

(77) **(A).** In the resting state, the edges of thin filaments (actin) on either sides of the thick filaments (myosin) partially overlaps the free ends of thick filaments, leaving the central part of the thick filaments. This central part of the thick filaments which is not overlapped by thin filaments is called H-zone.

(78) **(C).**

(79) **(C).** Temporal bone are two in number.

(80) **(D).** Limb consists of 30 bones.

(81) **(A).** Sternum (breast bone) It is narrow, elongated and fattened structure, present just under the skin in the middle of the front chest. It is longer in male than in female.

(82) **(A).** Skeletal system constitutes hard internal or external living or non-living parts that forms the supporting frame work of the body. It consists of bones and cartilage.

(83) **(A).** Human vertebral column is formed by 20 serially arranged units called vertebrae. In the embryonic state, it consists of 33 but later they fuse and forms 26 vertebrae. It extends from the base of the skull and constitutes the main framework of the trunk. Each vertebra has a central hollow portion (neural canal) through, which the spinal canal passes.

(84) **(A).** Appendicular skeleton lies laterally and is attached toaxial skeleton. It is made up of girdles (pectoral and pelvic) and limb bones (forelimb and hindlimb). Pectoral girdle and pelvic girdle supports forelimb and hindlimb respectively. The appendicular skeleton consists of 126 bones.

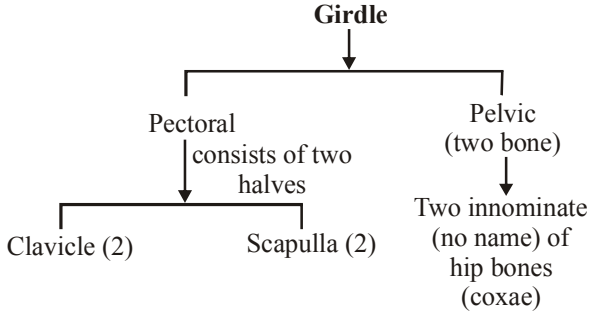
(85) **(C).** Intervertebral discs are found in the vertebral column of mammals. They are present between adjacent vertebrae from second cervical vertebra to the sacrum. The discs form strong joints, allow various movements of the vertebral column and absorb vertical shock.

(86) **(C).** Originally human skeleton consists of 270 bones, which gets fused to become 206 bones and out of which 6 bones are ear ossicles. The remaining 200 bones are distributed into axial and appendicular skeleton.

(87) **(B).** The first vertebra is the atlas and it articulates with the occipital condyles. It is articulated to the skull.

(88) **(A).**

(89) **(C).** Pelvic and pectoral girdle bones help in the articulation of the upper and lower limbs respectively with the axial skeleton.



(90) **(D).** Cervical vertebrae are present in neck region.Thoracic vertebrae are present in the chest region. Lumbar vertebrae are present in abdomen. Sacrum is present in hip area and coccyx is considered as vestigial tail.

(91) **(D).** The vertebral column protects the spinal cord, supports the head and serve as a point of attachment for ribs and musculature of back. Sternum is a flat bone on the vertebral midline of thorax.

(92) (A) **(93) (B)** **(94)** (D)

(95) **(B).** Each pectoral girdle consists of two bones: 1 clavicle and 1 scapula. At the point where the superior and lateral borders of the scapula meet there is the lateral angle which presents a shallow articular surface termed as glenoid cavity into which the head of the humerus is articulated.

(96) **(B).** Each middle ear contains three tiny bones (i) Malleus (ii) Incus (iii) Stapes which are collectively called ear ossicles.

(97) **(B).**

(98) **(B).** There are 12 pairs of ribs. Each rib is a thin flat bone connected dorsally to the vertebral column and ventrally to sternum.

(99) **(A).** Bones and cartilage are specialised connective tissues. The former has a very hard matrix due to calcium salts in it and the later has slightly pliable matrix due to chondroitin salts.

(100) **(B).** **Cartilaginous Joints :** They are slightly moveable joints. Disc of white fibrocartilage is strong but more elastic and compressable than the white fibrous tissue. These joints holds the bones together at joints between the bodies of vertebrae, at pubis and between the sternum and ribs. The bones make some movements at such joints through compression of the discs of cartilage.

(101) **(D).**

(102) **(A).** Pivot joint allows only a rotatory movement of one bone on the other, which remains stationary. A rounded end of one bone fits into a shallow pit of another bone. e.g., joint between atlas and axis vertebrae which enables the head to turn from side to side.

(103) **(D).** Cartilaginous joints allows only some movements at the joints through the compression of the discs of cartilages. e.g., vertebrae of vertebral column.

(104) **(A).** A hinge joint allows movement in one plane. Spool (reel) like surface of one bone fits into the Concave surface of another bone. The elbow, the knee, ankle and interphalangeal joint are examples of hinge joints. Joint between humerus and pectoral girdle is an example of ball and socket joint.

(105) **(A).** Joints are the points of contact between the bones or between the bones and cartilages. Force generated by the muscles is used to carry out the movements through joints.

(106) **(A).** Sutures are the dense fibrous connective tissues through which the skull bones fuses with each other to form cranium.

(107) **(C).** **Fibrous Joints :** These are the immovable or fixed joints. These joints don't allow any movement due to the presence of strong white and tough cartilaginous fibres. e.g., joints in tooth socket and between skull bone.

(108) **(D).**

(109) **(D).** In ball and socket joint, the one bone fits into a cup-like depression of other bone, so that the former is freely movable in all directions. e.g., shoulder joint and hip joint.

(110) **(A).**

(111) **(A).** Joints have been classified into three major structural forms.

(i) **Fibrous joints** don't allow any movement. This type of ioint is shown by flat skull bones, which fuse end to end by fibrous connective tissue to form sutures of the cranium.

(ii) **Cartilaginous joints** allows only limited movements. Bones are joint together with the help of cartilages. The joint between the adjacent vertebrae in the vertebral column is cartilaginous joints.

(iii) **Synovial joints** are characterised by the presence of fluid filled synovial cavity between the articulating surfaces of the two bones. Such an arrangement allows considerable movement.

(112) **(B).** Atlas and axis are joined by pivot joint. It is also known as rotatoria. Pivot joints fixes one of the two bones in its place and bear a peg like process over which the other bone rotates.

(113) **(B).** **Synovial Joints :** Those joints are the perfect joints which allows free movements in one or more directions. Synovial joints are of different types depending upon the nature of articulation and degree of movement. Bones end bear synovial membranes and enclose a cushion of synovial fluid.
Synovial fluid lubricates the joints to allow nearly frictionless movement of bones on each other and nourishes the structures participating in the joints. It also serves to keep the bones held together like a film of water between the two glass plates does.

(114) **(C).** Rapid spasm is also called wild contraction of the muscles. It takes place due to the low level of Ca^{2+} ions in the sarcoplasmic reticulum or during the muscular contraction the level of Ca^{2+} lowers ions than the normal concentration.

(115) **(D).** Atherosclerosis is a disorder of circulatory system.

(116) **(B).**

(117) **(C).** **Muscular dystrophy :** Progressive degradation of skeletal muscle mostly due to genetic disorder.

(118) **(A).** **Osteoporosis :** Age-related disorder characterised by decreased bone mass and increased chances of fractures. Dereased levelof oestrogen is a common cause of this disease.

(119) **(B).** **Arthritis :** Inflammation of joints.
Rheumatoid arthritis : Hard tissue deposites over articular cartilage along with the higher secretion of synovial fluid, causing pain and stiffness which leads to rheumatoid arthritis.
Osteoarthritis : Tearing of articular cartilage and development of bony lumps at places causing pain, stiffness and permanent bending which lead to osteoarthritis.

(120) **(B).**

EXERCISE-2

(1) **(C).** (C) is correct because only actin and myosin filaments move relative to one another; (B) is not correct because actin and myosin are arranged parallel to one another; (D) is not correct because actin does not normally dissociate during sarcomere shortening.

(2) **(D).** The spinal column has three main sections- the cervical spine, the thoracic spine, and the lumbar spine. The first seven vertebrae form the cervical spine. The mid back, called the thoracic spine, consists of 12 vertebrae.

(3) **(B).** The axial skeleton is the part of the skeleton that consists of the bones of the head and trunk of a vertebrate. In the human skeleton, it consists of 80 bones and is composed of six parts; the skull bones, the ossicles of the middle ear, the hyoid bone, the rib cage, sternum and the vertebral column.

(4) **(A).** Myoglobin, a protein found in the muscle cells of animals. It functions as an oxygen-storage unit, providing oxygen to the working muscles.

(5) (D) **(6)** (D)

(7) **(B).** Purine metabolism refers to the metabolic pathways to synthesize and break down purines that are present in many organisms.When a defective gene causes gaps to appear in the metabolic recycling process for purines and pyrimidines, these chemicals are not metabolised properly, and adults or children can suffer from any one of twenty-eight hereditary disorders, possibly some more as yet unknown. Symptoms can include gout, anaemia, epilepsy, delayed development, deafness, compulsive self-biting, kidney failure or stones, or loss of immunity.

(8) (C) **(9)** (A) **(10)** (B)

(11) **(D).** Endochondral bone: Any bone that develops in and replaces cartilage.
The cartilage is partially or entirely destroyed by the process of calcification.

(12) **(A).** The hip bone (innominate bone, pelvic bone or coxal bone) is a large flat bone, constricted in the center and expanded above and below.

In some vertebrates (including humans before puberty) it is composed of three bones: the ilium, ischium, and the pubis.

(13) (A) **(14)** (D) **(15)** (C) **(16)** (D)

(17) (C) **(18)** (D) **(19)** (A)

(20) **(C).** The junction between a motor neuron and the sarcolemma of the muscle fibre is called the neuromuscular junction or motor end plate. A neural signal reaching this junction releases a neurotransmitter, acetylecholine which generates an action potential in the sarcolemma.

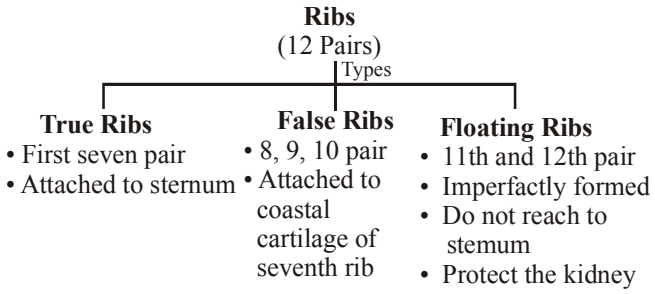
(21) **(D).** Beyond the cardiac, smooth, and striated, muscle fibers can also be divided by type: Type I, Type IIa, and Type IIb. These are divided based on differences in the amount of mitochondria (the powerhouse of the cell) they have, how quickly they contract, color, and other factors.

Type I : Red in color due to high concentrations of myoglobin (the compound in muscles that carries oxygen)
Very resistant to fatigue.
Contains large amounts of mitochondria.
Contracts slowly.
Produces a low amount of power when contracted.
Used in aerobic activities such as long distance running.
Also called slow twitch fibers.

Type IIa : Red in color due to high concentrations of myoglobin.
Resistant to fatigue (but not as much as Type I fibers).
Contains large amounts of mitochondria
Contracts relatively quickly.
Produces a moderate amount of power when contracted.
Used in long-term anaerobic activities such as swimming (activities lasting less than 30 minutes).
Also called fast twitch A fibers.

Type IIb : White in color due to low myoglobin concentrations.
Fatigue very easily.
Contains low amounts of mitochondria.
Contracts very quickly.
Produces a high amount of power when contracted.
Used in short-term anaerobic activities such as sprinting and lifting heavy weights (activities lasting less than a minute).
Also called fast twitch B fibers.

(22) **(B).**



(23) (B)

(24) **(D).** The Achilles tendon or heel cord, also known as the calcaneal tendon , is a tendon of the back of the leg, and the thickest in the human body. It serves to attach the plantaris, gastrocnemius (calf) and soleus muscles to the calcaneus (heel) bone. These muscles, acting via the tendon, cause plantar flexion of the foot at the ankle, and flexion at the knee.

(25) (D) **(26)** (A) **(27)** (A)

(28) **(D).** Periosteum : A dense layer of vascular connective tissue enveloping the bones except at the surfaces of the joints.

(29) (A)

(30) **(A).** A sarcomere is the basic unit of striated muscle tissue. Skeletal muscles are composed of tubular muscle cells (myocytes called muscle fibers) which are formed in a process known as myogenesis. Muscle fibers are composed of tubular myofibrils.

(31) **(D).** Contractile proteins are the force generators of muscle contraction. The two contractile proteins in myofibrils are actin and myosin, which are part of the thin filament and thick filament respectively.

(32) **(C).** Sharpey's fibres (bone fibres, or perforating fibres) are a matrix of connective tissue consisting of bundles of strong collagenous fibres connecting periosteum to bone.

They are part of the outer fibrous layer of periosteum, entering into the outer circumferential and interstitial lamellae of bone tissue.

(33) (D)

(34) **(A).** The atlantoaxial joint is a joint in the upper part of the neck between the first and second cervical vertebrae; the atlas and axis. It is a pivot joint.

(35) (B)

(36) **(C).** The muscle contraction cycle is triggered by calcium ions binding to the protein complex troponin, exposing the active-binding sites on the actin.

(37) **(C).** A suture is a type of fibrous joint which only occurs in the skull (or "cranium"). The bones are bound together by Sharpey's fibres. A tiny amount of movement is permitted at sutures, which contributes to the compliance and elasticity of the skull. These joints are synarthroses.

(38) (C) **(39)** (B) **(40)** (D) **(41)** (B)

(42) **(D).** Adenosine Triphosphate (ATP) is the immediate source of (chemical) energy for muscle contraction.

(43) (B)

(44) **(C).** Synovia, more often called synovial fluid, is a viscous, non-Newtonian fluid found in the cavities of synovial joints. With its egg white-like consistency, the principal role of synovial fluid is to reduce friction between the articular cartilage of synovial joints during movement.

(45) **(A).** Calcium triggers contraction by reaction with regulatory proteins that in the absence of calcium prevent interaction of actin and myosin.

(46) (C) **(47)** (A)

(48) **(C).** Ball and socket joints involve the round head of one bone (the ball) fitting snuggly into the rounded pocket of another bone (the socket). The upper arm (humerus) and shoulder (scapula) are connected using a ball and socket joint.

(49) (B)

(50) **(B).** The trochanter is an anatomical part of the femur connecting to the hip bone.

(51) (B) **(52)** (A)

(53) **(A).** Craniology : The scientific study of the shape and size of the skulls of different human races.

(54) **(A).** White Skeletal Muscle (Fast twitch fibre) Their fibres are much thicker and of light colour due to the absense of myoglobin. The number of mitochondria is low in white fibres. They have little or no storage of oxygen. They are meant for fast and strenous physical activity over a short duration as they get tired soon. They carry out anaerobic contraction by accumulating lactic acid. e.g., muscels of eye ball, flight muscle of fast flying birds such as sparrows.

(55) **(C).** The osteon or haversian system is the fundamental functional unit of much compact bone.

(56) (B)

(57) **(C).** The angular is a large bone in the lower jaw (mandible) of amphibians and reptiles (birds included), which is connected to all other lower jaw bones: the dentary (which is the entire lower jaw in mammals), the splenial, the suprangular, and the articular.

(58) **(A).** Each muscle fibre is lined by the plasma membrane called sarcolemma enclosing the sarcoplasm.
Muscle fibre is a syncitium as the sarcoplasm contains many nuclei. The endoplasmic reticulum, i.e., sarcoplasmic reticulum of the muscle fibres is the store house of calcium ions. A characteristic feature of muscle fibre is the presence of large number of parallely arranged filaments in the sarcoplasm called myofilaments or myofibrils.

(59) **(C).** By utilising the energy from ATP hydrolysis, the myosin head binds to the exposed active sites on actin to form a cross bridge. This pulls the attached actin filaments towards the centre of A-band. The Z-line attached to these actin are also pulled inwards thereby causing the shortening of sarcomere, i.e., contraction.

(60) **(D).** Synovial joints are of following types

(i) **Ball and Socket Joint :** Between humerous and pectoral girdle.

(ii) **Hinge Joints :** Knee joint

(iii) **Pivot Joint :** Between atlas and axis

(iv) **Gliding joints :** Between carpals

(v) **Saddle joints :** Between carpals and metacarpals of thumb.

EXERCISE-3

(1)	(C)	**(2)**	(C)	**(3)**	(A)	**(4)**	(D)
(5)	(D)	**(6)**	(B)	**(7)**	(C)	**(8)**	(A)
(9)	(D)	**(10)**	(A)	**(11)**	(C)	**(12)**	(D)

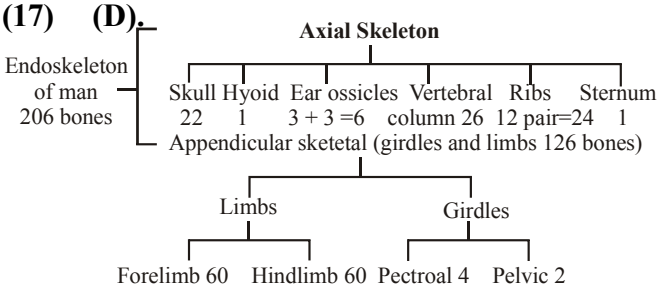
(13) **(B).** During strenous exercise, the muscle does not get sufficient oxygen to meet its energy needs immediately. So, it contracts anaerobically and accumulates lactic acid. During recovery, the oxygen consumption of the muscle far exceeds than in the resting state. The extra oxygen consumed during recovery is called oxygen debt of the muscle.

(14) **(C).** Arthritis or inflammation of a joint makes the joint painful and may even immobilise the movements at the joint. This may result from a lack of the synovial fluid at the joint. The ossification of the articular cartilage, deposition of uric acid crystals in the joint cavity or other changes at the joint.

(15) **(B).** 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.

(16) **(C).** Skeleton is made up of several bones and cartilages. Bone marrow is a soft and semisolid fatty neurovascular tissue, present inside the bones and carries the tissues for the formation of blood cell. Both the erythrocytes an leucocytes are produced in the red bone marrow present in the interstices of the spongy bones of vertebrae, sternum, scapula and in the ends of long bones, such as humerus and femur. Blood is a connective tissue whose continual flow in the blood vessels maintains a fairly constant environment for the body cells.

(17) **(D).**



(18) **(D).** Most of the mammals have 7 cervical vertebrae. There are some exceptions as follows:

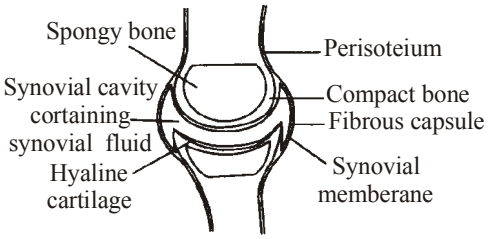
2-toed sloth = 6 Cervical vertebrae

Manatae = 6 Cervical vertebrae

Anthear = 8 Cervical vertebrae

3-toed sloth = 9 Cervical vertebrae

(19) **(D).** Structure of synovial joint is as follows:



Structure of synovial/freely movable joint

(i) Synovial Cavity

(a) Contains mucin, a lubricant for joint surfaces.

(b) Reduces friction between the joint surface.

(c) Allows the movements of nutrients and respiratory gases.

(ii) Hyaline Cartilage

(a) Contains no blood vessels or nerves.

(b) Reduces the friction between bones during movement.

(c) Because of its elastic property, it also acts as shock absorber.

(iii) Fibrous Capsule

(a) Formed by the number of ligaments.

(b) Arrangement in such a way, as to cope effectively with the particular stresses suffered by the joints.

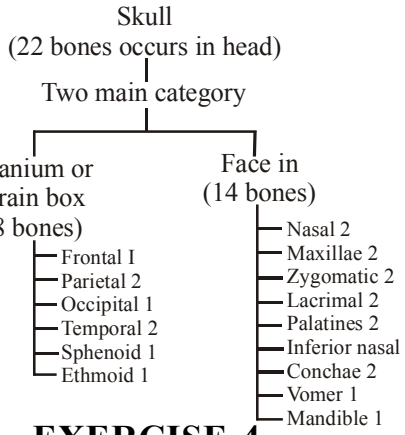
(iv) Synovial membrane

(a) Secretes synovial fluid (a clear sticky fluid) into the synovial cavity.

(b) Acts as water proof seal, preventing escape of synovial fluid.

(c) Allows movement of nutrients and respiratory gases

(20) (A).



EXERCISE-4

(1) (C). Accumulation of uric acid crystals in joints causes their inflammation and this disease is called gout.

(2) (D). **Synovial joints** are characterised by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones. Such an arragement allows considerable movement. These joints help in locomotion and many other movements. Ball and socket joint (between humerus and pectoral girdle), Hinge joint (knee joint), Pivot joint (between atlas and axis), Gliding joint (between the carpals) and Saddle joint (between carpal and metacarpal of thumb) are some examples.

(3) (D). H-zone in skeletal muscle is the central gap between actin filaments extending through myosin filaments in the A band.

(4) (D). Joint between carpals is gliding joint.

(5) (A). During muscle contraction motor nerve secrete Acetylcholine neurotransmitter which goes on the muscle fibre through diffusion. Relation of motor nerve and muscle is called as neuromuscular junction.

(6) (B). Sliding filament theory tells that actin slides over myosin during contraction where the length of I-Band &sarcomere reduces but no change in length of any filament.

(7) (C). Glenoid cavity articulates humerus with scapula.

(8) (B). Production of body heat is the function of adipose tissue.

(9) (D). Fibrous joint are immovable joints where two bones are connected with the help of fibrous connective tissue.

(10) (C). Sustained muscle contraction due to repeated stimulus is known as tetanus.

(11) (A). Calcium ions bind with subunit of troponin which is responsible for unmasking of active sites for myosin for crossbridge activity during muscles contraction.

(12) (C). Osteoporosis in aged female after menopause is due to decreased level of estrogen.

(13) (C). Synovial joints are freely movable joint which allow considerable movements. Pivot joint is a type of synovial joint which provide rotational movement as in between atlas and axis vertebrae of vertebral column.

(14) (A). In human, 12 pairs of ribs are present in which 7 pairs of ribs (1st to 7th pairs) are attached dorsally to vertebral column and ventrally to the sternum.

(15) (C). Signal for contraction increase Ca^{++} level many folds in the sarcoplasm.
Ca^{++} now binds with sub-unit of troponin (troponin "C") which is masking the active site on actin filament and displaces the sub-unit of troponin.
Once the active site is exposed, head of the myosin attaches and initiate contraction by sliding the actin over myosin.

(16) (D).

- Vertebrosternal ribs are true ribs, dorsally they are attached to the thoracic vertebrae and ventrally connected to the sternum with the help of hyaline cartilage. First seven pairs of ribs are called true ribs.
- 8^{th}, 9^{th} and 10^{th} pairs of ribs do not articulate directly with the sternum but join the seventh ribs with the help of hyaline cartilage. These are vertebrochondral or false ribs.
- Last 2 pairs (11 & 12) of ribs are not connected ventrally and are therefore, called floating ribs.
- Only first seven pairs of ribs are ventrally connected to the sternum.