20. Locomotion and Movement

1. Introduction

Movement is one of the most distinct feature of living beings. Animals and plants exhibit wide range of movements e.g., streaming of protoplasm in the unicellular organisms like Amoeba is a simple form of movement, movement of cilia, flagella and tentacles are shown by many organisms. Human beings can move limbs, jaws, eyelids, tongue, -etc.

Difference between Locomotion and Movement

1	Locomotion takes place at organism level	movement can take place at any biological level from cellular to organisms
2	Locomotion is usually voluntary	movement could be either voluntary or involuntary
3	locomotion does not essentially require energy when the free-floating organisms are considered	Movement essentially requires energy. plants do not move from place to place, but there are various types of movements take place inside plants.

2. Types of Movement

Movements can be of 2 categories

2.1. Non-Muscular Movements

These movements persist in the animals in some of their cells.

(1) Protoplasmic Streaming : Streaming of protoplasm called cyclosis, has been seen in most of the cells such as leucocytes, Amoeba and other unicellular organisms.

(2) Pseudopodia' Movements : Leucocytes and macrophages move about in the tissues with the help of pseudopodia in the same manner as of Amoeba.

(3) Flagellar Movements : The flagella of certain cells (e.g., choanocytes of poriferans) maintain by their ceaseless vibrations a regular current of water through the canal system of sponges. The flagella of certain gastrodermal cells circulate fluid in the coelenteron of Hydra by regular beating. Sperms- swim in water or in female genital tract by flagellar movements.

(4) Ciliary Movements : The cilia of the cells lining the trachea, oviducts and vasa efferentia propel dust particles, eggs and sperms in specific direction. The cilia of flame cells push waste material in excretory canals in flatworms.

(5) The non-muscular ciliary locomotion is retained by some animal larvae such as the planula larva of coelenterates and the trochophore of annelids, and even some adults such as planarians.

2.2. Muscular Movements

This depends upon the use of muscle fibres which have ability to exert force by alternate contraction and relaxation. Most multicellular organisms have muscle fibres for moving different body parts or locomotion.

A muscle contraction does not always result in movement. It may at times maintain status quo, as in a fresh water mussel (mollusc), muscle contract to keep shell closed for safety.

3. Muscles

Muscle is a specialized tissue of mesodermal origin. Muscular tissue is made up of specialized cells called myocytes that remain bound together.

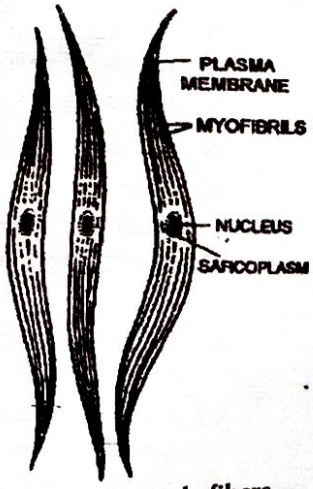
3.1. Types of Muscles

There are three types of muscle tissue based on their location

(1) **Striated or Striped, Skeletal muscles-** They are present in the limbs, body walls, tongue, pharynx and beginning of oesophagus. Control motor movements and posture.

(2) **Nonstriated or Unstriped or Smooth-** Fibre do not show cross-striations, instead, they look smooth. Smooth muscles cannot be moved voluntarily. So they are also called Involuntary Muscles. Functionally, smooth muscles are of two types.

- **Single-Unit Smooth Muscles** are composed of muscle fibres closely joined together. All its fibres contract together as a single unit. They may contract automatically and rhythmically. Such smooth muscles occur on the walls of hollow visceral organs such as the urinary bladder and the gastrointestinal tract.
- **Multi-Unit Smooth Muscles** are composed of more independent muscle fibres, not so closely joined together. Individual fibres of such smooth muscles contract as separate unit. These occur at hairy roots and in the walls of large bold vessels. E.g., Arrector pili muscles.



Nonstriated muscle fibers

(a) Smooth muscle fibres are elongated spindle-shaped cells. They are packed parallel to each other in branching bundles.

(b) Each fibre contains a single, spindle shaped nucleus as its thick central part. The smooth muscle fibre is generally shorter than a striated muscle fibre.

(c) Mitochondria and other organelles are less extensive and protein filaments are not regularly arranged to give rise to striations.

Differences between Single-unit and Multi-unit Smooth Muscles

Single- unit smooth muscles	Multi-unit smooth muscles
(i) They have number of muscle fibres closely joined together.	(i) They have number of muscle fibres not so closely joined.
(ii) All the fibres contract together as a single unit, automatically and rhythmically, *e.g.* walls of hollow visceral organs like stomach, intestine, urinary bladder etc.	(ii) The individual fibres contract as separate units more or less as independent muscle fibre. *e.g.* hair roots, and on the walls of large blood vessels.

- **Contraction in Smooth Muscles :** In comparison with contraction in a skeletal muscle fibre, contraction in a smooth muscle fibre starts more slowly and lasts much longer Troponin is absent in smooth muscle so they have regulator protein called Calmodulin that binds to Ca^{2+} in the cytosol. Using ATP, myosin head part can bind to actin & contraction can occur. Most smooth muscle fibres contract or relax in response to action potentials from the autonomic nervous system.
- **Cardiac muscles :** Occurs exclusively in the heart. It possesses considerable automatic rhythmicity and generates its own wave of excitation. The excitation can also pass directly from fibre to fibre in the cardiac muscle. It is not under voluntary control. It shows cross-striation, but striations are much fainter than those of striated muscle. Between the cardiac muscle fibres intercalated are present. They are specialized regions of cell membrane of two adjacent fibres. The intercalated discs function as boosters of contraction wave and permit the wave of contraction to be transmitted from one cardiac fibre to another.
- **Cardiac muscle cells :** are short cylindrical cells joined end to end to form rows. They possess abundant cytoplasm with myofibrils (sarcoplasm) and numerous mitochondria and glycogen granules. This is because they need a large amount of energy. Faint but regular, alternate dark and light bands gives rise to cross-striations in the cardiac muscle fibres and indicate regular and alternate arrangements of thin and thick filaments in the fibres. Sarcomeres are also present. Cardiac muscle cell frequently branches to form junctions with neighbouring cells, Where two cardiac muscles cells meet end to end, dense zig-zig junction is formed between them. It is called an Intercalated Disc. Long refractory period is present in cardiac muscles.
- **Contraction in cardiac muscles :** Cardiac muscle fibres have the same arrangement of actin & myosin and the same bands, zones and Z discs as skeletal muscle fibres. Gap junctions allow muscle action potential to spread from one muscle fibre to another. As a consequence, when a single muscle fibre is stimulated, all the other fibres in the network become stimulated as well. Thus, each network contracts as a functional unit. Cardiac muscle tissue has a long refractory period and can use lactic acid produced by skeletal muscle fibres to make ATP.

4. Structure of Skeletal Muscle

The striated muscle forms 80% or more of the mass of soft tissues in a vertebrate body.

Skeletal muscles are having a connective tissue sheath on the outer side and are called epimysium. A transverse section of it shows a number of bundles or fascicule. Each fasciculus is surrounded by connective tissue cover called perimysium.

Within a fasciculus, are present a large number of muscle fibres each surrounded by connective tissue cover endomysium. There is a broad band of fibrous connective tissue beneath the skin or around muscles called fascia.

Each muscle fibre is cylindrical, uniform in diameter. Sarcolemma is present on outer side and at places is invaginated to form T or transverse tubules. A skeletal or striated muscle fibre is multinucleated or syncytial.

4.1. Ultra Structure of Skeletal Muscle Fibre

(1) A striated muscle consists of long, narrow, cylindrical, unbranched fibres with blunt ends. Each fibre is bounded by an elastic sarcolemma and contains many elongated, flattened nuclei characteristically located near the sarcolemma.

(2) Multinucleate condition results from cell fusion. Hence, a striated muscle fibre is syncytium.

(3) The striated muscle fibres contain numerous mitochondria and glycogen granules for the supply of adequate energy.

(4) The myofibrils of a striated muscle fibre show alternating dark and light cross bands, the striations, or stripes, hence the name of the muscle. The dark bands are called anisotropic or A bands.

(5) Each A band has at its middle a light zone termed Henson's line, or H zone. The light bands are isotropic and are known as the isotropic or I bands

(6) Each I band is crossed through its centre by a dark membrane, the membrane of Krause, or Z line. this membrane continues right-across the whole fibre and joins the sarcolemma surrounding the fibre.

(7) It seems to hold the myofibrils together and to carry the signals for the contraction of the fibrils inward from the T-tubules (transverse tubules).

(8) The latter are invaginations of sarcolemma into the fibre adjacent to the Z lines. The part of the myofibril between two successive Z lines functions as a contractile unit termed the sarcomere.

(9) The sarcoplasm also contains a protein pigment myoglobin, which can take up store or given up oxygen like haemoglobin. Electron microscope reveals that each sarcomere is a bundle of fine longitudinal myofilaments of two types: primary and secondary.

- **Primary Myofilaments :** The primary myofilaments are thicker and confined to the A band only. They are composed of the protein myosin, bear minute projections called cross-bridges of the protein meromyosin, and are free at both the ends.
- **Secondary Myofilaments :** The secondary myofilaments are thinner and occur in I bands, but extend for some distance into the A band between the primary myofilaments. This partial over lapping of the primary myofilaments by the secondary myofilaments imparts dark appearance to the A bands.

The secondary myofilaments are composed of the proteins actin, tropomyosin and troponin, have a smooth surface and are attached to the Z lines by one end, being free at the other end. The secondary (actin) myofilaments are more numerous than the primary (myosin) myofilaments. Six actin myofilaments surround each myosin myofilament and each actin myofilament is surrounded by three myosin myofilaments.

Difference between skeletal, cardiac and smooth muscles.

	Characteristic	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
1.	Cell appearance and features	Long cylindrical fibre with many peripherally located nuclei: striated; unbranched	Branched cylindrical usually with one centrally located nucleus; striated; intercalated discs join neighbouring fibres	Spindle-shaped fibre with one centrally positioned nucleus; no striations
2.	Location	Attached primarily to bones	Heart	Walls of hollow viscera, blood vessels, iris and ciliary body of eye, arrector pili of hair follicles
3.	Fibre diameter	Very large (10 – 100 μm)	Large (14 μm)	Small (3 – 8μm)
4.	Connective tissue components	Epimysium, perimysium, and endomysium	Endomysium	Endomysium
5.	Fibre length	100 μm to 30 cm	50 – 100 μm	30 – 200 μm
6.	Organization of contractile proteins into sarcomeres	Yes	Yes	No
7.	Sarcoplasmic reticulum	Yes	Yes	Scanty
8.	Transverse tubules	Yes, aligned with each A-I band junction	Yes, aligned with each Z disc	Absent
9.	Gap in junctions between fibres	No	Yes	Yes, in single-unit smooth muscle; not in multi-unit smooth muscle
10.	Autorhythmicity	No	Yes	Yes (in visceral smooth muscle only)
11.	Source of Ca^{2+}	Sarcoplasmic reticulum	Sarcoplasmic reticulum and extracellular fluid	Sarcoplasmic reticulum and extracellular fluid
12.	Regulator proteins	Troponin and tropomyosin	Troponin and tropomyosin	Calmodulin and myosin light chain kinase
13.	Speed of contraction	Fast	Moderate	Slow
14.	Nervous control	Voluntary (somatic nervous system)	Involuntary (autonomic nervous system)	Involuntary (autonomic nervous system)
15.	Contraction regulated by	Acetylcholine released by somatic motor neurons	Acetylcholine, norepinephrine released by autonomic motor neurons; several hormones.	Acetylcholine, norepinephrine released by autonomic motor neurons; several hormones, local chemical changes (pH, O_2 level, CO_2 level); stretching
16.	Capacity for regeneration	Limited	None	Considerable compared with other muscle tissues but limited compared with tissues such as epithelium

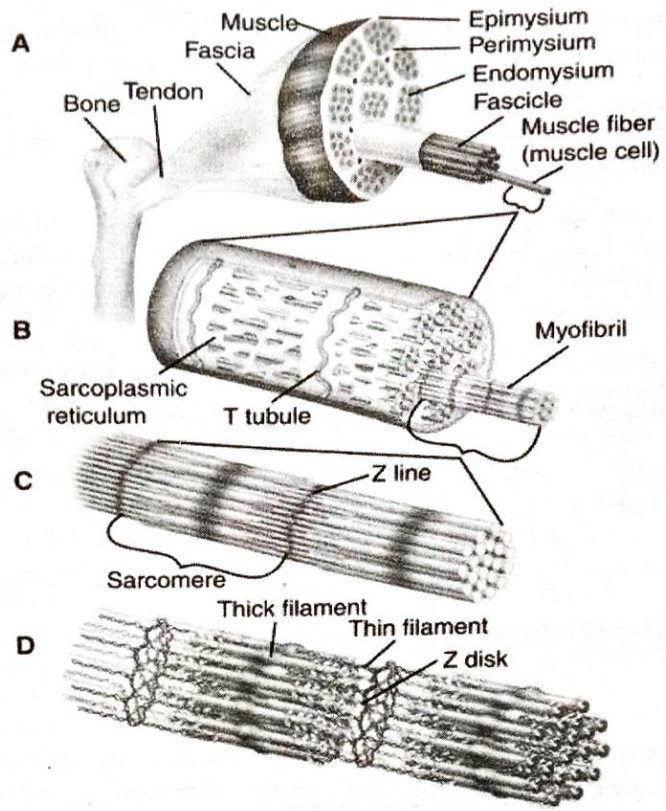


Fig. : Structure of a vertebrate striated muscle at magnifications progressively increasing from above downward.

Important -

(1) T-tubules are inwardly directed extensions of sarcolemma into muscle fibre at the junction of A-I band (striped muscle). This region is in continuity with ECF meant for rapid transmission of action potential from cell membrane to all the fibrils in the muscle.

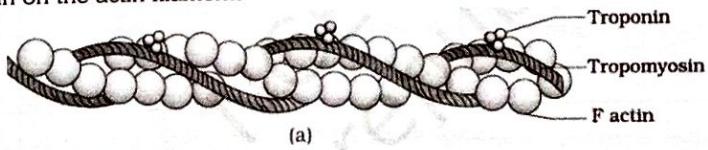
(2) M-line is seen in the middle of H-band.

(3) The myosin found in the muscle is with two globular heads and a long tail.

(4) Actinin and titin are muscle proteins that binds actin and myosin to Z-line respectively.

4.2. Structure of Contractile Proteins

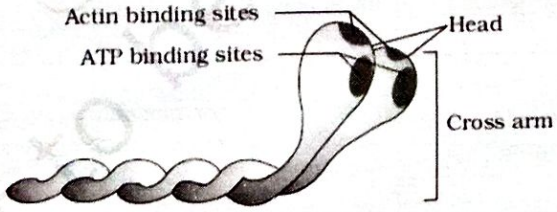
Each actin (thin) filament is made of two 'F' (filamentous) actins helically wound to each other. Each 'F' actin is a polymer of monomeric 'G' (Globular) actins. Two filaments of another protein, tropomyosin also run close to the 'F' actins throughout its length. A complex protein Troponin is distributed 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



(a)

An actin (thin) filament

Each myosin (thick) filament is also a polymerised protein. 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.



Myosin monomer (Meromyosin)

4.3. Muscle Contraction

(1) When a nerve impulse reaches the synaptic end bulbs, it triggers exocytosis of synaptic vesicles. In this process, the synaptic vesicles fuse with the plasma membrane and liberate (acetylcholine) ACh, which diffuses into the synaptic cleft between the motor neuron and the motor end plate.

(2) When ACh binds to its receptor, a channel that passes small cations, most importantly Na+ opens The inrush of Na+ changes the resting membrane potential, which triggers a muscle action potential that travels along the muscle cell plasma membrane and initiates the events leading to muscle contraction.

(3) Hanson and Huxley proposed that skeletal muscle shortens during contraction because thin filaments slide over thick filament. Their model is known as the sliding filament mechanism of muscle contraction.

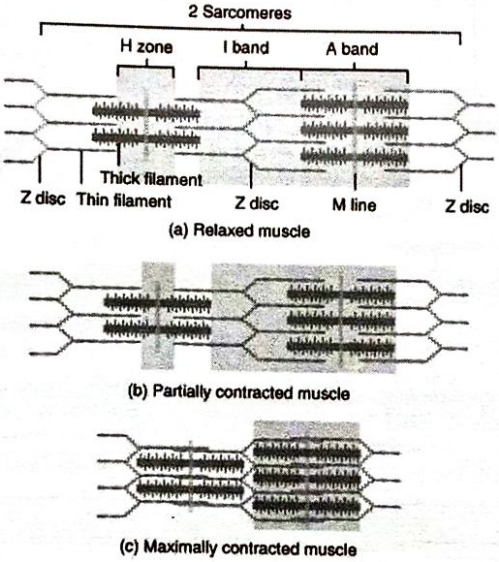
4.4. Sliding Filament Mechanism

(1) During muscle contraction, myosin heads pull on the thin filaments, causing them to slide inward towards the H zone at the centre of the sarcomere.

(2) The myosin cross bridges may even pull the thin filaments of each sarcomere so far inward that their ends overlap in the centre of the sarcomere.

(3) As the thin filaments slide inward, the Z discs come towards each other, and the sarcomere shortens, but the lengths of the thick and thin filaments do not change.

(4) The sliding of filaments and shortening of the sarcomeres cause shortening of the whole muscle fibre and ultimately the entire muscle.



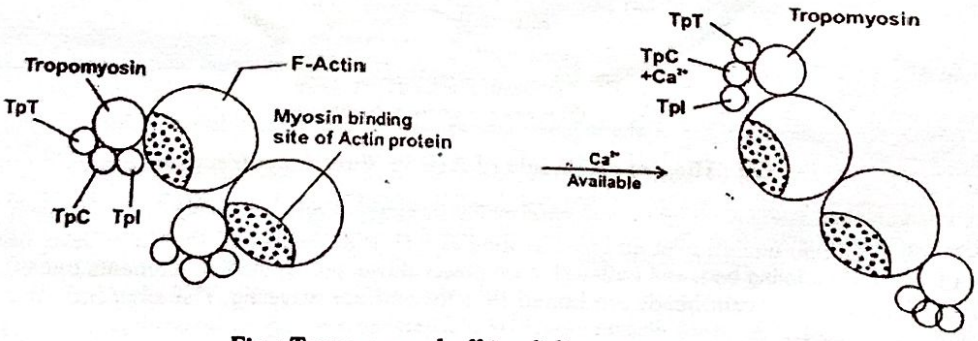


Fig : Turns on and off in sliding process

(5) An increase in Ca2+ concentration in the sarcoplasm starts filament sliding, while a decrease turns off the sliding process.

(6) When a muscle fibre is relaxed (not contracting), the concentration of Ca+2 in its sarcoplasm is low. This is because the sacroplasmic reticulum (SR) membrane contains Ca2+ active transport pumps that move Ca2 from the sarcoplasm into the SR. Ca2+ is stored or sequestered inside the SR.

(7) As a muscle action potential travels along the sarcolemma and into the transverse tubule system, however, Ca2+ release channels open in the SR membrane.

(8) As a result, Ca2+ floods into the sarcoplasm around the thick and thin filaments. The Ca2+ released from the sarcoplasmic reticulum combine with troponin, causing it to change shape. This shape change moves the troponin tropomyosin complex away from the myosin-binding sites on actin.

Role of Ca2+in muscle contraction by exposing myosin binding site of actin protein

Troponin has 3 units (tri units structure)

(9) T_PT – Tropomyosin binding troponin

(10) T_pC - Calcium binding protein

(11) T_P I - Inhibitor i.e., blocks myosin binding site of actin proteins

4.5. The Power Stroke and the Role of ATP

(1) Muscle contraction requires Ca2+ ions and energy in the form of ATP. The sequence of events during sliding of the filaments are

(2) While the muscle is relaxed, ATP attaches to ATP-binding sites on the myosin cross bridges (heads). A portion of each myosin head acts as an ATPase, an enzyme that splits the ATP into ADP + p (phosphate group) through a hydrolysis reaction. This reaction transfers energy from ATP to the myosin head, even before contraction begins. The myosin cross bridges are thus in an activated (energized) state.

(3) When the sarcoplasmic reticulum releases Ca+2, its level rises in the sarcoplasm. Rise in Ca+2 binds with troponin and change its configuration that moves away tropomyosin from its blocking position. .

(4) The activated myosin heads spontaneously bind to the myosin-binding sites on actin.

(5) The shape change that occurs as myosin heads bind to actin produces the power stroke of contraction. During the power stroke, the myosin heads swivel toward the centre of the sarcomere, like the oars\ of a boat during rowing. This action draws the thin filaments past the thick filaments toward the H zone. As the myosin heads swivel, they release ADP.

(6) Once the power stroke is complete, ATP again combines with the ATP-binding sites on the myosin heads. As ATP binds, the myosin head detaches from actin.

(7) Again, the myosin ATPase splits ATP, transferring its energy to the myosin ATPase splits head, which returns to its original upright position.

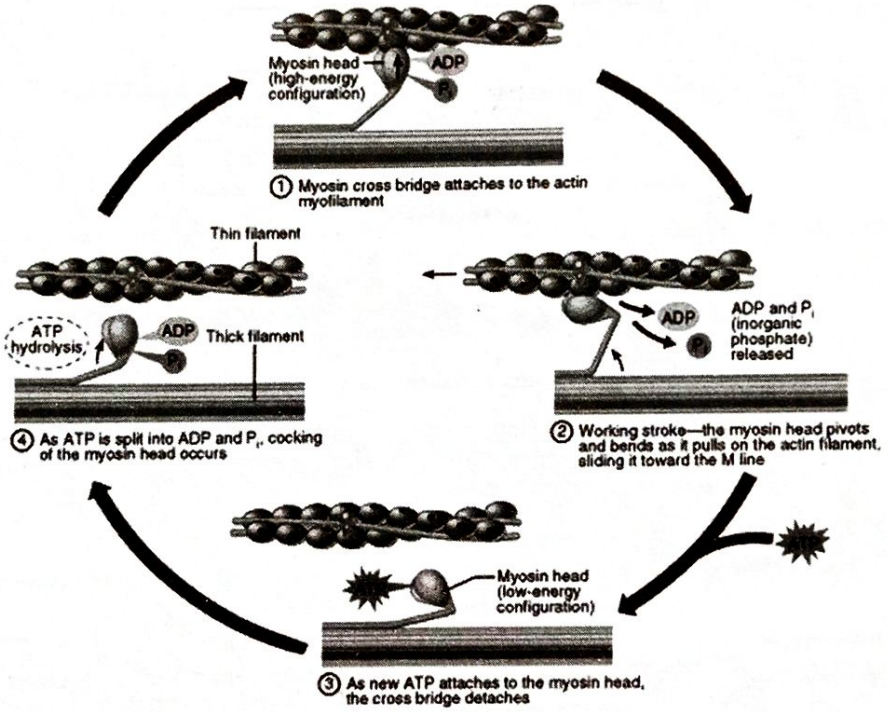


Fig : Diagram ATP role of ATP in Muscle contraction

(8) The myosin head is then ready to combine with another myosin-binding site further along the thin filament.

(9) The steps (iii) through (vii) repeats over and over as long as ATP is available and the Ca^{+2} " level near the thin filament is high. The myosin heads keep rotating back and forth with each power stroke, pulling the thin filaments toward the H zone. At any one instant, about half of the myosin heads are bound to actin and are swiveling. The other half are detached and preparing to swivel again.

4.6. Stages in Cross Bridge Formation, Rotation of Head and Breaking of Cross Bridge

(1) This continual movement of myosin heads applies the force that draws the Z discs toward each other, and the sarcomere shortens. The myofibrils thus contract and the whole muscle fibre shortens.

(2) During a maximal muscle contraction, the distance between Z discs can decrease to half the resting length. H-line and M-line disappear. I- band almost disappears, A-band remains constant. But the power stroke does not always result in shortening of the muscle fibres and the whole muscle.

(3) Contraction without shortening is called an isometric contraction, for example, in trying to lift a very heavy object. The myosin heads (cross bridges) swivel and generate force, but the thin filaments do not slide inward.

4.7. Muscle Relaxation

Two changes permit a muscle fibre to relax after it has contracted.

(1) First, acetylcholine is rapidly broken down by an enzyme called acetylcholinesterase (AChE). When action potentials cease in the motor neuron, release of ACh stops, and AChE rapidly breaks down the ACh already present in the synaptic cleft. This ends the generation of muscle action potentials, and the Ca^{+2} release channels in the sarcoplasmic reticulum membrane close.

(2) Second, Ca^{2+} active transport pumps rapidly remove Ca^{2+} from the sarcoplasm into the sarcoplasmic reticulum, where molecules of a calcium-binding protein, appropriately called calsequestrin, bind to the Ca^{2+}. With this, the tropomyosin troponin complex move back over the myosin binding site of actin which prevents further binding of myosin head to actin and the thin filaments slide back to their normal relaxed position.

5. Specialized muscle phenomenon

Both contraction and relaxation of muscle are active processes and require energy provided mainly by ATP.

5.1. All or None Principle

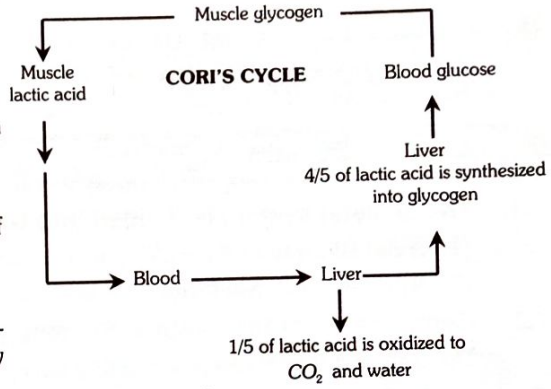
A minimal strength of a stimulus required to cause the contraction of a muscle fibre brings about maximum contraction, and no further increase in contraction would occur by increasing the strength of the stimulus.

5.2. Single Muscle Twitch

A single, quick isolated contraction of a muscle fibre to a single stimulus of threshold value is called single muscle twitch in the laboratory experiments.

5.3. Energy Source of Muscle Contraction

Energy for muscle contraction is provided by hydrolysis of ATP by myosin ATP-ase enzyme. This hydrolysis produces ADP, inorganic phosphate and energy (used in muscle contraction).



Phosphocreatine donates its high energy and phosphate to ADP, producing ATP. Phosphocreatine serves as an energy source for a few seconds for metabolic processes in the muscle cells to begin to produce greater quantities of ATP. Phosphocreatine is again formed in relaxing muscle by using ATP produced by carbohydrate oxidation.

$$ATP + H_2O \xrightarrow{\text{Myosin ATPase}} ADP + Pi + Energy$$

(inorganic phosphate)

cneatine

$$\text{Phosphocreatine} + ADP \xrightarrow{\text{Contracting Muscle}} \text{Creatine}$$

At the end of muscle contraction, the conversion of ADP into ATP takes place. The muscle is rich in glycogen which is broken down into lactic acid through a series of reactions (glycolysis) and liberates energy. Some of this energy is used for the reformation of phosphocreatine and also for the conversion of 4/5th of lactic acid back into glycogen. The 1/5th of lactic acid is oxidized to water and carbon dioxide. These reactions taking place in the muscle and liver, are proposed by Con and Cori, hence known as Cori's cycle.

5.4. Rigor Mortis

Extreme rigidity of body after death is called rigor mortis. It is due to complete depletion of ATP and phosphocreatine.

5.5. Oxygen Debt

It is the extra oxygen required by the body muscles during relaxation or recovery period of a muscle.

6. Red and White Muscle Fibres

Birds and mammals have two kinds of striated muscle fibres in their skeletal muscles; red or slow muscle fibres and white or fast muscle fibres.

- The percentage of fast and slow muscle fibres within each muscle is genetically determined. This ratio is more or less fixed and cannot be changed with physical training.
- Heat normally works under complete aerobic condition with essentially no accumulation of lactic acid.

Differences between red muscle fibres and white muscle fibres

	Red Muscle Fibres/Type-I Aerobic muscle fibre	White Muscle Fibres/Type-II Anaerobic muscle fibres
1.	They are thinner.	They are much thicker.
2.	These muscle fibres are dark red due to the presence of red haemoprotein called myoglobin. Myoglobin binds and stores oxygen as oxymyoglobin in the red fibres. Oxymyoglobin release oxygen for utilization during muscle contraction.	These muscle fibres are pale or whitish in colour as they have less myoglobin.
3.	Amount of sarcoplasmic reticulum is low.	Amount of sarcoplasmic reticulum is high.
4.	Red muscle fibres are rich in mitochondria. Mainly carries oxidative pathway i.e., depend on aerobic process of energy	White muscle fibres are poorer in mitochondria, mainly carries glycolytic pathway i.e., depend on anaerobic process of energy.
5.	They carry out consider aerobic oxidation so these muscle fibres can contract for a longer period without fatigue.	They depend mainly on anaerobic oxidation (glycolysis) for energy production and so these contractions accumulate lactic acid in considerable amount during strenuous work and soon get fatigued.
6.	These muscle fibres have slow rate of contraction so mean to perform sustained work.	These muscle fibres have fast rate of contraction so are specialization for strenuous work.
7.	Extensor muscles on the back of the human body are very rich in red muscle fibres. Some flight muscles of birds are red muscles.	The muscles for eye ball movements are very rich in white muscle fibres. Flight muscles which are used in short fast flying such as in sparrow, are white muscles.

Important-

(1) **Strongest muscle :** Masseters.

(2) **Largest muscle :** Gluteus maximus.

(3) **Sharpey's fibres :** Calcified bundles of white and yellow perforating and holding periosteal bone lamellae.

(4) **Electromyography :** Graphic recording of electric current produced by an active muscle, as during muscle twitch, EMG is electromyogram.

7. Skeletal System

7.1. The skeletal system is divided into two main parts.

(1) **Axial Skeleton :** It lies along the principal axis of the body. It includes skull, vertebral column, ribs, sternum and ribs.

(2) **Appendicular Skeleton :** It is made up of the girdles and limb bones.

7.2. Components of the Skeletal System

The skeletal system is composed of four main fibrous and mineralized connective tissues: bones, ligaments, tendons, and joints.

(1) **Bone :** A rigid form of connective tissue that is part of the skeletal system of vertebrates and is composed principally of calcium

(2) **Ligament :** A small band of dense, white, fibrous elastic tissue. Ligaments connect the ends of bones together in order to form a joint. They also assist in holding organs in place.

(3) **Tendon :** A tough, flexible and inelastic band of fibrous connective tissue that connects muscles to bones.

(4) **Joint :** Joints hold the skeleton and support movement. They can be grouped together by function and structure, such as ball-and-socket, hinge, and pivot joints.

7.3. Types of Bones

There are five types of bones in the human skeletal system: long, short, flat, irregular and sesamoid.

(1) **Long Bone :** Helps to facilitate movement and support the weight of the body. Long bones are characterized by a long tubular shaft and an articular surface at each end of the bone where ligaments and tendons attach. These bones include the major bones of the arms and legs such as the humerus and femur, tibia and fibula, and the radius and ulna.

(2) **Short Bone :** Helps to provide stability and movement within the ankle and wrist joints. They provide little to no movement. Short bones are roughly cube shaped and are as long as they are wide. Examples of this type of bone include the carpals and metacarpals in the wrists and ankles.

(3) **Flat Bone :** The primary purpose of this type of bone is to protect internal organs such as the brain, heart and lungs. It also provides a large surface area for muscles to attach to. Examples of this type of bone include the cranium (skull), the thoracic cage (sternum and ribs) and the ilium (pelvis).

(4) **Irregular Bone :** These types of bones vary in size and structure with the shape usually being very complex. Irregular bones serve different functions depending on location. For example, vertebrae protect the spinal cord and together make up the spinal column. Another example would be the hyoid bone which helps to maintain tracheal and pharyngeal support.

(5) **Sesamoid Bone :** The function of this bone is to protect tendons and diminish friction and wear on joint surfaces. This type of bone is usually small and round and is found in the hands, feet and knees. A common example of a sesamoid bone is the patella (kneecap).

7.4. Endoskeleton

An endoskeleton is a skeleton that is on the inside of a body. The endoskeleton develops within the skin or in the deeper body tissues. The vertebrate endoskeleton is basically made up of two types of tissues (bone and cartilage). During early embryonic development the endoskeleton is composed of notochord and cartilage. The notochord in most vertebrates is replaced by the vertebral column and cartilage is replaced by bone in most adults. In three phyla and one subclass of animals, endoskeletons of various complexity are found: Chordata, Echinodermata, Porifera and Coleoidea. An endoskeleton may function purely for support (as in the case of sponges), but often serves as an attachment site for muscle and a mechanism for transmitting muscular forces. A true endoskeleton is derived from mesodermal tissue. Such a skeleton is present in echinoderms and chordates.

The shells of certain sponges and the various groups of shelled molluscs, including those of snails, clams, tusk shells, chitons and nautilus, are also exoskeletons. Some animals, such as the tortoise, have both an endoskeleton and an exoskeleton

7.5. Exoskeleton

An exoskeleton is the external skeleton that supports and protects an animal's body, in a human. In usage, some of the larger kinds of exoskeletons are known as "shells". Examples of animals with exoskeletons include insects such as grasshoppers and cockroaches, and crustaceans.

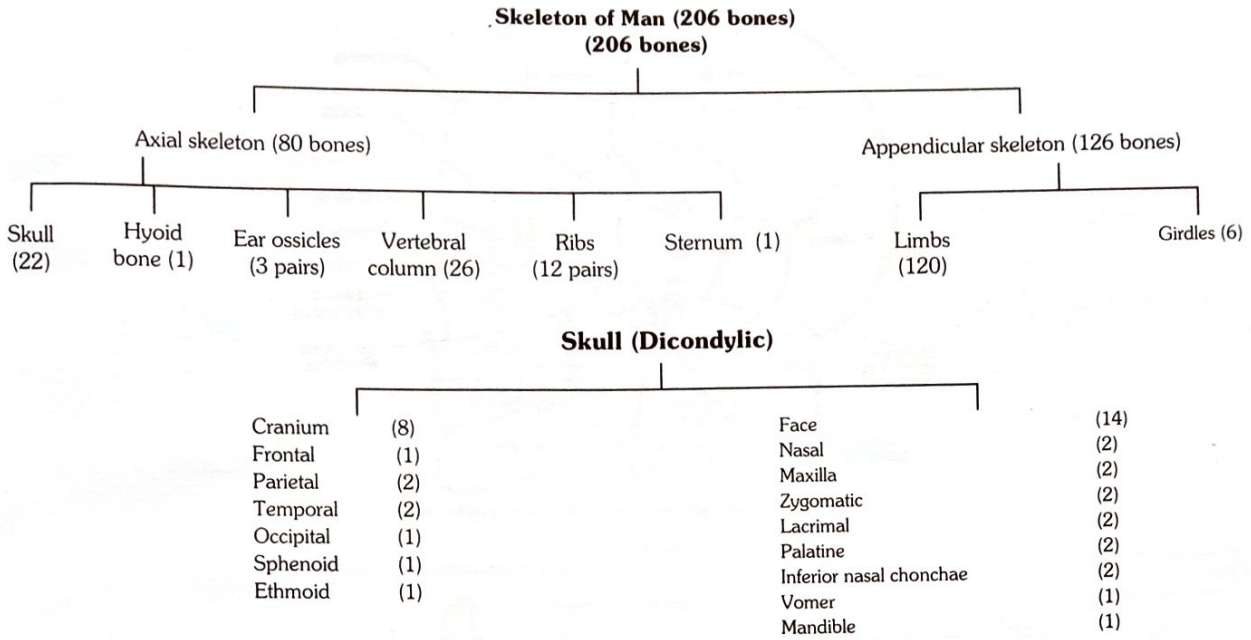
7.6. Function of the skeleton

(1) It provides protection to the major organs in particular the chest and rib cage.

(2) Muscles attach to bones to enable movement.

(3) Production of red blood cells within the bone marrow (a spongy substance is found in the cavities of long bones). Red blood cells carry oxygen around the body.

8. Skeletal System of human



The human skeleton is comprised of the total set of bones that provide the human body a multifunctional structure. The adult human skeletal system contains 206 bones. On the basis of their position , this endoskeleton is categorized as axial skeleton and appendicular skeleton.

8.1. Axial Skeleton

Axial skeleton is present along the middle longitudinal axis of the body. It includes skull, vertebral column, ribs and sternum. These four components together constitute 80 bones.

(1) Skull - consist of 29 bones and encloses brain inside. Base of the skull has a large opening called foramen magnum.It includes following parts.

(a) Cranium - Hollow and nearly rounded bony structure.

Cranial Bones	Number	Location
Frontal bone	1	Anterior part of cranium and forms forehead
Parietal bone	2	Greater portion of sides and roof of cranial cavity
Temporal	2	Inferior lateral aspect of cranium and part of cranial floor
Occipital	1	Posterior part and most of the base of cranium. A large aperture, foramen magnum is in the inferior part of the bone through which medulla oblongata connects with spinal blood.
Sphenoid	1	Lies at the middle part of the base of skull and hold all the cranial bones together. It has saddle shaped structure, sella tursica to enclose pituitary gland.
Ethmoid	1	Sponge like in appearance, located on the midline in the anterior part of cranial floor. The cribriform plate forms roof of nasal cavity through which olfactory never passes to brain. Perpendicular plate forms superior portion of nasal septum.

(b) Facial bones - consist of frontal part of the skull i.e. the facial region.

Facial Bone	Number	Location
Nasal Bone	2	Bridge of nose
Maxillae	2	Upper jaw; articulates with every bone f face except Mandible
Zygomatic	2	Prominance of cheek
Lacrimal	2	Thin bone houses lacrimal sec
Palatine	2	Make posterior part of hard palate and form floor and lateral wall of nasal cavity
Inferior nasal conchae	2	Form part of inferior lateral wall of nasal cavity, clear air that passes through nose
Vomer	1	Triangular bone forms inferior portion of nasal septum
Mandible	1	Lower jaw, largest and strongest facial bone

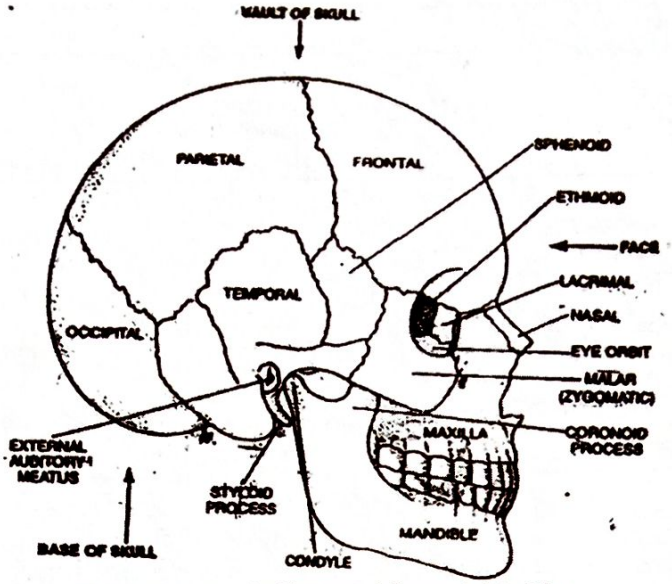


Fig. : Human skull viewed from right side

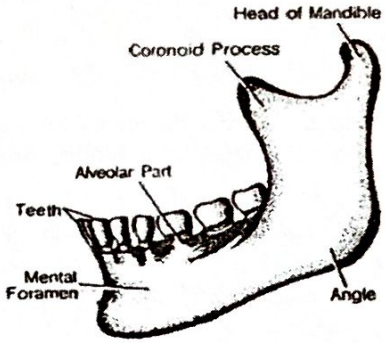


Fig. : Han – Half of the mandible (Lower Jaw)

Important-

(1) Ends of long bones are covered with hyaline cartilage, so it called as articular cartilage.
(2) Function of long bones in mammals is to provide support and to produce RBCs and WBCs.
(3) Epiphysial plates at the extremities of long bones help in the elongation bone.

(c) Hyoid - It serves as a point of attachment for some of the muscles of the tongue and floor of the mouth but does not articulate with any other bone.

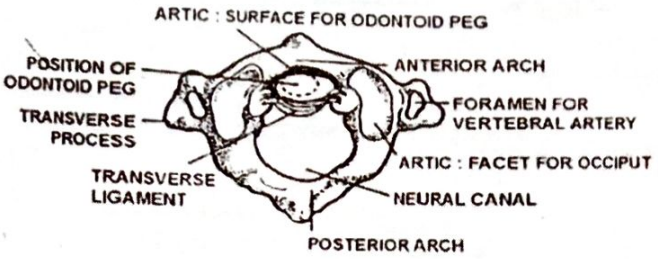
(d) Ear Ossicle - Ear ossicles are three in number

Ear ossicles	Shape	Modified form of
M = Malleus	Hammer	Articular Bone
I = Incus	Anvil	Quadrate Bone
i = Stapes	Stirrup	Hyomandibular

(2) Vertebral column (Backbone) - Vertebral column protects the spinal cord, supports the head and serves as the point of attachment for the ribs and musculature of the back.

Vertebrae Type	Embryonic stage	Adult
Cervical	7	7
Thoracic	12	12
Lumbar	5	5
Sacral	5	1
Coccyx	4	1
Total	33	26

- **Cervical Vertebrae (7)** - The first seven vertebrae of vertebral column are called cervical vertebrae. Among the cervical the first vertebrae is called atlas and the second is called axis. Atlas supports the head and it consist of a complete ring of bone. Axis acts as a pivot on which atlas turns to allow movement of head. Odontoid process of axis helps in this articulation.



The Atlas

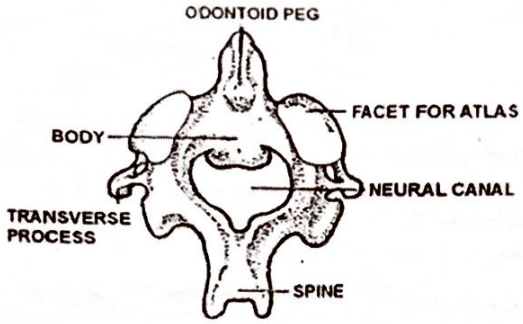
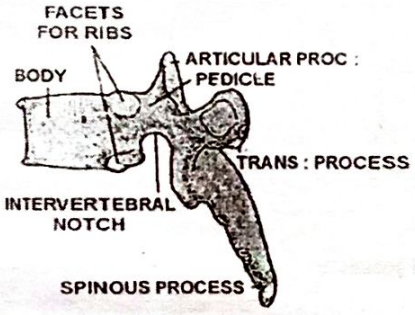
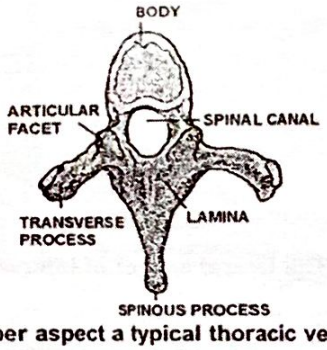


Fig. : The Axis

- **Thoracic Vertebrae (12) -** These are larger than the cervical and located in the chest. These 12 vertebrae form the dorsal side of rib cage to protect heart and lungs.Their transverse processes are thick and strong to provide additional space for the attachment of thoracic muscles.Their spinous processes are long and directed downwards.



Lateral aspect



Upper aspect a typical thoracic vertebra

- **Lumbar Vertebrae (5) -** These are the strongest vertebrae as compared with the bodies of the other vertebrae and kidney-shaped. The spinous process is broad and hatchet-shaped. The transverse processes are long and slender. The fifth lumbar vertebra articulates with the sacrum at the lumbo-sacral joint.

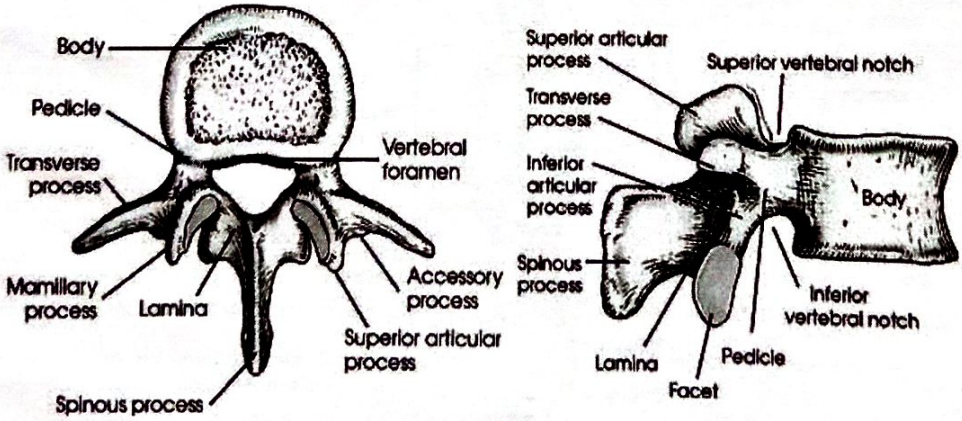
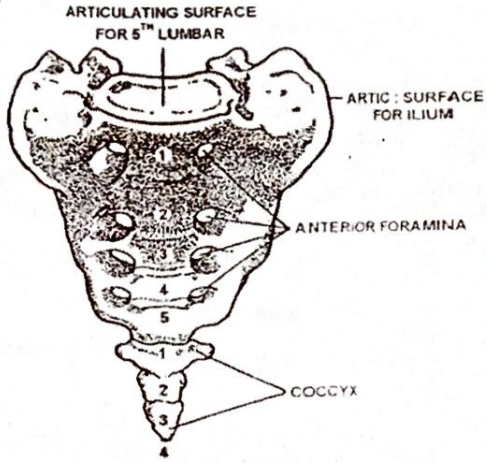


Fig. : A typical lumbar vertebra

- **Sacrum (5) -** It is a triangular bone situated at the lower part of the vertebral column, wedged in between the two innominate bones and forming the back of the pelvic cavity. The base of the sacrum lies above and articulates with the fifth lumbar vertebra, forming a typical intervertebral joint. The junction between the fifth lumbar vertebra and the sacrum forms the sacro-vertebral angle. At the extremities of transverse ridges, on each side, *sacral foramina* are present for the passage of nerves. The apex of the sacrum articulates with the coccyx. At the sides the sacrum articulates with the innominate bones, forming the right and left sacra-iliac joint.



The anterior surface of the Sacrum and Coccyx

- **Coccyx (4) -** It is composed of four rudimentary vertebrae, fused to form one bone. it articulates above with the sacrum.
- **Intervertebral discs -** are thick pads of fibro-cartilage between the bodies of the movable vertebrae. It is strengthened by ligaments running in front and behind the vertebral bodies throughout the entire length of the column. Masses of muscle on each side materially aid in the stability of the spine.

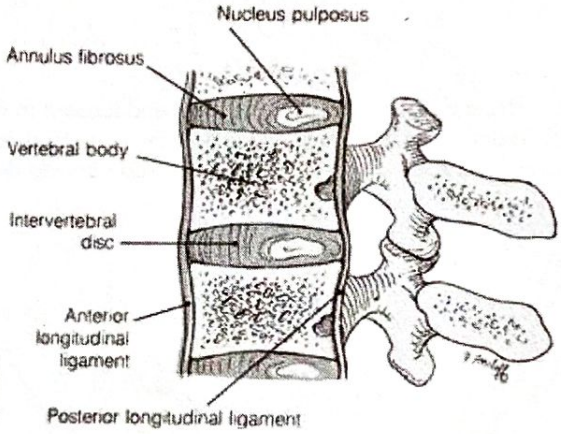
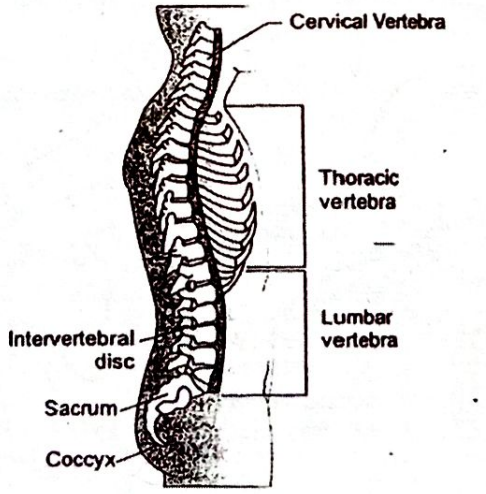


Fig: The lateral aspect of intervertebral joints of Thoracic lumbar regions

- **The Curves of the Vertebral Column -** The vertebral column presents four antero-posterior curves : the cervical curve in the neck which is convex forwards, the thoracic curve, convex backwards, the lumbar curve convex forwards, and the pelvic curve, convex backwards.



Vertebral column (right lateral view)

(3) 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 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 called vertebrosternal (true) ribs.

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

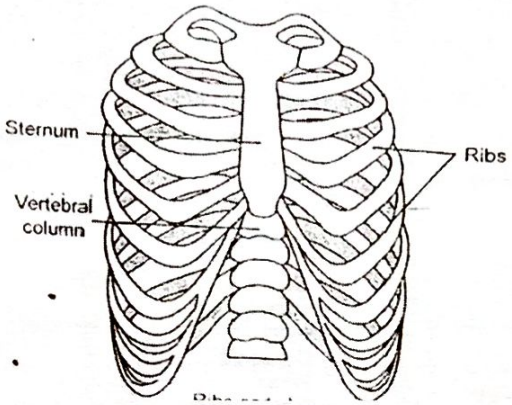


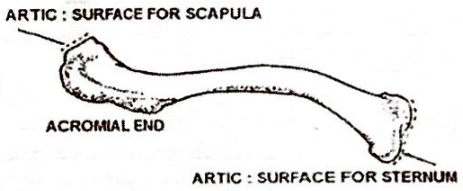
Fig : Ribs and Rib cage

(4) Sternum - It is a flat bone on the ventral midline of thorax.

8.2. Appendicular skeleton

The appendicular skeleton includes forelimbs, hindlimbs, pectoral girdle and pelvic girdle. 126 bones come under appendicular skeleton.

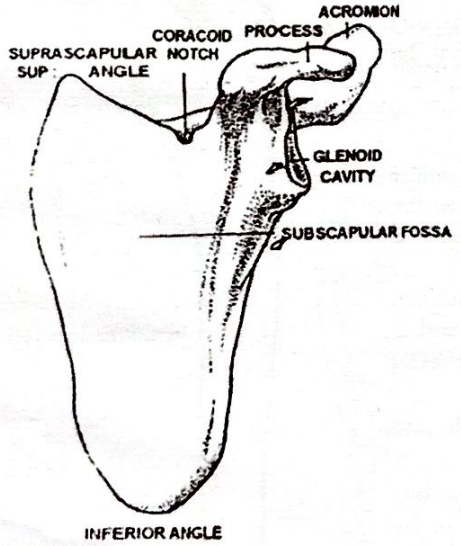
(1) Pectoral Girdle/Shoulder Girdle -It consists of two bones clavicle and scapula.



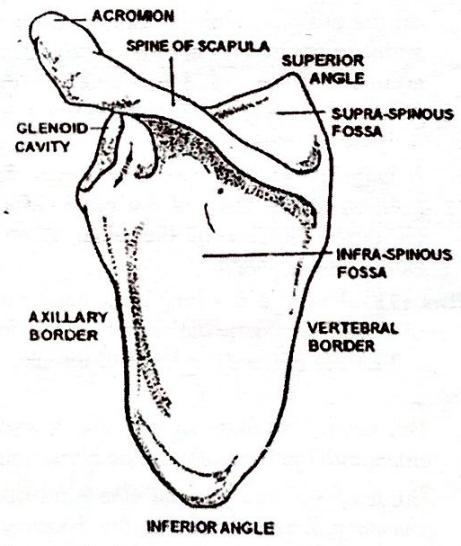
The upper surface of the left clavicle

(a) Clavicle : This is a long, narrow, S-shaped bone. It extends horizontally in upper anterior region of thorax, above the first rib in each side. It is also known as collar bone.

(b) Scapula : The scapula forms *the* posterior part of the shoulder girdle and lies at the back of the thorax superficially to the ribs. It is a triangular flat bone. Its anterior or costal surface-is called the *subscapular fossa,* and lies nearest the ribs. The posterior-or dorsal surface is divided by a prominent ridge of bone, called the *spine of the scapula,* which passes across it to end in the acromion process, which overhangs the shoulder joint.



The anterior aspect of the left scapula



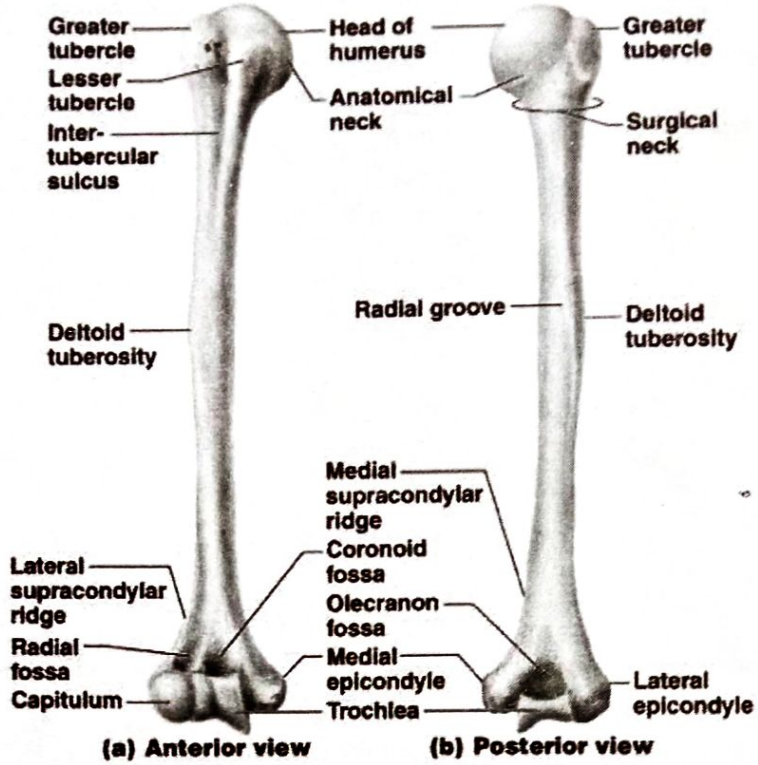
The posterior aspect of the left scapula

- Scapula show glenoid cavity, which is a shallow directed outwards to receive the head of the humerus in the formation of the shoulder joint, humero-scapular joint.
- The joint between the head of humerus and glenoid cavity is also called as ball and socket joint.
- The *corticoid process* of the scapula arises internal to the glenoid cavity and projects forward. It gives attachment to the short head of biceps and pectoralis minor.

(2) Bones of Forelimb - Each forelimb consist of 30 bones.

(a) Humerus (1) - The humerus is the longest bone of the upper limb. It presents a shaft and two extremities.

- The upper extremity of the humerus consists of one third of a sphere – the head, which articulates with the glenoid of scapula in the formation of the shoulder joint.



- Immediately below the head is a slightly constricted part called the anato- mica! neck. Below the anatomical neck, is a rough prominence, the greater tuberosity, and at the front is a smaller prominence, the lesser tuberosity. The bone becomes narrower below the tuberosities, and at this point it is called the surgical neck, because of the liability of fracture at that part.
- A rough tubercle on the lateral aspect of the shaft, just above the middle, is called the deltoid tuberosity. It receives the insertion of the deltoid muscle. So, characteristic feature of humerus is Deltoid ridge.
- The lower extremity is broad and flat. At its lowest part the articulating surfaces for the bones of the forearm lie.
- The trochlea on the inner side is a pulley-shaped surface for articulation with the ulna and the capitulum on the outer side for the radius. Above the articulating surface for the ulna is a depression in front called the coronoid fossa of the humerus, into which the coronoid process of the ulna received, when the elbow is flexed or bent.
- A large cavity, the olecranon fosses, lies in a similar position at the back of the bone, which receives the olecranon process of the ulna, when the elbow is extended or straight.

(b) Ulna (1) - The ulna is a long bone having a shaft and two extremities. It is the medial bone of the forearm, and is longer than the radius. The head of the ulna is at the lower end.

- The upper extremity of the ulna is strong, thick, and enters into the formation of the elbow joint.
- The trochlear notch of the ulna is formed by these two processes, it articulates with the trochlear surface of the humerus in the formation of the elbow joint. i.e. Hinge joint.
- The radial notch is on the lateral aspect of the upper extremity of the bone, near the coronoid process. The side of the head of the radius articulates with the radial notch as the radius rotates round the ulna, thus forming the superior radio-uinar articulation. The upper ends of forearm bones articulate with each other forming pivot joint.
- The flexors coming from the anterior and the extensors from the posterior surface. The muscles pronating and supinating the forearm are also attached to the shaft.

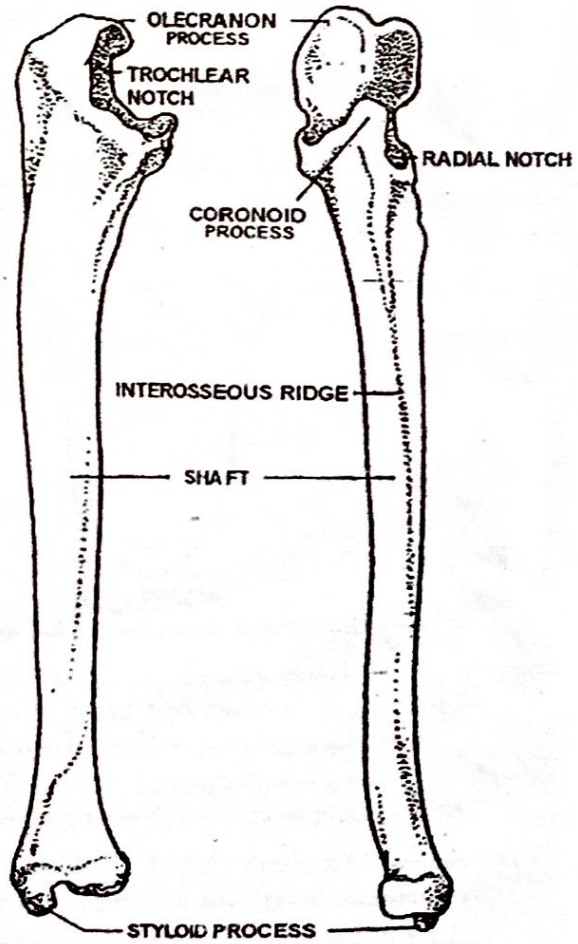


Fig : The left showing enterer and lateral aspects

- The lower extremity is small. Two eminences arise from it. A small rounded eminence, the head of the ulna, articulates with the medial side of the lower extremity of the radius in the formation of the inferior radioulnar joint. A pointed process, the stytoid process, projects downwards from the back of the lower extremity. Ulna is towards the little finger.

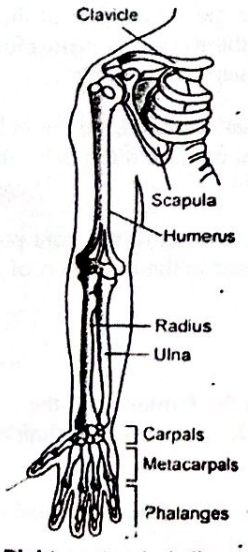
(c) Radius (1) - The radius is the lateral bone of the forearm. It is a long bone with a shaft and two extremities. It is shorter than the ulna. Radius is towards the thumb. Colle's fracture is the break of the lower end of radius, by falling on the outstretched hand. This results in characteristic deformity of wrist and hand.

(d) Carpal (8) - Composed of eight bones arranged in two rows, four bones in each row.

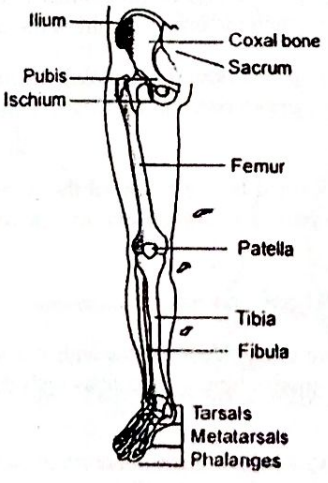
Carpus		
Scaphoid	Boat shaped (most often may be fractured)	Proximal Row
Lunate	Crescentic like a half moon	
Triquetral	Wedge Shaped	Distal/Lower Row
Pisiform	Pea shaped	
Trapezium	Metacarpal of thumb	
Trapezoid	Wedge shaped	
Capitate	Largest carpal	
Hamate	Hook like process arise from it	

(e) Metacarpals (5) - There are five metacarpal bones. Each bone has a shaft and two extremities.The extremity articulating with the carpal bones is called the carpal extremity, and the joint so formed the carpo-metacarpal joint which is gliding joint. The distal extremity articulates with the phalanges and is called the head.

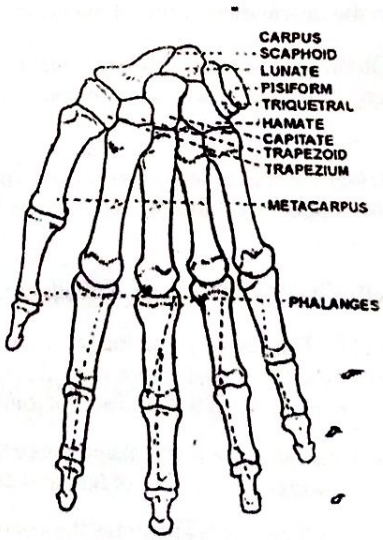
(f) Phalanges (14) - These are also long bones, having a shaft and two extremities. The shaft tapers towards the distal end. There are fourteen phalanges, three in each finger and two in the thumb. The joint between metacarpals and phalanges is ellipsoid or condyloid join



Right pectoral girdle and upper arm (Frontal view)



Right pelvic girdle and lower limb bones (frontal view) (The skeleton of lower limb is attached to the pelvic girdle/hip girdle)



The anterior aspect of the bones of the right wrist and hand

(3) The Pelvic Girdle / Body Pelvis

The pelvic girdle is the means of connection between the trunk and lower extremities. This girdle is formed by part of the axial skeleton – the *sacrum* and coccyx being wedged in between the two innominate bones.

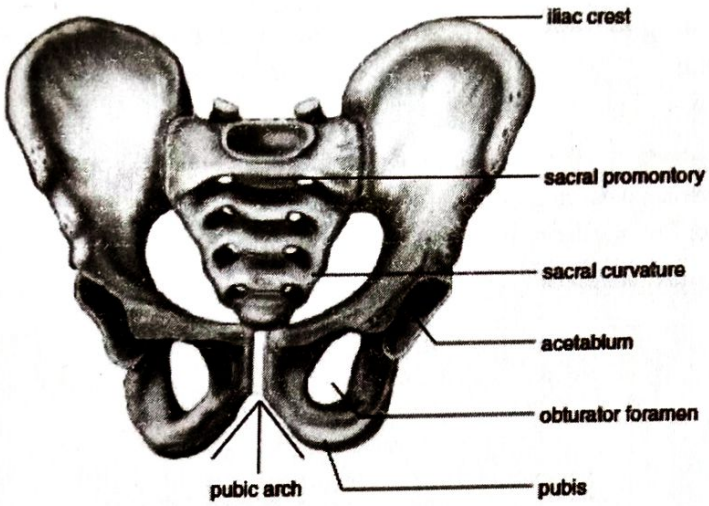


Fig : Male pelvis

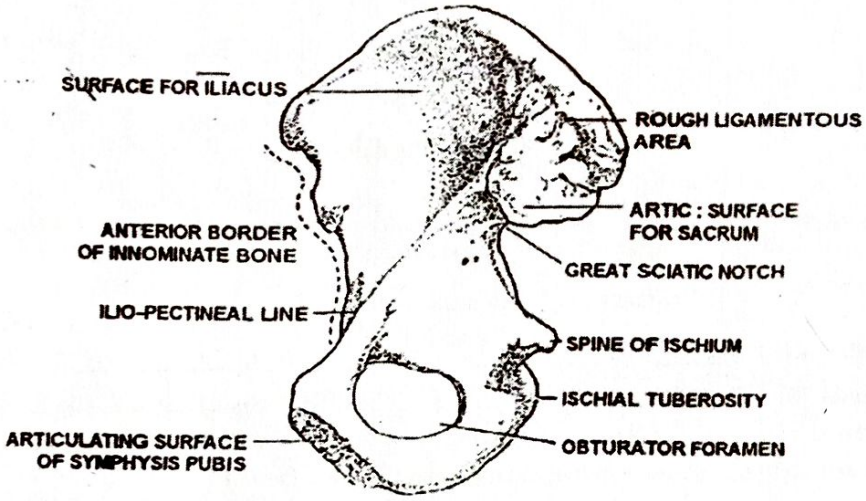
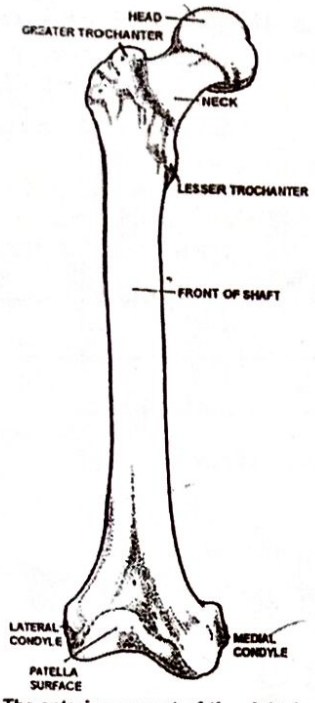


Fig : The Internal surface or right innominate bone

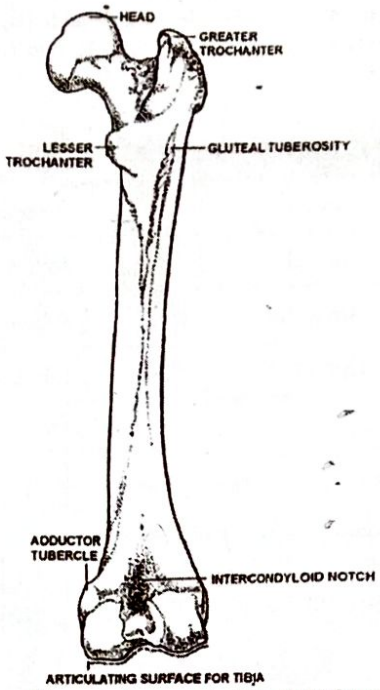
- The Ischium is the thickest and strongest portion of the bone. The *tuberosity* of *the ischium* lies at its lowest point, and on this the trunk rests when sitting. The tuberosity is marked by two facets which give attachment to the hamstring muscles.
- A pointed eminence, the *spine of the ischium,* arises from the back of the bone and marks the lowest part of the sciatic notch. The body of the Ischium forms the posterior boundary of the obturator foramen, from this the ramus passes forwards, to join the descending ramus of the pubis. While sitting the entire weight of the body falls on Ischium.
- The Obturator Foramen is a large oval foramen lying below the acetabulum and bounded, as described, by the pubis and ischium. It is filled in with membrane, and at its upper part the obturator vessels and nerves pass from the pelvis into the thigh
- The Acetabulum is a deep, cup-shaped cavity formed by the union of the three bones; the pubis forms the front parts, the ilium the upper part, and the ischium the back part, The acetabulum articulates with the femur in the formation of the hip joint.

(4) Bones of Hindlimb - It is altogether made up of 30 bones, namely

- Femur (1) - The femur is the longest bone in the body. It articulates with the acetabulum in the formation of the hip joint, and from here the bone inclines medially to the knee, where it articulates with the tibia. It is a long bone with a shaft and two extremities. Hip joint is ball and socket joint.
- The great trochanter is a prominent process of bone which gives attachment to several muscles including the gluteal muscles and are characteristic features of femur. The lesser trochanter is very distinctly raised.
- The intercondylar notch separates the condyles behind. The surfaces of this notch give attachment to the cruciate ligaments of the knee joint. The condyles are separated in front by the patellar surface which extends over the anterior aspect of both condyles; on this surface the patella rests. The tibial surface of the femoral condyles lies below and rests on the upper articulating surface of the condyles of the tibia.
- The femur articulates with three bones, the innominate bone, the tibia, and the patella, but it does not articulate with the fibula.



The anterior aspect of the right femur



The posterior aspect of the right femur

- The patella (knee cap) is a *sesamoid bone* developed in the tendon of the quadriceps extensor muscle. The apex of the patella points downwards.
- Tibia - The lower extremity of tibia enters into the formation of the ankle joint. It is slightly expanded, and is prolonged downwards on the medial side as the medial *malleolus.*
  (i) The lower extremity articulates with the talus, the margins of the bone giving attachment to the ligaments of the joint. The front of the tibia is smooth, and tendons passing to the foot glide over it.
  (ii) The lateral surface of the lower extremity articulates with the fibula at the inferior tibio-fibular joint. The tibia articulates with three bones, the femur, fibula, and talus.

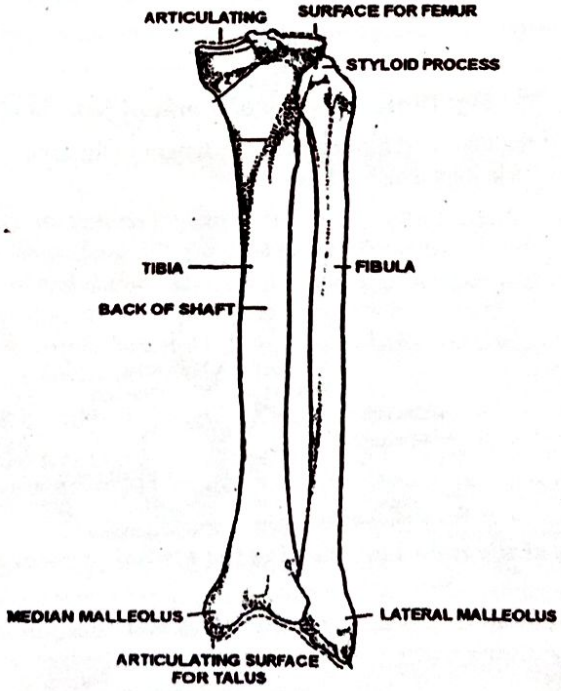


Fig : The posterior aspect of right labia and fibula

- Fibula- The Fibula is the lateral bone of the leg. It is a long bone with a shaft and two extremities. The upper extremity forms the *head,* and articulates with the back of the outer condyle of the tibia, but does not enter into the formation of the knee joint.
  (i) The shaft is slender and deeply embedded in the muscles of the leg, to which it gives numerous attachments. The lower extremity is prolonged downwards as the *lateral malleolus.*
  (ii) A rough depression lies behind the lateral malleolus is called the *malleolar fosse,* provides a surface for the attachment of some of the powerful ligaments of the ankle joint.
  (iii) The *lateral malleolus* extends lower than the medial malleolus of the tibia. Its lateral surface is subcutaneous and its medial surface articulates with the lateral surface of the talus in the formation of the ankle joint.

- Tarsal: There are seven bones known collectively as the *tarsus,* They are short bones, made up of cancellous bone tissue, with a covering of compact tissue. These bones support the weight of the body in standing.

Tarsals	
Calcaneum/Calcis	From heels, largest and strongest
Talus	Articulates with tibia and fibula and form ankle
Cuboid	Anterior, cube shaped
Navicular	A little boat
Cuneiform	I, II, III, wedge shaped

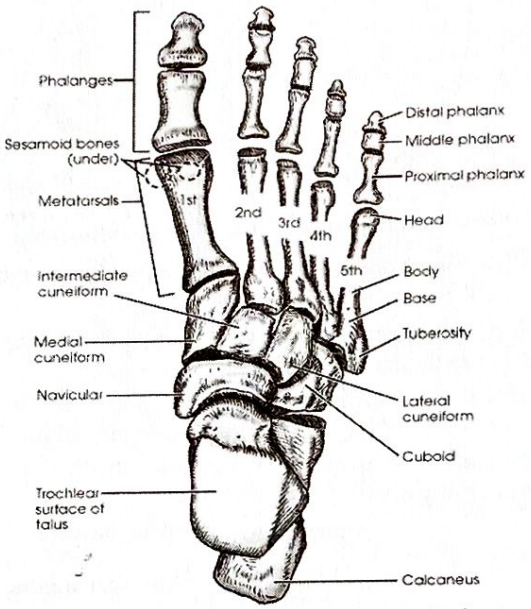


Fig: Dorsal aspects of bones of right foot

- Calcaneum helps to support the talus and it also gives attachment to the spring ligaments, which is important in maintaining the medial arch of the foot. Ankle joint which is hinge joint.

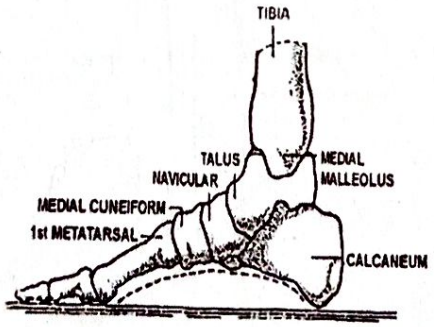
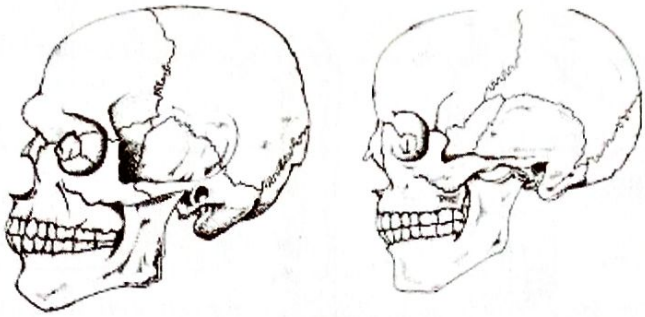


Fig. : The bones of the right foot showing the medial or inner longitudinal arch

General difference is skeleton of male and female

	Male	Female
1.	Shoulder bones are broad	Narrow
2.	Hip bones are narrow	Broad
3.	Pelvic cavity is not wide	Wide, to accommodate growing foetus during pregnancy
4.	Obturator foramen is oval	Triangular
5.	Sacrum is longer and narrow	Shorter and wide
6.	Coccyx is not so movable	More movable



(a) Male (b) Female

Fig : difference between skeleton of male and female

9. Joints

Joints are the structural arrangement where two bones articulate i. e. meet each other. The study of such joints is known as arthrology. There are three principal types of bone joints:

9.1. Fibrous joints or immovable or fixed joints/synarthrosis

These joints are immovable or fixed. They do not show any movement due to the presence of strong and tough white collagenous fibres and there is no joint cavity. These joints include:

(1) **Sutures :** Found between skull bones, articulating bones are held together by white fibrous tissue.
(2) **Gomphoses :** Teeth in mandibles and in maxillary bones.
(3) **Shindylases :** One bone fits into slit in another e.g., ethmoid bone in vomer.

9.2. Cartilaginous Joints or Slightly movable joints / Amphiarthrosis

They are slightly movable joints. Discs of white fibrocartilage, strong but more elastic and compressible than the white fibrous tissue, hold the bones together at the joints between the bodies of the vertebrae, at the symphysis pubis, and between the sternum and ribs. The bones make some movements at such joints through compression of the discs of the cartilage.

9.3. Synovial joints or freely movable joints/Diarthrosis

Synovial joints are of different types depending upon the nature of articulation and degree of movement. Synovial joints are of the following types:

(1) **Ball and socket joints (= Enarthroses) :** The 'head' of one bone fitting with the 'socket' of the other bone and allowing free movement in all planes; e.g. shoulder joint and hip joint.
(2) **Hinge joints (= Ginglynni) :** The perfect joints which allow the movements only in a single plane. e.g. elbow joint, knee joint and ankle joint.
(3) **Pivotal joints (= Rotary joints or rotaria) :** One of the two bones is fixed in its place and bears a peg like process over which rotates the other bone; *e.g.* atlas along with the skull rotating over the odontoid process of axis vertebra in mammals.
(4) **Saddle joints :** It is similar to ball and socket joints but are poorly developed and movements are comparatively less free, e.g. the joint between the metacarpal of thumb with the carpals below.
(5) **Gliding joints :** The joints which permit sliding of the articulating bones on each other; e.g. joint between the zygapophyses of successive vertebrae, and between sternum and clavicle.

9.4 Angular joints (= or ellipsoid or condyloid)

These joints allow the movements in two directions, i.e., side to 'Side and back and forth; e.g., metacarpophalangeal joints.

10. Lever System

In producing movement, bones act as levers and joints function as fulcrum. Lever may be defined as rigid rod that moves around fixed point called fulcrum (F). Lever is acted at two different points by- two different forces the effort (E) which causes movement and the resistance or load (R) which opposes movement. The effort is the force exerted by muscular contraction, whereas the resistance is typically the weight of the body part that is moved. Motion occurs when effort applied to the bone at insertion exceeds resistance.

Functioning of all the three types of levers can be observed in the human skeleton.

10.1. First Class Lever

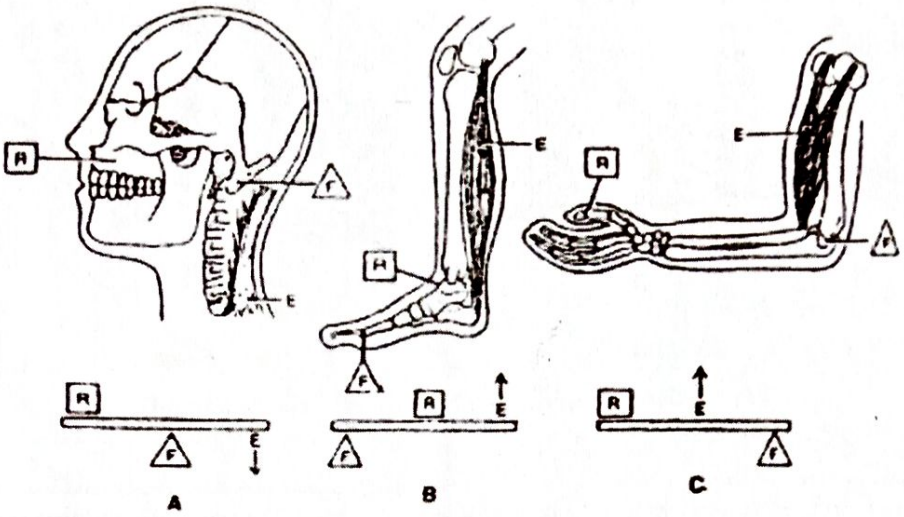
The joint between the first vertebra (atlas) and occipital bone of skull exhibits the example of first class lever in which joint is the fulcrum, contraction of back muscle is the effort, and facial part of the skull on raised head acts as the resistance.

10.2. Second Class Lever

Human body resting on tip of toes is the example of second class lever, as the toe forms the fulcrum and \contracting calf muscle provides effort distally. The body functions as resistance exerting in between the fulcrum and effort.

10.3. Third Class Lever

The flexing movements of the elbow of forearm are based on the principle of third class lever. Here, the elbow-joint acts as fulcrum and the distal part of hand provides resistance The contracting biceps muscles attached near the elbow joint exert the effort in between fulcrum and resistance.



Classes of levers A - First class lever, B - Second Class lever, C - Third class lever

F = fulcrum, E = Point of effort, R = Resistance

11. About Bones

11.1. Types of Bones (on the basis of their formation)

(1) **Cartilaginous or replacing bones or endochondrial bones :** These bones develop from the pre-existing cartilage e.g. humerus, femur.

(2) **Investing or dermal or membrane bone :** These bones-develop in the dermis of the skin as thin plates and sink to get attached over original cartilages e.g. frontal, nasals, vomers, parietals of the skull.

(3) **Sesamoid bones :** These bones are formed in tendons at the joints clavicle e.g. patella (Knee cap), pisciform.

(4) **Visceral bones :** These bones are present in organs and dissociated from the rest of the skeleton. In the heart of some ungulates (ruminates) bones develops in the connective tissue of the cardiac skeleton as OS cordis.

Type of Bone	Example
(i) Long bones	Humerus, radius, ulna, femur, tibia, flbula
(ii) Short bones	Carpals and tarsals
(iii) Flat bones	Skull bones, sternum and ribs
(iv) Irregular bones	Ear ossicles (malleus, incus, stapes) and vertebrae
(v) Sesamoid bones	Patella (knee cap), fabellae and pisciform

11.2. Functions of Bones

Bones have many functions, including the following:

(1) Support: Bones provide a framework for the attachment of muscles and other tissues.

(2) Protection: Bones such as the skull and rib cage protect internal organs from injury.

(3) Movement: Bones enable body movements by acting as levers and points of attachment for muscles.

(4) Mineral storage: Bones serve as a reservoir for calcium and phosphorus, essential minerals for various cellular activities throughout the body.

(5) Blood cell production: The production of blood cells, or hematopoiesis, occurs in the red marrow found within the cavities of certain bones.

(6) Energy storage: Lipids, such as fats, stored in adipose cells of the yellow marrow serve as an energy reservoir.

12. Disorders of Bones, Joints and Muscles

12.1. The rheumatoid arthritis

It is diagnosed by the presence of rheumatoid factor (a type of immunoglobulin IgM). It is the primary symptom of inflammation of synovial membrane. If it is left untreated, then the membrane thickens and synovial fluid increases, exerting pressure that causes pain. The membrane then starts secreting abnormal granules, called pannus, which after accumulating on the surface of the cartilage, cause its erosion. As a result, the fibrous tissues are attached with the bones and become ossified, making the joints immovable heat treatment and physiotherapy pain and inflammation and in extreme cases, replacement of the damaged joints is recommended.

12.2. Osteoarthritis

it is a degenerative joint disease characterized by the degeneration of the articular cartilage and proliferation of new bones. Usually, affected joints are of spine, knees and hands.

12.3. Gouty Arthritis or Gout

It is caused either due to excessive formation of uric acid, or inability to excrete it. It gets deposited in joints as monosodium salt.

12.4. Osteomalacia and Rickets

Osteomalacia, called rickets when it occurs in childhood. In this disorder bones contain insufficient amounts of calcium and phosphorus. The cause of disease is vitamin D deficiency, and an inherited defect.

12.5. Osteoporosis

Osteoporosis is a disease in which bone loses minerals and fibres from its matrix. Individuals taking hydrocortisone for arthritis, allergies, or other disorders are especially prone to bone loss.

12.6. Bursitis

The bursae of joints often become inflamed, a condition known as bursitis. The inflammation can be caused by a physical injury or by constant pressure to the same joint over a long period of time.

12.7. Dislocation

A dislocation is a displacement of the articular surfaces of a joint, it usually involves a damage to the ligaments surrounding the joint. Most dislocations result from falls, blows, or extreme exertion and are most often seen in the joints of the thumb, fingers, knee or shoulder. Symptoms of dislocation include swelling, pain, and loss of motion.

12.8. Sprain and Strains

A sprain is a twisting of a joint without dislocating it, Such an injury causes damage to ligaments and also often damages tendons, muscles, blood vessels, and nerves. Severe sprains are quite painful and require immobilization during the healing process. In contrast to a sprain, a strain is a less severe stretching or twisting of a joint. Muscles and tendons may be stretched and become somewhat painful, but only minor damage is done to the tissues of the joint.

12.9. Myasthenia gravis

Auto immune disorder affecting neuromuscular junction leading to fatigue, weakening and paralysis of skeletal muscle.

12.10. Muscular dystrophy

Progressive degeneration of skeletal muscle mostly due to genetic disorder.

12.11. Tetany

Rapid spasm (wild contraction) in muscle due to low Ca++ in body fluid.

12.12. Fracture

It is breakage of bone, either complete or incomplete.

Types of Fractures:

(1) **Simple or closed fracture :** A fracture breaking the bones into two fully separate parts with little damage to surrounding tissues and no break in the overlying skin.

(2) **Green stick fracture :** A break of the bone in the form of only a crack, with broken parts still holding together.

(3) **Comminuted fracture :** In this fracture, the bone is broken into more than two fragments with some of the fragments losing any connection with blood circulation.

(4) **Compound Open fracture :** The broken ends of the fractured bone protrude through skin.

Important-

Healing of fractures: when a bone is broken callus is formed in large quantities at the site, as the fracture heals this is replaced by true bone which can take the strain of weight and movement.

(1) **Kinesiology:** Study of body movements.

(2) **Longest bone in human body:** Femur.

(3) **Longest bone in frog:** Tibio fibula.

(4) **Largest formen:** Foramen magnum.

(5) **Motor unit:** A single nerve fibre with its supply to muscle fibre (as many as it covers).

Types of Vertebrae

	Type	About Centurm	Examples
1.	Amphicoelous	Centrum concave on both sides	e.g. Cartilaginous fishes, 8th vertebra of frog
2.	Procoelous	Centrum concave anteriorly and convex posteriorly	e.g., Typical vertebra of frog and vertebrae of lizard
3.	Opisthocoelous	Centrum convex anteriorly and concave posteriorly	e.g. Vertebrae of Urodela (Tailed Amphibia)
4.	Acoelous	Centrum without concavity on either sides	e.g., IX vertebra of frog
5.	Heterocoelous	Anterior face of the centrum concave from side to side and convex from above downwards and posterior surface is just reverse or it.	e.g., Cervical Vertebrae of fowl
6.	Amphiplatyan	Centrum flat on both sides	e.g., Vertebrae of mammals

20. Locomotion and Movement – Multiple Choice Questions

1. Axial skeleton

1. The bony sockets of the jaws in which the teeth are implanted, are known as
(a) Alveolus (b) Fossae
(c) Dentaries (d) Thecae

2. Number of cranial nerves in mammal are
(a) 10 pairs (b) 8 pairs
(c) 12 pairs (d) 16 pairs

3. The opening at the base of the skull for the spinal cord is called
(a) Foramen Magnum (b) Foramen of Monro
(c) Obturator foramen (d) Foramen of Magendie

4. 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
(e) 5, 12, 7, 1, 1

5. Lumbar vertebra are found in
(a) Neck region (b) Abdominal region
(c) Hip region (d) Thorax

6. What is correct about human body
(a) There are 5 vertebras in the neck
(b) Brain box is made up of 4 bones
(c) There are 15 pairs of ribs
(d) There are 12 thoracic vertebras

7. In mammals, the largest vertebra is
(a) Cervical (b) Lumbar
(c) Caudal (d) Sacral

8. How many ribs are present in human beings
(a) 6 pairs (b) 9 pairs
(c) 12 pairs (d) 15 pairs

9. The smallest bone in rabbit's or man's skeleton is
(a) Nasal (b) Stapes
(c) Patella (d) Palatine

10. In man the thoracic basket is composed of
(a) Ribs and thoracic vertebrae
(b) Ribs and sternum
(c) Ribs, sternum and vertebrae
(d) Ribs, sternum and thoracic vertebrae

11. The last two pairs of ribs are named floating ribs because
(a) Their sternal parts are attached to the sternum directly
(b) Their sternal parts are attached on the 7^{th} pair of ribs
(c) Their sternal parts remain free and do not even reach the sternum
(d) They float in the body cavity

12. In man the axial skeleton is made up of
(a) 80 bones (b) 100 bones
(c) 103 bones (d) 106 bones

13. Human vertebral column consists of 33 vertebrae and ____ bones
(a) 33 (b) 26
(c) 27 (d) 29

14. Intervertebral disc is found in the vertebral column of
(a) Birds (b) Reptiles
(c) Mammals (d) Amphibians

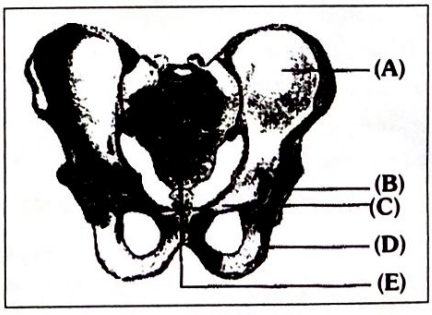
15. Which one of the following is showing the correct sequential order of vertebrae in the vertebral column of human being
(a) Cervical – lumbar – thoracic – sacral – coccygeal
(b) Cervical – thoracic – sacral – lumbar – coccygeal
(c) Cervical – sacral – thoracic – lumbar – coccygeal
(d) Cervical – thoracic – lumbar – sacral – coccygeal

16. The membranous areas between the cranial bones of the foetal skull are called
(a) Areolas (b) Foramina
(c) Sutures (d) Fontanelle

17. Skull of mammals is
(a) Amphicondylous (b) Condylous
(c) Dicondylous (d) Monocondylous

18. Nucleus pulposus is
(a) A type of special cell found in myelin sheath of a nerve cell of vertebrate
(b) A depression for pituitary is found in mammalian skull
(c) A large nucleus found in Schwann cells of nerve fibre
(d) A remain of embryonic notochord found in the central portion of inter-vertebral discs of vertebrae of mammals

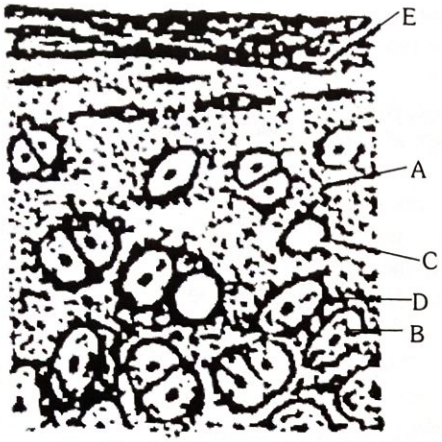
19. In the pelvic girdle of man A, B, C, D and E respectively represents



(a) A – pubis, B – acetabulum, C – ilium, D – ischium, E – pubic symphysis
(b) A – ilium, B – acetabulum, C – pubis, D – ischium, E – pubic symphysis
(c) A – ischium, B – acetabulum, C – pubis, D – ilium, E – pubic symphysis
(d) A – ilium, B – pubis, C – acetabulum, D – pubic symphysis, E – ischium
(e) A – ilium, B – acetabulum, C – pubic symphysis, D – ischium, E – pubis

20. Which bone during its development is not a cartilage
(a) Malleus (b) Humerus
(c) Incus (d) Nasal

21. In the diagram of section of Hyaline cartilage, the different parts have been indicated by alphabets; choose the answer in which these alphabets correctly match with the parts they indicate



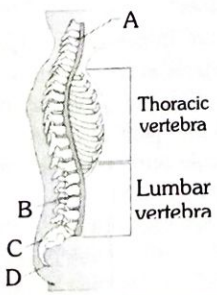
(a) A = perichondrium B= Chondrocyte
C= Lacuna D= Capsular matrix
E= Chondrin
(b) A= Capsular matrix B= Chondrocyte
C= Lacuna D= Perichondrium
E= Chondrin
(c) A= Chondrin B= Chondrocyte
C= Lacuna D= Capsular matrix
E= Perichondrium
(d) A= Chondrin B= Lacuna
C= Chondrocyte D= Capsular matrix
D= Perichondrium

22. The bones that form a bridge between the cranium and the upper jaw dorsally and ventrally, are respectively
(a) Squamosal and pterygoid
(b) Quadratojugal and pro-otic
(c) Both the exo-occipitals
(d) Maxillary and quadrate

23. Axis vertebra of a mammal differs from atlas in
(a) Absence of centrum
(b) Presence of centrum
(c) Presence of central canal
(d) Presence of odontoid process

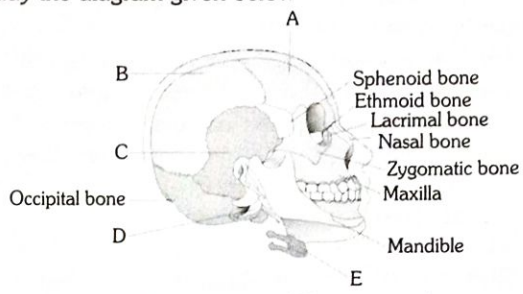
24. A vertebra has a convexity both in front and behind it. It is called
(a) Procoelous (b) Amphicoelous
(c) Acoelous (d) Amphiplatyan

25. The given figure indicates vertebral column of human (right lateral view). Parts labeled as A, B, C and D respectively represent



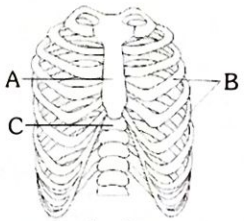
(a) Cervical vertebra, intervertebral disc, Sacrum and Lumbar vertebra
(b) Cervical vertebra, Interventebral disc, Lumbar vertebra and Coccyx
(c) Cervical vertebra, intervertebral disc, Sacrum and Coccyx
(d) Lumbar vertebra, intervertebral disc, Sacrum and Coccyx

26. Study the diagram given below



Parts labeled as A, B, C, D and E respectively represent
(a) Parietal bone, Frontal bone, Temporal bone, Occipital condyle and Hyoid bone
(b) Frontal bone, Parietal bone, Temporal bone, Hyoid bone and Occipital condyle
(c) Frontal bone, Temporal bone, Parietal bone, Occipital condyle and Hyoid bone
(d) Frontal bone, Parietal bone, Temporal bone, Occipital condyle and Hyoid bone

27. The given figure represents rib cage. Identify A, B and C respectively



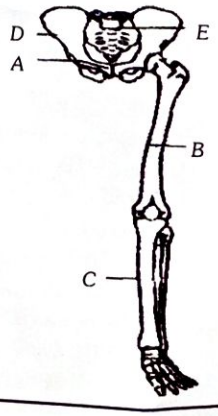
(a) Tarsal, ribs, vertebral column
(b) Scapula, ribs, vertebral column
(c) Sternum, ribs, vertebral column
(d) Coccyx, ribs, vertebral column

28. Which of the following bones are cartilaginous
(a) Exoccipital and frontoparietal
(b) Exoccipital and spenethmoid
(c) Exoccipital and parasphenoid
(d) Frontoparietal only

2. Appendicular skeleton

1. The longest bone of the human body is
(a) Humerus (b) Tibia
(c) Vertebra (d) Femur
(e) Incus

2. Consider the diagram given below



Parts labeled as 'A', 'B', 'C', 'D', and 'E' respectively indicates
(a) Femur, Ilium, Tibia, Pubis and Sacrum
(b) Pubis, Tibia, Femur, Ilium and Sacrum
(c) Ilium, Femur, Tibia, Pubis and Sacrum
(d) Tibia, Pubis, Femur, Ilium and Sacrum
(e) Pubis, Femur, Tibia, Ilium and Sacrum

3. Outer covering of cartilage is
(a) Perichondrium (b) Periosteum
(c) Endo-osteum (d) Peritoneum

4. Symphysis contains
(a) Hyaline cartilage (b) Fibrous cartilage
(c) Calcified cartilage (d) None of these

5. The pectoral and pelvic girdles and the bones of limb form
(a) Axial skeleton (b) Appendicular skeleton
(c) Visceral skeleton (d) Outer skeleton

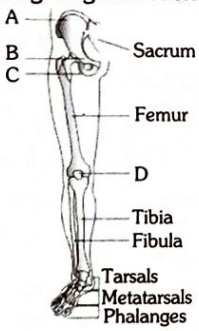
6. Number of bones in human body is
(a) 260 (b) 206
(c) 306 (d) 203

7. Pectoral girdle constitute
(a) Scapula and Clavicle (b) Radius and Ulna
(c) Ilium and Ischium (d) Maxilla and mandible

8. Phallangeal formula of hand of man is
(a) 1, 2, 2, 2, 2 (b) 2, 1, 1, 1, 1
(c) 2, 3, 3, 3, 3 (d) 2, 3, 3, 2, 2

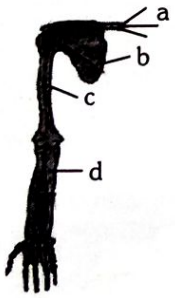
9. Haversian canals are found in
(a) Spinal cord (b) Brain
(c) Long bones (d) Sponge

10. Consider the following diagram. Identify A, B, C and D



(a) A - Ilium, B - Pubis, C - Ischium, D - Patella
(b) A - Ilium, B - Pubis, C - Patella, D - Ischium
(c) A - Ischium, B - Pubis, C - Ilium, D - Patella
(d) A - Pubis, B - Ilium, C - Ischium, D – Patella

11. Which option is correct for the region labeled as a, b, c and d in the given diagram



(a) a – Clavicle, b – Scapula, c – Humerus, d – Ulna
(b) a – Scapula, b – Clavicle, c – Humerus, d – Ulna
(c) a – Clavicle, b – Ulna, c – Radius, d – Humerus
(d) a – Clavicle, b – Glenoid cavity, c – Radius, d – Ulna

12. Which cartilage is present at the joints of long bones
(a) Calcified (b) Hyaline
(c) Elastic (d) Fibrous

13. Which one of the following is not a disorder of bone
(a) Arthritis (b) Osteoporosis
(c) Rickets (d) Atherosclerosis

14. 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

15. Obturator foramen is present in
(a) Skull (b) Radio-ulna
(c) Pelvic girdle (d) Quadrate

16. Synsacrum of fowl is consist of about
(a) 29 vertebrae (b) 3 vertebrae
(c) 16 vertebrae (d) Sigel vertebrae

17. The pelvic girdle of birds is attached to a complex structure formed by the fusion of last thoracic, all lumbar and first five caudal vertebras. This structure is called
(a) Synsacrum (b) Symphysis
(c) Synkaryon (d) Sympelvis

18. Deltoid ridge is found in which one of the following bones
(a) Radius (b) Tibia
(c) Femur (d) Humerus

19. Which of the following is absent in the segment of cockroach's leg
(a) Fibula (b) Coxa
(c) Tibia (d) Femur

20. What is the difference between the bone of rabbit and that of frog
(a) In the bone of rabbit haversian canal is found
(b) Yellow marrow is found
(c) Osteocytes are of different types
(d) Bone of frog is spongy

21. The Paget's disease is caused by
(a) Prolonged deficiency of vitamin D in adults
(b) Abnormal bone resorption by abnormal osteoclasts
(c) Excess alkaline phosphatase
(d) Excess production and abnormal organization of collagen

22. Volkman's canals connect
(a) Haversian canal with matrix
(b) Haversian canal with Haversian canal
(c) Haversian canal with marrow cavity
(d) Lacunae to lacunae

3. Joints

1. Hinge joint is present between
(a) Humerus and pectoral girdle
(b) Femur and acetabulum
(c) Humerus and radio-ulna
(d) Femur and pelvic girdle

2. The example of pivot joint is
(a) Hip joints
(b) Metacarpophalangeal joints
(c) Ankle joints
(d) Radioulnar joints

3. The gliding joints are important for gliding movements. One example of such a joint is between the
(a) Zygapophysis of adjacent vertebrae
(b) Humerus and the glenoid cavity
(c) Occipital condyle and odontoid process
(d) Femur and tibia-fibula

4. The joint between the lower jaw and the skull is
(a) Gliding (b) Hinge
(c) Perfect joint (d) Saddle joint

5. When the head of humerus fits into glenoid cavity, joint is
(a) Ball and socket joint (b) Hinge joint
(c) Pivot joint (d) Saddle joint

6. The end of long bones are connected to each other by
(a) Muscles (b) Tendons
(c) Ligaments (d) Cartilage

7. Synovial joints is
(a) Pivot joint (b) Hinge joint
(c) Ball and socket joint (d) All of these

8. Tendon is a structure which connects
(a) A bone with another bone (b) A nerve with a muscle
(c) A muscle with a bone (d) A muscle with a muscle

9. Match the following and mark the correct option

Column I		Column II	
A.	Sternum	i.	Synovial fluid
B.	Glenoid cavity	ii.	Vertebrae
C.	Freely movable joint	iii.	Pectoral girdle
D.	Cartilaginous 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-iii

10. Fabellae bones are associated with
(a) Angular joint (b) Elbow joint
(c) Knee joint (d) Neck joint

4. Muscles

1. Sarcolemma is a membrane found over in
(a) Nerve fibre (b) Cardiac muscle
(c) Skeletal muscle fibre (d) Heart

2. Ensheathing of muscles is called
(a) Fascia (b) Peritoneum
(c) Ligament (d) Tendon

3. The generation of excitation-contraction coupling involves all the following events except
(a) Generation of end-plate potential
(b) Release of calcium from troponin
(c) Formation of cross-linkages between actin and myosin
(d) Hydrolysis of ATP to ADP

4. The muscle fatigue occurs due to accumulation of
(a) Pyruvic acid (b) ATP
(c) Lactic acid (d) Eroman CO_2

5. The dark bands in a myofibril are due to overlapping of
(a) Only thick bands
(b) Only thin bands
(c) Both thick and thin bands
(d) None of the above

6. The total number of muscles in the body of man is
(a) 409 (b) 439
(c) 539 (d) 639

7. Major protein in the thick filament of skeletal muscle fibre is
(a) Tropomyosin (b) Myosin
(c) Actin (d) Troponin

8. Muscles of the heart are
(a) Voluntary, striated (b) Voluntary, smooth
(c) Involuntary, striated (d) Involuntary, smooth

9. The biceps and triceps muscles are found in
(a) Fore arm (b) Shank
(c) Shoulder (d) Upper arm

10. During muscle contraction
(a) Chemical energy is changed into electrical energy
(b) Chemical energy is changed into mechanical energy
(c) Chemical energy is changed into physical energy
(d) Mechanical energy is changed into chemical energy

11. 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

12. Smallest muscle in the human body
(a) Sartorius (b) Spinal muscle
(c) Stapes (d) Stapedius

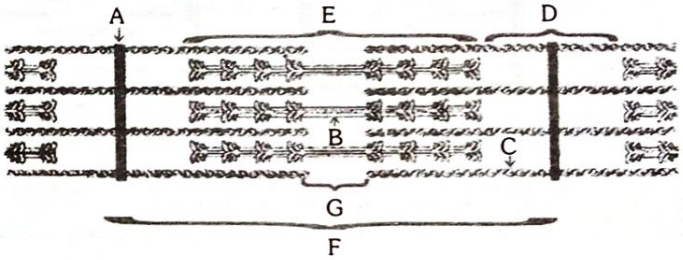
13. Standing on tip toe is an example of
(a) Elevation (b) Flexion
(c) Extension (d) Retraction

14. Latissimus dorsi muscles are
(a) Muscles of fore arm (b) Muscles of lower jaw
(c) Muscles of the chest (d) Muscles of the shoulder

15. See the figure of actin (thin) filaments. Identify A, B and C

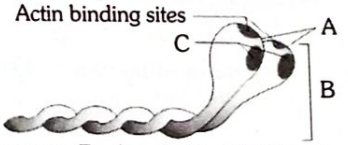
(a) A - Troponin, B - Tropomyosin, C - F - actin
(b) A - Troponin, B - Tropomyosin, C - Myosin
(c) A - Troponin, B - Myosin, C - F - Tropomyosin
(d) A - Tropomyosin, B - Troponin, C - F – actin

16. Select the letter from the figure that most appropriately corresponds to the structure



I. A – band II. II. band
III. Sarcomere IV. H - zone
V. Myosin
VI. Actin, Troponin, Tropomyosin
VII. Z- line
(a) I - E, II - D, III - F, IV - A, V - B, VI - C, VII - G
(b) I - E, II - D, III - F, IV - G, V - C, VI - A, VII - B
(c) I - E, II - D, III - C, IV - G, V - B, VI - A, VII - F
(d) I - E, II - D, III - F, IV - G, V - B, VI - C, VII – A

17. The given figure is associated with myosin monomer (meromyosin). Identify A to C



(a) A - cross arm, B - head, C - ATP binding sites
(b) A - head, B - cross arm, C - ATP binding sites
(c) A - head, B - cross arm, C - Ca^{+2} binding sites
(d) A - head, B - cross arm, C - GTP binding sites

18. Match the following and mark the correct option

Column I		Column II	
A.	Fast muscle fibres	I.	Myoglobin
B.	Slow muscle fibres	II.	Lactic acid
C.	Actin filament	III.	Contractile unit
D.	Sarcomere	IV.	I-band

Options:

(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

19. See the following figure describing muscle contraction

Identify A, B, C, D and E

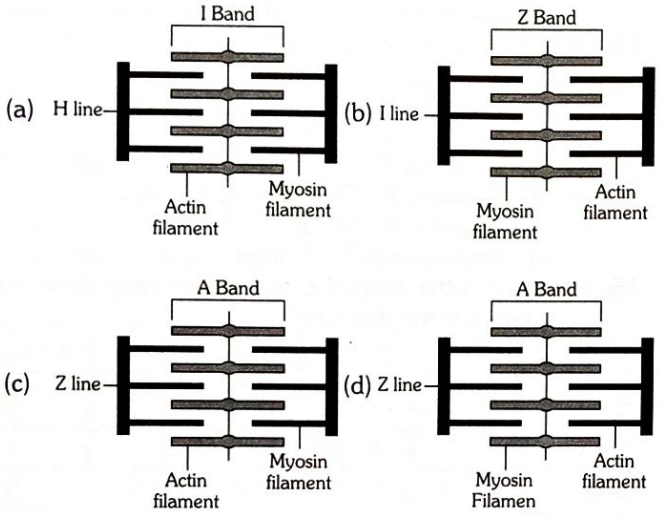
(a) A - Cross bridge B - Cross bridge formation, C - Sliding/ rotation D - ADP, E - Breaking of cross bridge

(b) A - Cross bridge, B - Breaking of cross bridge, C - Sliding rotation, D - Cross bridge formation, E - AMP

(c) A - Cross bridge, B - Cross bridge formation, C - Sliding/ rotation, D - Breaking of cross bridge, E - ATP

(d) A - Cross bridge, B - Cross bridge formation, C Breaking of cross bridge, D - Sliding (rotation), E – ATP

20. Which of the following sarcomeres is labeled correctly



5. NEET - AIMPMT / CBSC - PMT

1. Bone marrow is largely composed of **[1990]**

(a) Periosteum and osteoblast

(b) Adipose tissue and blood vessels

(c) Yellow and elastic tissue

(d) Cartilage and elastic tissue

2. Which one of the following items gives its correct total number **[2008]**

(a) Types of diabetes – 3

(b) Cervical vertebrae in humans – 8

(c) Floating ribs in humans – 4

(d) Amino acids found in proteins – 16

3. The number of floating ribs in human body is **[1995; 2000]**

(a) 6 pairs (b) 3 pairs

(c) 5 pairs (d) 2 pairs

4. The vertebrae which bears the whole weight of the skull is **[1993]**

(a) Axis (b) Sacral

(c) Cervical (d) Atlas

5. Special fibrous joint occurring exclusively in skull which is the tightest type of joint is **[1993]**

(a) Suspensorium (b) Suspensory ligament

(c) Suture (d) Occipital

6. The number of cervical vertebrae in camels is **[2002]**

(a) Same as that in rabbit (b) Same as that in frog

(c) Less than that in giraffe (d) More than that in horse

7. Which one of the following is the correct description of a certain part of a normal human skeleton **[2010]**

(a) Parietal bone and the temporal bone of the skull are joined by fibrous joint

(b) First vertebra is axis which articulates with the occipital condyles

(c) The 9th and 10th pairs of ribs are called the floating ribs

(d) Glenoid cavity is a depression to which the thigh bone articulates

8. In birds, some of the vertebrae are fused to form **[2001; 2001]**

(a) Keel (b) Synsacrum

(c) Syncytium (d) Furcula

9. Bone related to skull is **[2000]**

(a) Atlas (b) Coracoids

(c) Arytenoids (d) Pterygoid

10. Typically all mammals have seven cervical vertebrae except in **[1990]**

(a) Elephant (b) Man

(c) Kangaroo (d) Sea cow

11. The vertebrae in birds are mostly **[2000; 2001]**

(a) Procoelous (b) Amphicoelous

(c) Opisthocoelous (d) Heterocoelous

12. In the human body, which one of the following is anatomically correct **[2007]**

(a) Floating ribs – 2 pairs

(b) Collarbones – 3 pairs

(c) Salivary glands – 1 pair

(d) Cranial nerves – 10 pairs

13. Osteoporosis an age – related disease of skeletal system may occur due to **[2016]**

(a) Immune disorder affecting neuromuscular junction leading to fatigue

(b) High concentration of Ca^{2+} and Na^{+}

(c) Decreased level of oestrogen

(d) Accumulation of uric acid leading to inflammation of joints

14. Out of X pairs of ribs in human only y pairs are true ribs. Select the option that correctly represent values of X and Y and provides their explaination **[2017]**

(a) $X = 12,\ Y = 5$ True ribs are attached dorsally to vertebral column and sternum on the two ends

(b) $X = 24,\ Y = 2$ The true ribs are dorsally attached to vertebral column but are free on venteral side

(c) $X = 24,\ Y = 12$ True ribs are dorsally attached to vertebral column but are free on venteral side

(d) $X = 12,\ Y = 7$ True ribs are attached dorsally to vertebral column and ventrally to sternum

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

(a) Cartilaginous joint (b) Saddle joint

(c) Synovial joint (d) Fibrous joint

16. Which one of the following is the correct matching of three items and their grouping category **[2009]**

(a) Malleus, incus, cochlea - Ear ossicles

(b) Ilium, ischium, pubis - Coxal bones of pelvic girdle

(c) Actin, myosin, rhodopsin - Muscle proteins

(d) Cytosine, uracil, thiamine - Pyrimidines

17. A shallow depression in the scapula which receives the head of the upper arm bone is known as the **[1993]**

(a) Acetabulum (b) Neural arch

(c) Glenoid cavity (d) None of the above

18. The protein present in the bones is known as **[1992]**

(a) Chondrin (b) Ossein

(c) Sclero protein (d) Globulin

19. Which one of the following component is the part of pectoral girdle [1994; 1994; 2007]
(a) Acetabulum (b) Hilum
(c) Sternum (d) Glenoid cavity

20. The total number of bones in your right arm is [2004]

Or

Total number of bones in the hind limb of a man is
(a) 30 (b) 32
(c) 35 (d) 40

21. An acromion process is characteristically found in rabbit/mammals in [1994, 95; 2005]
(a) Pelvic girdle (b) Pectoral girdle
(c) Skull (d) Sternum

22. Pelvic girdle of rabbit consist of [2002; 2005]

Or

The coxal of the pelvic girdle is formed by the fusion of [2009; 2011]

Or

In mammals, each half of pelvic girdle or obturator foramen in pelvic girdle is formed by [1998, 2013; 2013]
(a) Ilium, ischium and pubis
(b) Ilium, ischium and coracoid
(c) Coracoid, scapula and clavicle
(d) Ilium, coracoid and scapula

23. Three of the following pairs of the human skeletal parts are correctly matched with their respective inclusive skeletal category and one pair is not matched. Identify the non-matching pair [2011]

	Pairs of skeletal parts	Category
(a)	Humerus and ulna	Appendicular skeleton
(b)	Malleus and stapes	Ear ossicles
(c)	Sternum and Ribs	Axial skeleton
(d)	Clavicle and Glenoid cavity	Pelvic girdle

24. Elbow joint is an example of [2009]
(a) Pivot joint (b) Hinge joint
(c) Gliding joint (d) Ball and socket joint

25. The type of joint between the human skull bones is [1994; 1999]
(a) Synarthrodial joint (b) Synovial joint
(c) Cartilaginous joint (d) Fibrous joint

26. Joint between femur and pelvic girdle is [1995; 2001; 2003]
(a) Pivotal (b) Ball and socket
(c) Hinge (d) Saddle

27. Articulation of the atlas with the axis is an example of [1999]
(a) Hinge joint (b) Ball and socket joint
(c) Gliding joint (d) Pivot joint

28. Which of the following joints would allow no movement [2015]
(a) Cartilaginous joint (b) Synovial joint
(c) Ball and socket joint (d) Fibrous joint

29. The characteristics and an example of a synovial joint in humans is [2011; 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

30. Joint between ribs and sternum is [2000]
(a) Cartilaginous (b) Angular joint
(c) Fibrous joint (d) Gliding joint

31. Which of the following pairs, is correctly matched [2005]
(a) Hinge joint – Between vertebrae
(b) Gliding joint – Between zygapophysis of the successive vertebrae
(c) Cartilaginous joint – Skull bones
(d) Fibrous joint – Between phalanges

32. ATPase enzyme needed for muscle contraction is located [2004]
(a) Myosin (b) Actin
(c) Actinin (d) Troponin

33. Electron microscopic studies of the sarcomeres have revealed that during muscle contraction [2013]
(a) The width of A–band remains constant
(b) The width of the H–zone becomes smaller
(c) The width of I–band increases
(d) The diameter of the fibre increases

34. Intercostal muscles are found in [1988]
(a) Fingers (b) Thoracic ribs
(c) Femur (d) Radius-ulna

35. The H-zone in the skeletal muscle fibre is due to [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

36. Which of the following is not a function of the skeletal system [2015]
(a) Storage of minerals
(b) Production of body heat
(c) Locomotion
(d) Production of erythrocytes

37. Identify the tissue shown in the diagram and match with its characteristics and its location [2013]

(a) Smooth muscles, show branching, found in the walls of the heart
(b) Cardiac muscles, unbranched muscles, found in the walls of the heart
(c) Striated muscles, tapering at both-ends, attached with the bones of the ribs
(d) Skeletal muscle, shows striations and closely attached with the bones of the limbs

38. Select the correct statement with respect to disorders of muscles in humans [2013]
(a) Failure of neuromuscular transmission in myasthenia gravis can prevent normal swallowing
(b) Accumulation of urea and creatine in the joints cause their inflammation
(c) An overdose of vitamin D causes osteoporosis
(d) Rapid contractions of skeletal muscles causes muscle dystrophy

39. Select the correct statement regarding the specific disorder of muscular or skeletal system **[2012]**

(a) Muscular dystrophy-age related shortening of muscles

(b) Osteoporosis-decrease in bone mass and higher chances of fractures with advancing age

(c) Myasthenia gravis–auto immune disorder which inhibits sliding of myosin filaments

(d) Gout-inflammation of joints due to extra deposition of calcium

40. Calcium is important in skeletal muscle contraction because it **[2018]**

(a) Prevents the formation of bonds between the myosin cross bridges and the actin filament

(b) Detaches the myosin head from the actin filament

(c) Activates the myosin ATPase by binding to it

(d) Binds to troponin to remove the masking of active sites on actin for myosin

6. AIIMS

1. In human beings the cranium is formed by **[2000; 2000; 2010]**

(a) Eight bones of which two are paired

(b) Fourteen bones of which six are paired

(c) Ten bones of which two are paired

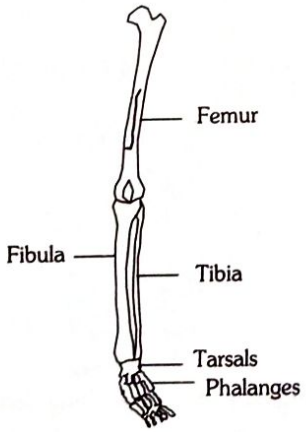
(d) Twelve bones of which four are paired

2. Patella, the knee cap is the example of **[2001; 2003; 2004; 2007]**

(a) Cartilage gland (b) Replacing bone

(c) Sesamoid bone (d) None of the above

3. Given below is a diagram of the left human hindlimb as seen from front. It has certain mistakes in labeling. Two of the wrongly labeled bones are **[2005]**



(a) Tibia and tarsals (b) Femur and fibula

(c) Fibula and phalanges (d) Tarsals and femur

4. Epiphyseal discs, which are present at the ends of long bones are responsible for **[1993]**

(a) Bone elongation

(b) Growth of thickness of the bone

(c) Remodelling the shape of bone

(d) Formation of Haversian canal

5. Which of the following is not found in birds **[1999]**

(a) Pectoral girdle (b) Pelvic girdle

(c) Hind limb (d) Fore limb

6. Astragalus and calcaneum are present in **[2001]**

(a) Fore limb (b) Hind limb

(c) Scapula (d) Clavicle

7. What is sprain **[1993]**

(a) More pulling of tendon (b) Less pulling of tendon

(c) More pulling of ligament (d) Less pulling of ligament

8. The immediate regeneration of ATP used up during muscle contraction is facilitated by **[1992]**

(a) Glucose (b) Glycogen

(c) Lactic acid (d) Creatine phosphate

7. Assertion and Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion

(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion

(c) If the assertion is true but the reason is false

(d) If both the assertion and reason are false

(e) If the assertion is false but reason is true

1. Assertion : Ball and socket joints are the most mobile joints

Reason : Synovial fluid is present here.

2. Assertion : Triceps is said to be an extensor muscle for elbow joint.

Reason : Triceps relaxes during extension of forearm at the elbow joint.