UNIT – III HUMAN ANATOMY AND PHYSIOLOGY

IIIA - THE MUSCULO- SKELETAL SYSTEM

Very Short Answer Questions

1. What is a 'motor unit' with reference to muscle and nerve?

A. Motor unit is composed with a motor neuron and set of muscle fibres innervated by all the telodendrites.

2. What is triad system?

A. In a skeletal muscle each transverse tubule (T – tubule) is flanked on either side by several terminal cisternae of the sarcoplasmic reticulum.

T – Tubule and the two terminal cisternae at its sides form the triad system. Most of the stored calcium of the sarcocyte is present in the cisternae.

3. Write the difference between actin and myosin?

A.

Actin	Myosin
1. It is a thin contractile protein 2. It is present in light band/ an isotropic band 3. Each actin filament is made of two 'F' actin molecules helically would around each other. Each 'F' actin is a polymer of monomeric 'G' (globular) actin molecules.	1. Myosin is a thick contractile protein. It is a motor protein which converts chemical energy in the ATP into mechanical energy. 2. It is present in dark band/ anisotropic band 3. Each myosin is made up of monomeric protein called meromyosins. Each meromyosin has two parts namely a globular head with a short arm (or) neck and a tail.

4. Distinguish between red muscle fibres and white muscle fibres?

A.

Red Muscle Fibers	White Muscle Fibers
1. They are red in colour as they contain large amount of myoglobin	1. They are white/pale in colour as they contain less quantity of myoglobin
2. They contain plenty of mitochondria	2. They contain few numbers of mitochondria but more amount of sarcoplasmic reticulum.
3. As mitochondria utilize large amount of oxygen for the production of ATP, these muscles are known as Aerobic muscles.	3. Depend on anaerobic process for the release of energy
4. They carry out slow and sustained contractions for a long period	4. They carry out high intensity contractions for short duration

Short Answer Questions

1. Write a short note on sliding filament theory of muscle contraction?

A. Sliding filament theory explains the process of muscle contraction.

It was proposed by Jean Hanson and Hugh Huxley. It states that contraction of a muscle fiber takes place by the sliding of the thin filaments over/in between the thick filaments, which shortens the myofibril.

Each muscle fiber contains special contractile proteins called actin and myosin.

Actin is the thin contractile protein present in the light band and is known as 'I' band, where as myosin is thick contractile protein present in dark band and is known as 'A' band. There is an elastic fiber called 'Z' line that bisects each 'I' band.

The central part of the thick filament that is not overlapped by the thin filament is known as 'H' zone.

During the muscle contraction, myosin heads bind to the exposed active sites on the actin molecules and form cross bridge. It shows power stroke.

As a result the thin filaments are pulled towards the centre of the A band.

The 'Z' line attached to the action filaments is also pulled leading to the shortening of the sarcomere i.e., contraction.

During the shortening of the muscle the 'I' bands get reduced in length, whereas the 'A' bands retain their length and 'H' zone disappears.

2. Describe the important steps in muscle contraction?

A. During skeletal muscle contraction, the thin filament slides over the thick filament by repeated binding and releases myosin along the filament.

Important steps in muscle contraction:

Step 1: Muscle contraction is initiated by signals that travel along the axon and reach the neuromuscular junction. As a result, acetylcholine is released into the synaptic cleft by generating an action potential in sarcolemma.

Step 2: The generation of this action potential releases calcium ions from sarcoplasmic reticulum in the sarcoplasm.

Step 3: The increased calcium ions in the sarcoplasm causes the troponin and tropomyosin complexed to move away from the active sites of actin molecules. Now the active sites are

exposed and this allows myosin heads to attach to this site and forms cross bridges by utilizing energy from ATP hydrolysis.

Step 4: The actin filaments are pulled. As a result, the 'H' zone reduces. It causes the contraction of the muscle occurs.

Step 5: After muscle contraction, the myosin head pulls the actin filament and releases ADP along with phosphate. ATP molecules bind and detach myosin and the cross bridges are broken and decrease the calcium ions contraction. As a result masking the actin filaments and leading to muscle relaxation.

3. Describe the structure of a skeletal muscle?

A. 1) Skeletal muscle is made up of number of muscle bundles (or) fascicles. The fascicles are held together by a common collagenous connective tissue layer called fascia.

2) Each fascicle contains a number of cylindrical muscle fibers. Each muscle fiber is lined by the plasma membrane called sarcolemma enclosing the sarcoplasm.

3) Skeletal muscle fiber is a syncytium/multinucleate as each fiber is formed by fusion of many embryonic, mononucleate myoblasts. It is characteristically peripheral nuclei.

4) The endoplasmic reticulum also called sarcoplasmic reticulum of muscle fibers is the store house of calcium ions.

5) A characteristic feature of the muscle fiber is the presence of a large number of parallel filaments called myofilaments in the sarcoplasm.

4. Write short notes on contractile proteins?

A. Actin and myosins are contractile proteins.

Actin:

1) Each actin filament is made of two 'F' (filamentous) actin molecules helically wound around each other.

2) Each actin is a polymer of monomeric 'G' (globular) actin molecules. Two filaments of another protein, called tropomyosin also run close to the 'F' actin molecules, throughout their length.

3) A complex protein called troponin is distributed at regular intervals on the tropomyosin.

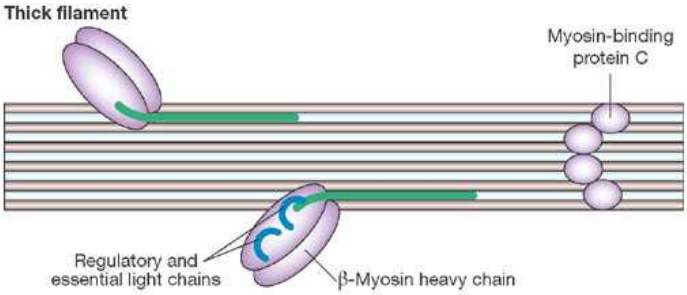
4) Troponin is made of three polypeptides namely Tn – T, Tn – I and Tn – C.

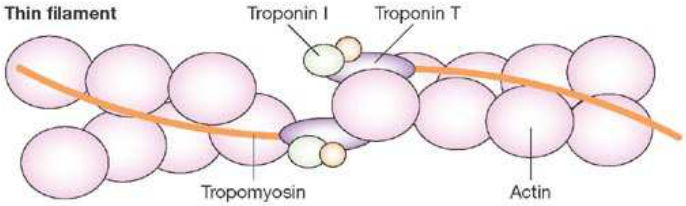
Tn – T binds to tropomyosin. Tn – I inhibits the myosin binding site on the actin, Tn – C can bind to Ca^{2+} when Ca^{2+} ions are bound to troponin, which block the active site of actin. When calcium ions attaches to Tn – C, the tropomyosin moves away from the active sites, allowing the myosin heads to bind the active sites of actin.

5) Troponin and tropomyosin are often called regulatory proteins, because of their role in masking and unmasking the active sites.

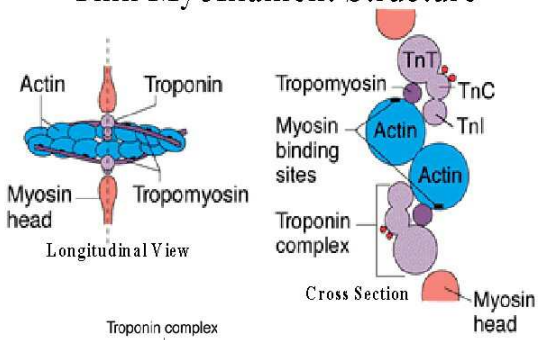
Myosin:

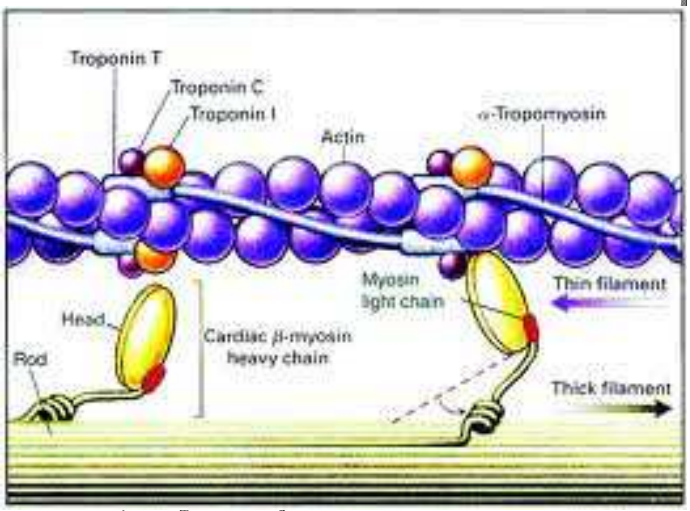
1) Myosin is a motor protein that is able to convert chemical energy in the ATP molecules into mechanical energy.
2) Each myosin filament is a polymerized protein, consists of monomeric proteins called meromyosins.
3) Each meromyosin has two important parts, a globular head with a short arm and tail.
4) The globular head with arm is composed of heavy meromyosin and the tail is made of light meromyosin.
5) The short arm / neck serve as a flexible link between the head and tail regions.
6) There are about 200 – 300 molecules of myosin per thick filament.
7) The head and short arm project outwards at regular distance and angels from each other from the surface of a polymerized myosin filament and is known as cross arm.
8) Each head has two binding sites, one for ATP and other for an active site on the actin molecule.

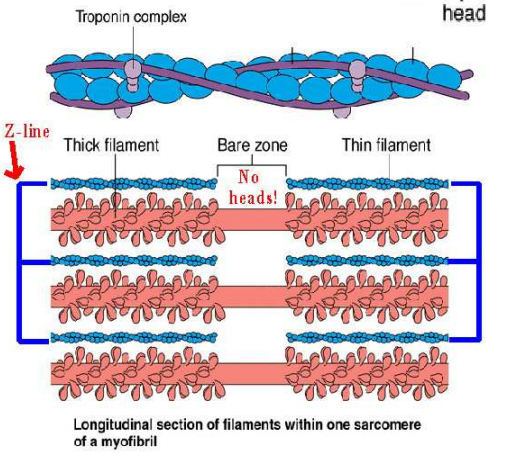




Thin Myofilament Structure



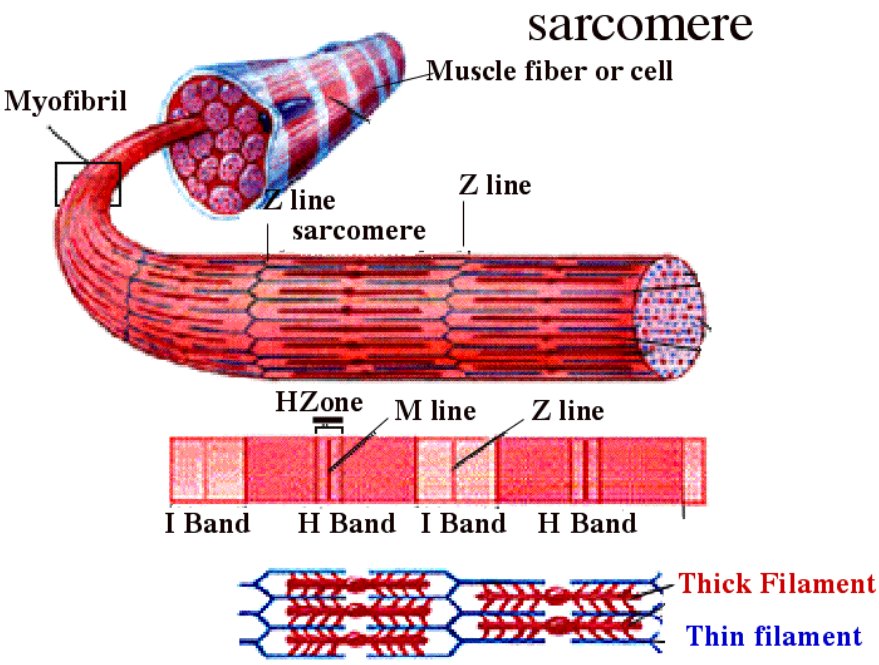


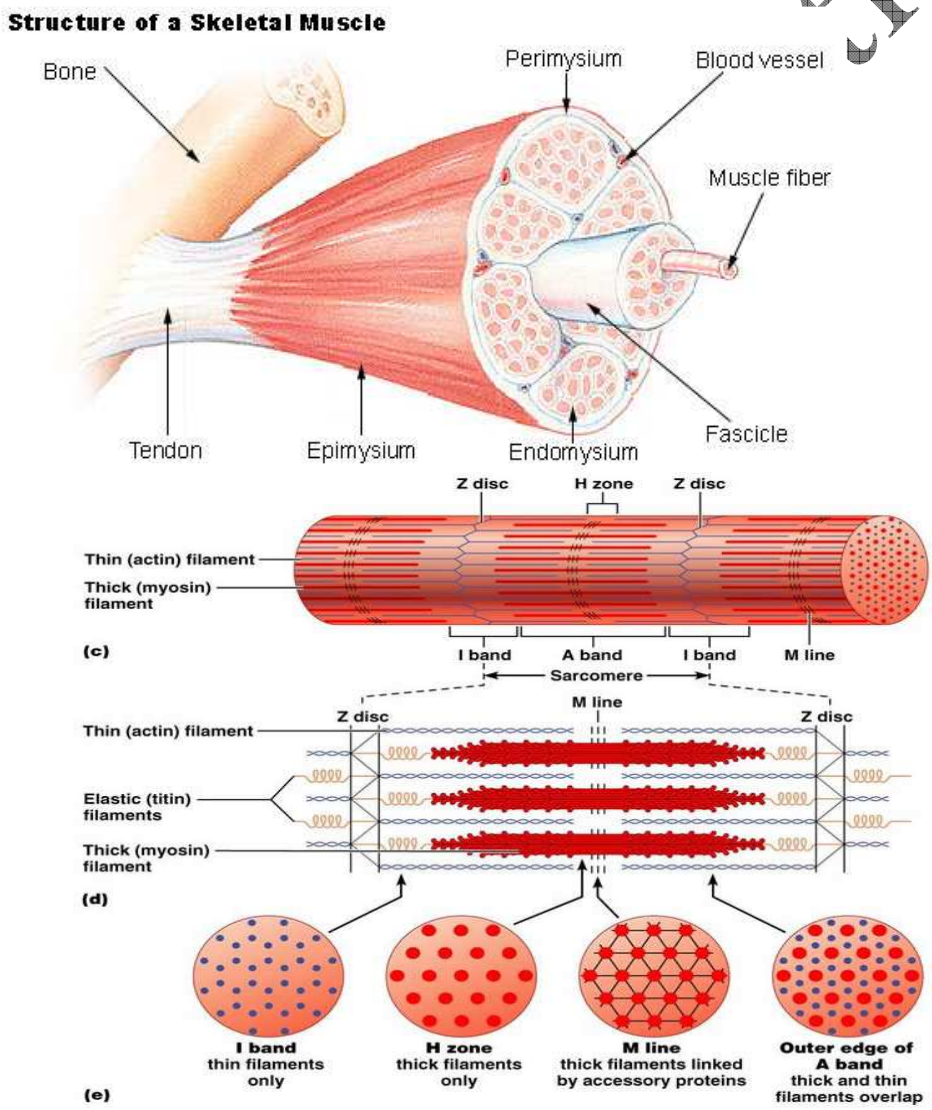


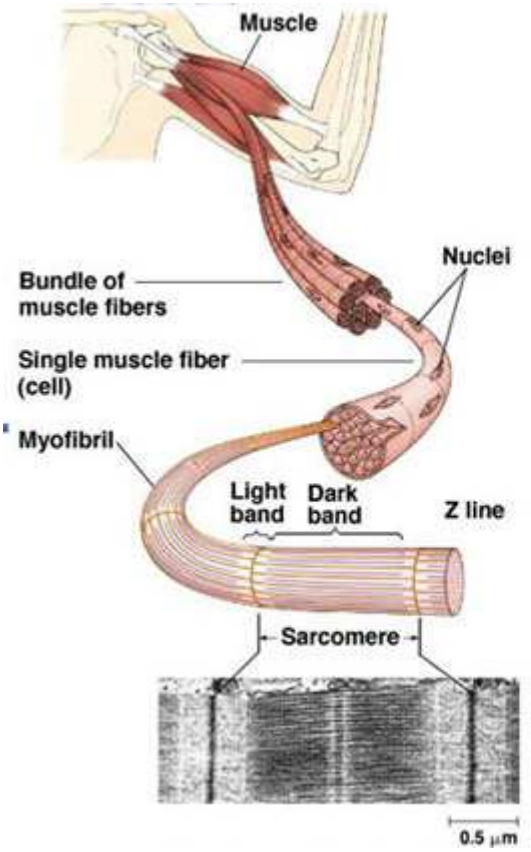
Longitudinal section of filaments within one sarcomere of a myofibril

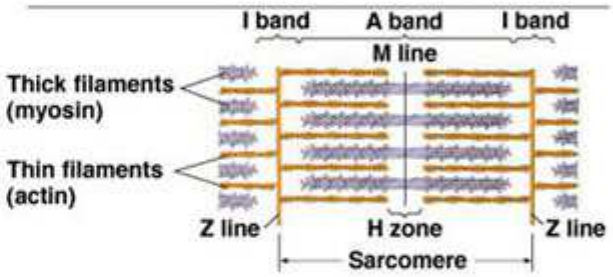
5. Draw a neat labeled diagram of the ultra structure of muscle fibre?

A.



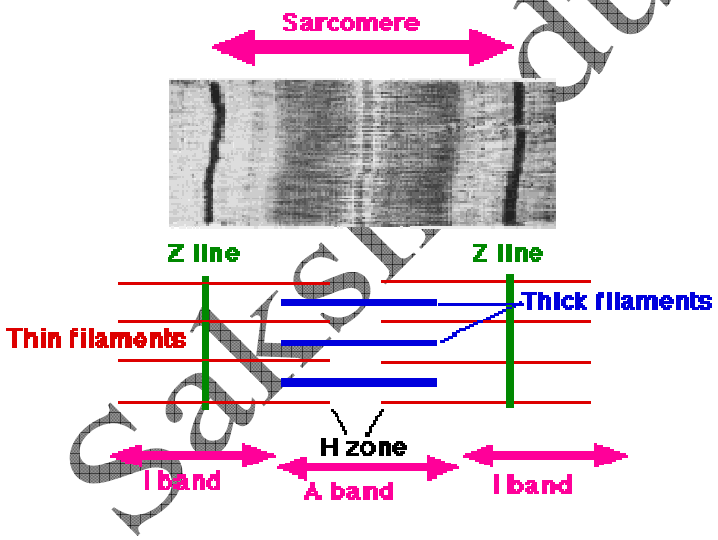






6. Draw the diagram of a sarcomere of skeletal muscle showing different regions?

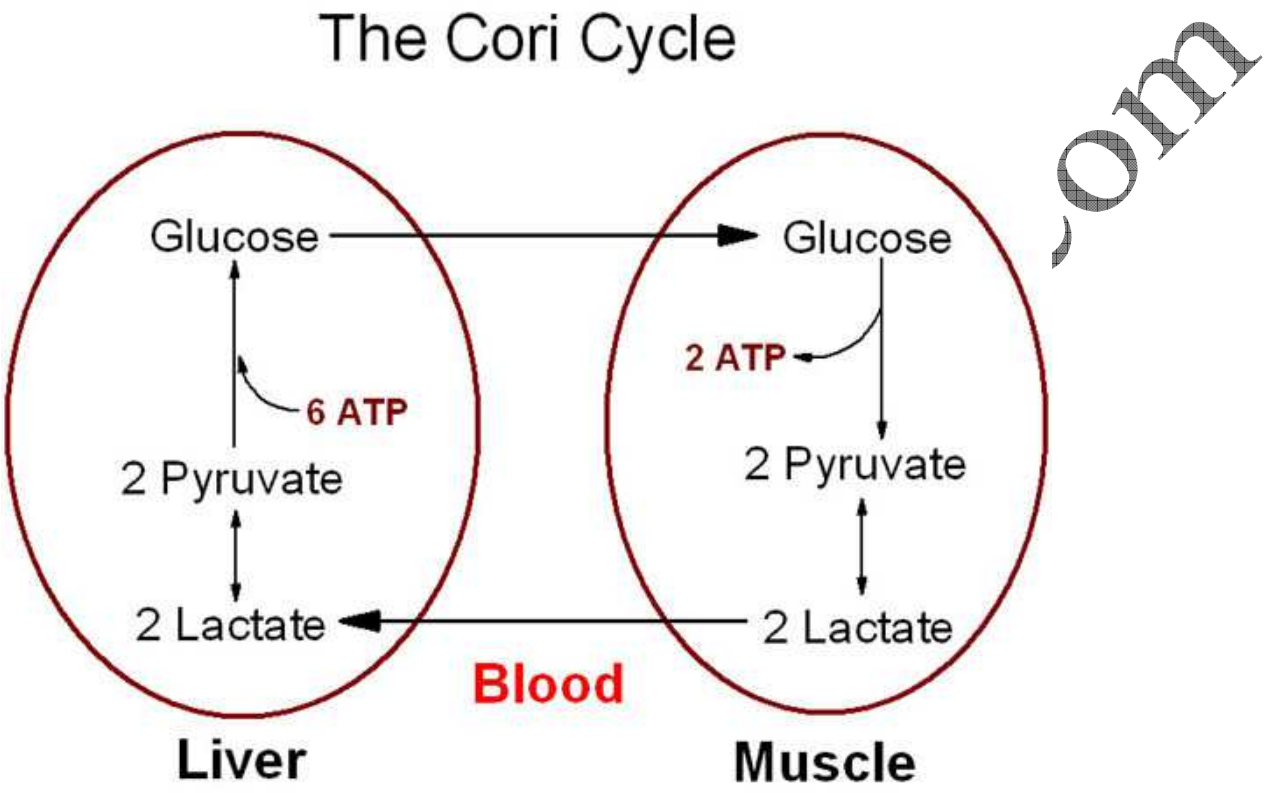
A.

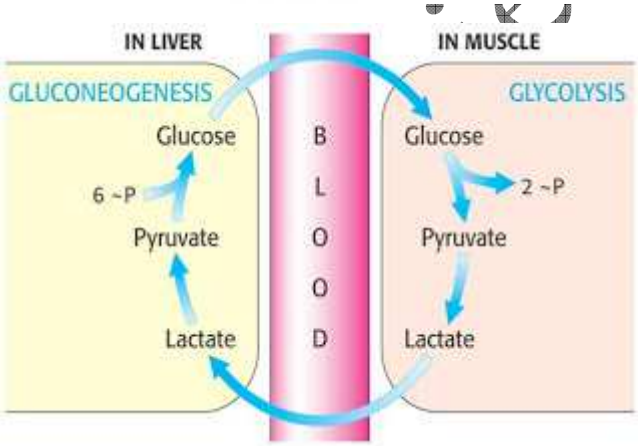


7. What is Cori cycle? Explain the process?

A. Lactate produced by anaerobic glycolysis in the muscle, moves to the liver and is converted to glucose by gluconeogenesis, which then return to the muscles and is converted back to lactate. This two way traffic between skeletal muscle and liver is called the Cori cycle.

Cori Cycle: The lactate produced during rapid contraction of skeletal muscles under low availability of oxygen is partly oxidized and a major part of it is carried to the liver by the blood, where it is converted into pyruvate and then to glucose through gluconeogenesis. The glucose can enter the blood and be carried to muscles and is immediately converted back to lactate. If by this time the muscles have stopped contraction, the glucose can be used to rebuild reserve of glycogen through glycogenesis.





Long Answer Questions

1. Explain the mechanism of muscle contraction?

A. Mechanism of muscle contraction is best explained by the sliding filament theory. It states that contraction of muscle fiber takes place by the sliding of the thin filament over the thick filaments.

Mechanism of Muscle Contraction:

1. Excitation of Muscle:

a) Muscle contraction is initiated by the signal sent by central nervous system via a motor neuron.

b) A neural signal reaching the neuromuscular junction between acetylcholine, which generates an action potential in the sarcolemma.

c) When the action potential spreads to the triad system through *Y* – tubules, the cisternae of the sarcoplasmic reticulum release calcium ions into the sarcoplasm.

2. Formation of Cross Bridge:

a) Increase in the Ca^{2+} level leads to the binding of calcium ions to the subunit Tn – C of the troponin of the actin filament (thin). This makes troponin and tropomyosin complex to move away from the active site of actin molecules.

b) In this stage the myosin head attaches to the exposed active site of actin and forms cross bridges by utilizing energy from ATP hydrolysis.

3. Power Stroke:

a) The cross bridge pulls the attached actin filaments towards the centre of the 'A' band.

b) The 'Z' lines attached to these actin filaments are also pulled in wards from both sides, there by causing shortening of the sarcomere i.e., contraction.

c) During the shortening the muscle the, I bands get reduced in length, whereas the 'A' bands retain their length.

d) As the thin filaments are pulled deep into the A bands making the H bands narrow, the muscle shows the effect contraction.

4. Recovery Stroke:

a) The myosin goes back to its relaxed state and releases ADP.

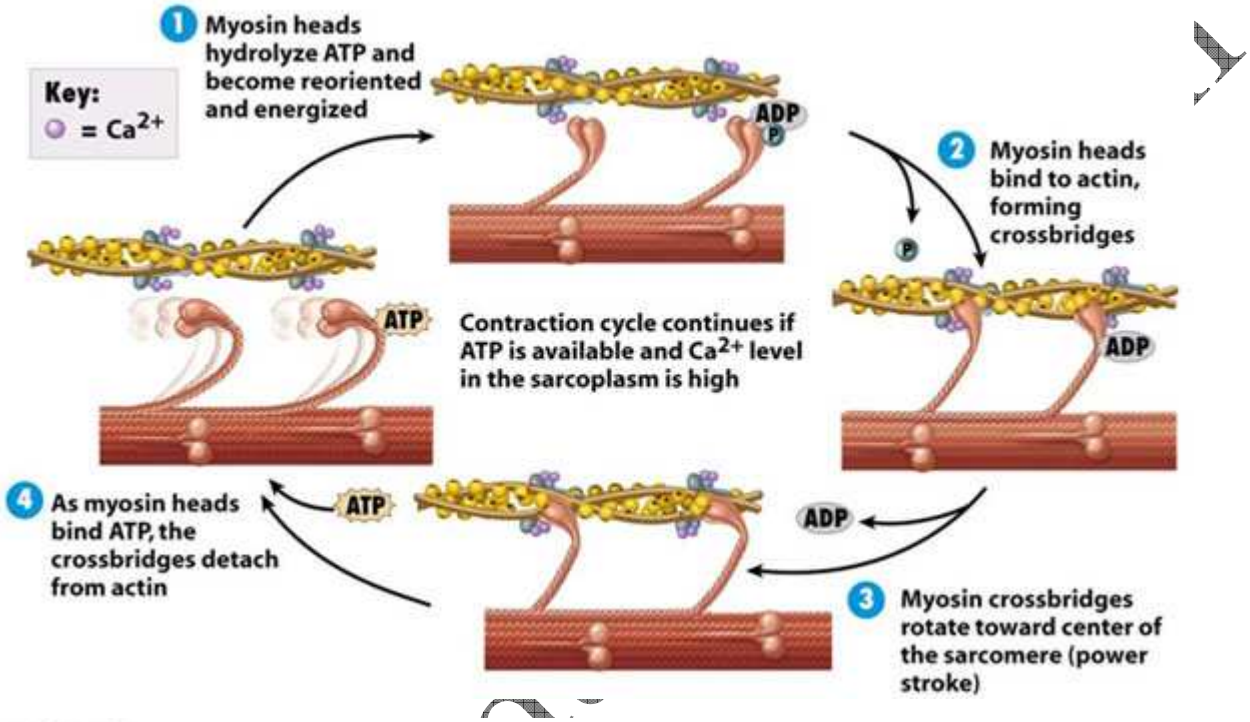
b) A new ATP molecule binds to the head of myosin and the cross bridge is broken.

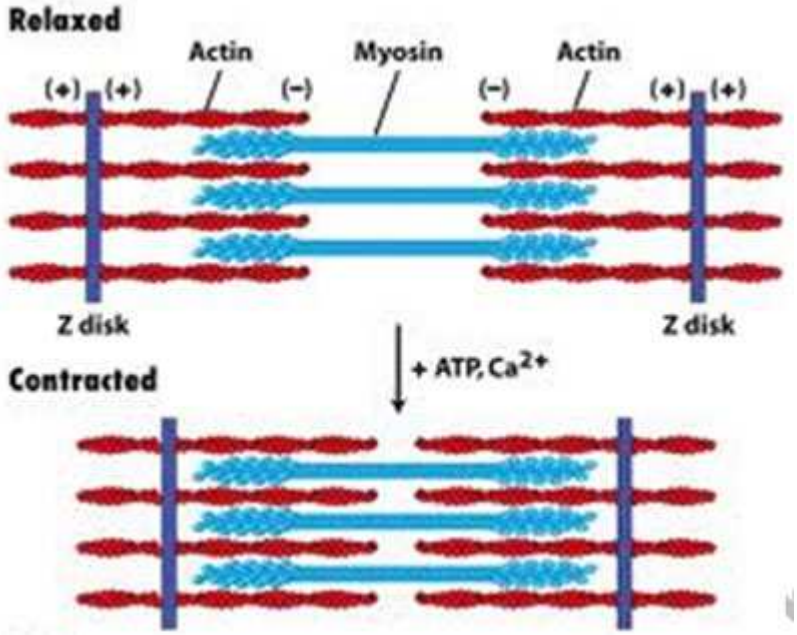
5. Relaxation of Muscle:

a) When motor impulses stop, the calcium ions are pumped back into the sarcoplasmic cisterna it results in the marking of active sites of the actin filaments.

b) The myosin heads fail to bind with the active sites of actin.

c) These changes cause the return of 'Z' lines back to their original position, i.e., relaxation.





2. List in sequence, the events that take place during muscle contraction?

A. During skeletal muscle contraction, the thin filament slides over the thick filament by repeated binding and releases myosin along the filament.

The following events take place during muscle contraction:

1. Muscle contraction is initiated by signals that travel along the axon and reach the neuromuscular junction (Or) motor end plate. As a result, acetylcholine is released into the synaptic left by generating an action potential in sarcolemma.
2. The action potential spreads to the triad system through the T – tubules, the cisterna of the sarcoplasmic reticulum release calcium ions into the sarcoplasm.
3. Increase in the calcium ions level leads to the binding of calcium ions to the sub unit Tn – C of the troponin of the thin filament. This makes troponin and tropomyosin complex to remove away from the active sites of actin molecules.
4. In this stage, the myosin head attaches to the exposed site of actin and forms cross bridge by utilizing energy from ATP hydrolysis.
5. The cross bridge pulls the attached actin filaments towards the centre of the 'A' band. The 'Z' lines attached to these actin filaments are also pulled inwards from both the sides, thereby causing contraction. During the contraction the 'I' bands get reduced in length, where as 'A' bands retain their size.
6. As the thin filaments are pulled deep into the 'A' bands making the 'H' bands narrow, the muscle shows the effect contraction.

Contraction is turned off by the following sequence of events:

7. Acetylcholine at the neuromuscular junction is broken down by acetyl cholinesterase and this terminates the stream of action potentials along the muscle fibre surface.
8. The sarcoplasmic reticulum ceases to release calcium ions and immediately calcium ions are pumped back into the sarcoplasmic cisternae.
9. In the absence of calcium ions a change in the configuration of troponin and tropomyosin i.e., masking of the active sites of the actin filaments.
10. The myosin heads fail to bind with active sites of actin. These changes cause the return of 'Z' lines back to their original position i.e., relaxation.

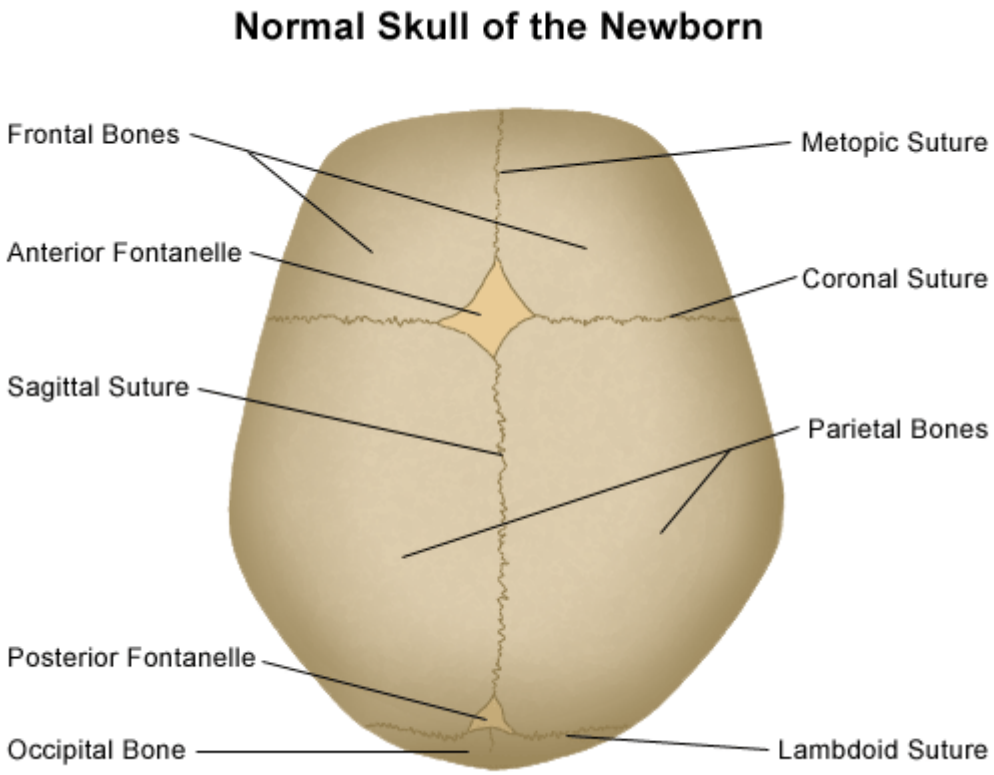
IIIA -- THE SKELETON

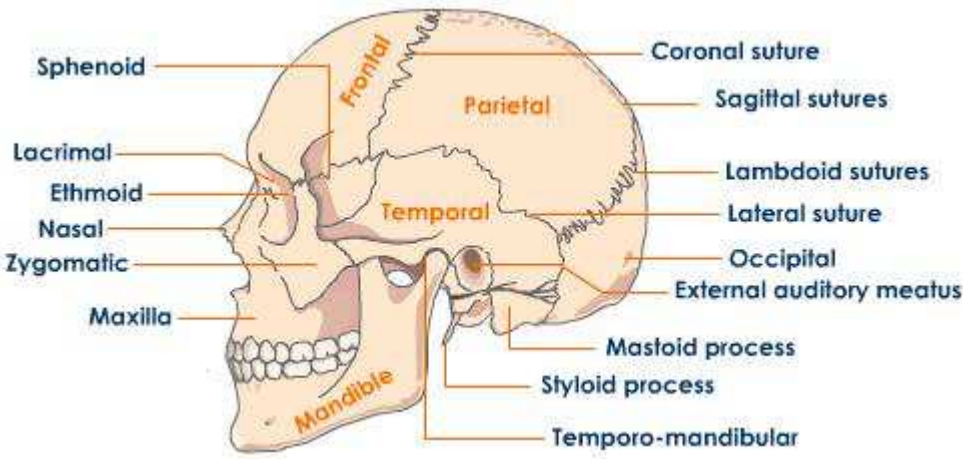
Very Short Answer Questions

1. Name two cranial sutures and their locations?

A. 1. **Coronal suture** - Between the frontal and parietal bones

2. **Lambdoid suture** - Between the parietal and occipital bones





2. Name the keystone bone of the cranium. Where is it located?

A. Sphenoid bone is the keystone bone of the cranium, because it articulates with all the other cranial bones.

It is present at the middle part of the base of the skull.

3. Human skull is described as dicondylic skull. Give the reason?

A. Human skull is described as dicondylic skull as it contains two occipital condyles one on each side of the foramen magnum of occipital bone.

4. Name the ear ossicles and their evolutionary origin in human beings.

A. Each middle ear contains three tiny bones called ear ossicles. They are:

Malleus - Modified of articular

Incus - Modified quadrate

Stapes - Modified hyomandibula

5. Name the type of joint between (a) atlas / axis, (b) carpal / metacarpal of the human thumb?

A. a) Joint between atlas / axis – Pivot joint

b) Joint between carpal / meta carpal of the human thumb – Saddle joints

6. Name the type of joint between (a) Atlanto – axial joint, (b) Femur – acetabulum joint?

A. a) Joint between altanto – axial joint – Pivot joint

b) Joint between Femur – acetabulum of pelvic girdle joint – Ball and Socket joint

7. Name the type of joint between (a) Cranial bones, (b) Inter – tarsal joint.

A. a) Joint between Cranial bones – Sutures (Fibrous joint),

E.g.: Coronal suture, lambdoid suture

b) Inter – tarsal joint – Gliding joint

Short Answer Questions

1. List out the bones of the human cranium?

A. Cranium, the brain box is formed by eight cranial flattened bones. They are:

i) Frontal Bone (1): Forms the forehead, anterior part of the cranial floor and roof of the orbit.

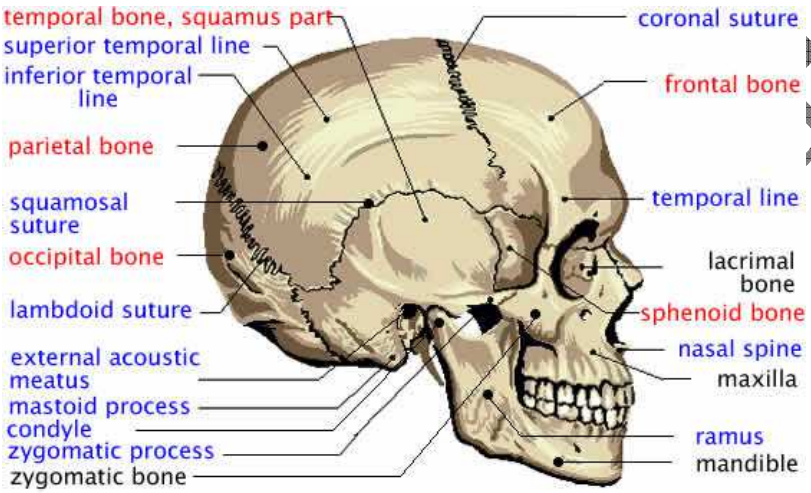
ii) Parietal Bones (2): Form the major portion of the sides and roof of the cranial cavity.

iii) Temporal bones (2): Form lateral walls of the cranium as well as housing the external ear.

iv) Occipital Bone (1): Forms the posterior part and most of the base of the cranium.

v) Sphenoid Bone (1): It is present at the middle part of the base of the skull. It is also called keystone bone of the cranium.

vi) Ethmoid Bone (1): It is present on the midline of the anterior part of the cranial floor.



2. Write short notes on the ribs of human being?

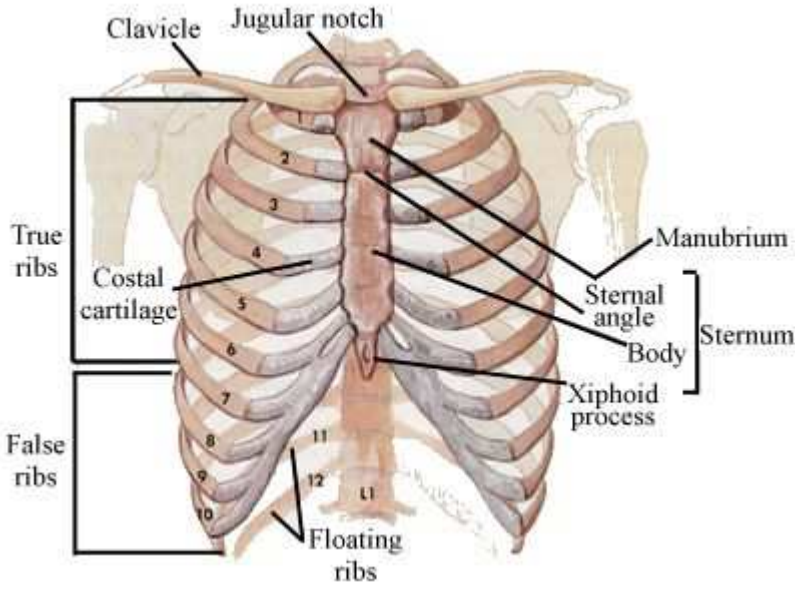
A. The ribs are thin, flat, curved bones that form a protective cage around the organs present in the human chest. They are comprised of 24 bones arranged in 12 pairs. These bones are divided into three categories:

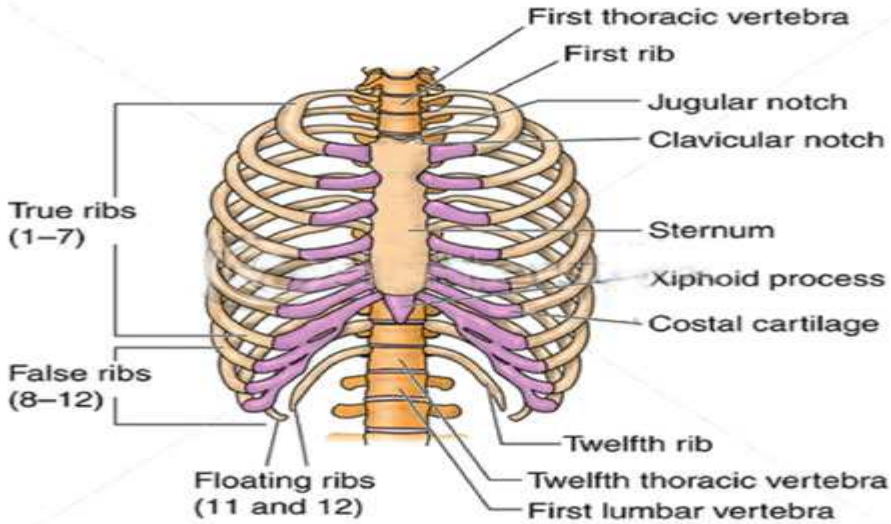
1) True Ribs: The first seven pairs of ribs are called true ribs. Dorsally, they are attached to the thoracic vertebrae and ventrally connected to the sternum with the help of hyaline cartilages (costal cartilages). These are vertebrosternal ribs.

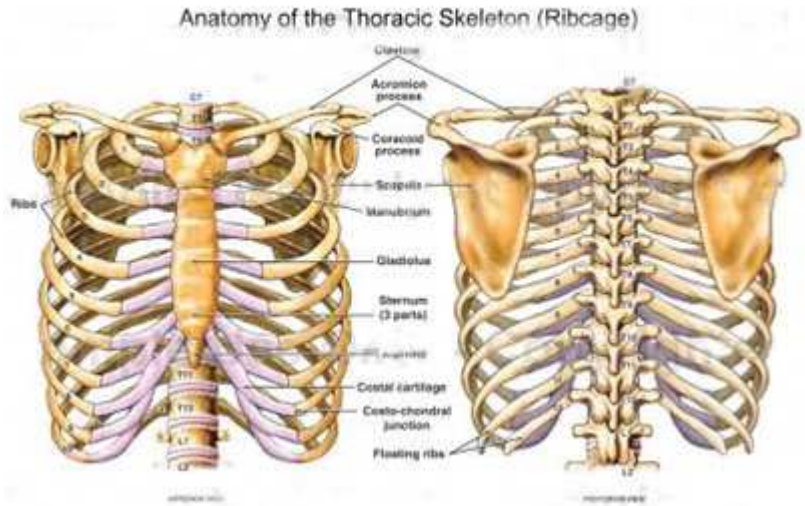
2) False Ribs: The remaining ribs are called false ribs. The 8^{th}, 9^{th} and 10^{th} pairs of ribs do not articulate directly with the sternum, but joint the cartilaginous parts of the seventh rib. These are called vertebrochondral (or) false ribs.

3) Floating Ribs: Last two pairs (11th and 12th) of the ribs are not connected ventrally either to sternum or the anterior ribs, hence called floating ribs.

The thoracic vertebrae, ribs and sternum together form the rib cage.







3. List the bones of the human fore limb?

A. Each fore limb of human is made of 30 bones. They are:

Humerus: Long bone in the fore limb that runs from shoulder to elbow.

Radius and Ulna: These bones form fore arm. It is the region between elbow and the wrist.

Carpals: These are the bones of wrist which are 8 in number.

Metacarpals: The metacarpals form the skeleton of the palm. They are 5 in number.

Phalanges: These are finger bones, fourteen in number, three for each finger and two for the thumb. 2, 3,3,3,3 (total 14).

4. List the bones of the human leg?

A. Each hind limb of human is made of 30 bones. They are:

Femur: Femur is the only bone in the thigh. It is the longest, heaviest and strongest bone in human body.

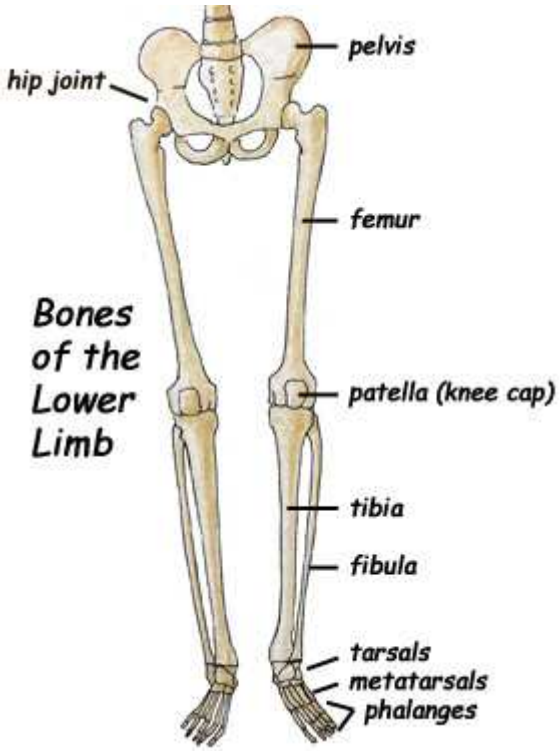
Tibia and Fibula: Both of these bones form lower leg i.e., the region from knee to ankle.

Tarsals: These are ankle bones, 7 in number.

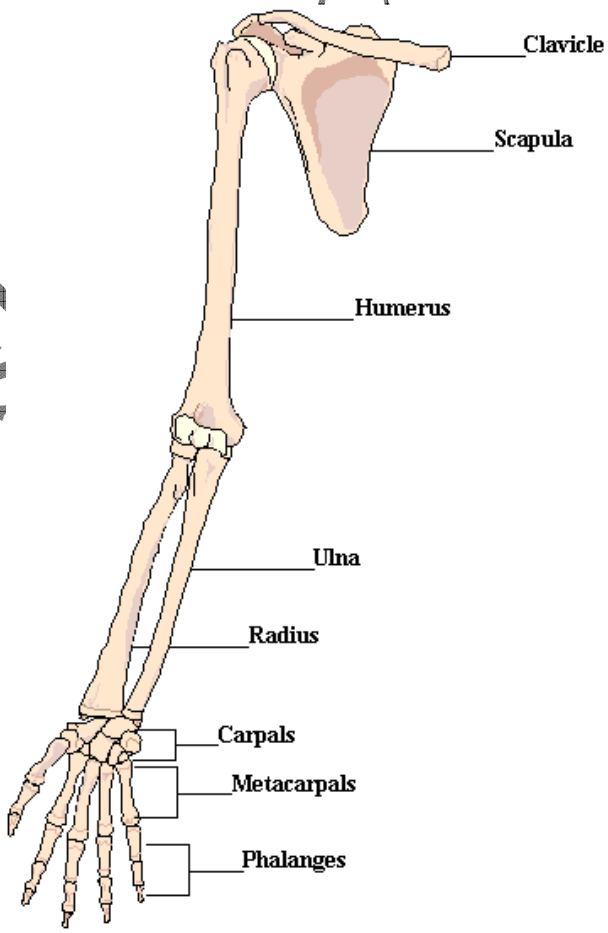
Meta Tarsals: These are 5 short tubular bones, distal to the tarsals and proximal to phalanges.

Phalanges: Foot has 14 phalanges, each toe has three phalanges, except for the first toe. 2, 3,3,3,3.

Patella: It is a cup – shaped bone, covers the knee joint vertically,

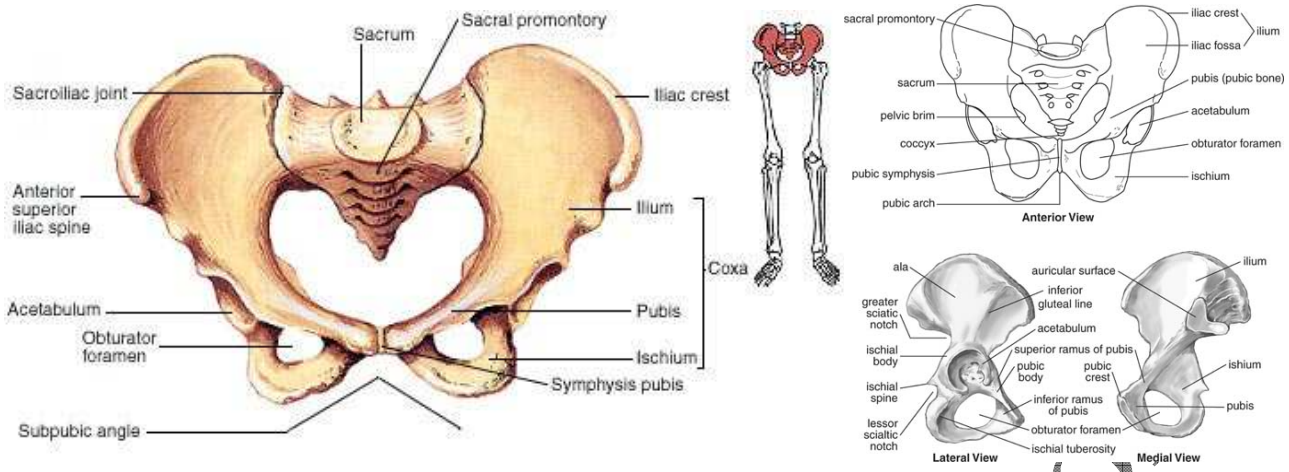


5. Draw a neat labelled diagram of the skeleton of the fore limb of man?



6. Draw a neat labelled diagram of pelvic girdle?

A.

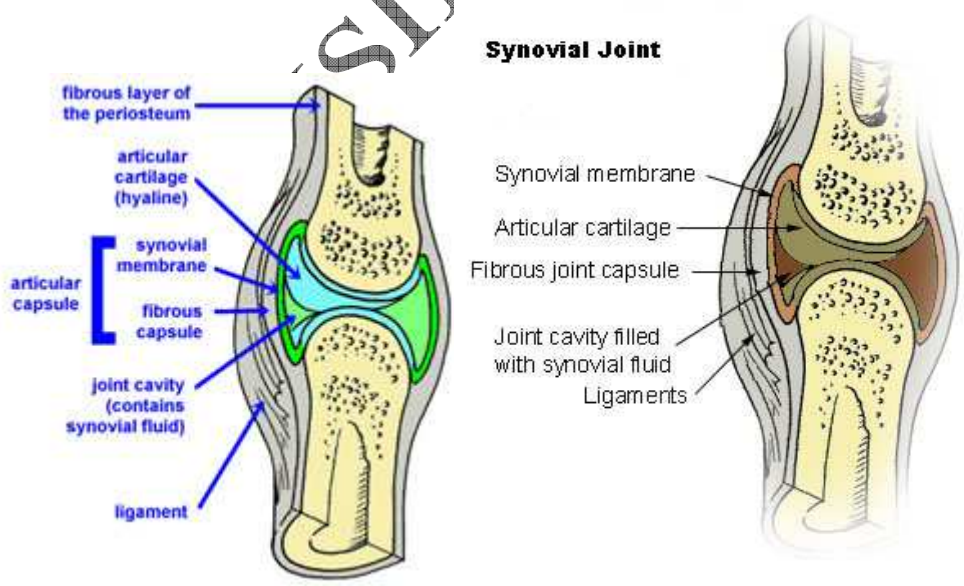


7. Describe the structure of synovial joint with the help of a neat labelled diagram?

A. Synovial joints are characterized by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones.

Structure of synovial joint: Synovial joint is covered by a double layered synovial capsule. The outer layer consists of dense fibrous irregular connective tissue with more collagen fibers. This layer is continuous with the periosteum and resists stretching and prevents the dislocation of joints. Some fibres of these membranes are arranged in bundles called ligaments.

The inner layer of synovial capsule is formed of areolar tissue and elastic fibers. It secretes a viscous synovial fluid which contains hyaluronic acid, phagocytes etc and acts as a lubricant for the free movement of the joints.



Long Answer Questions

1. Describe the structure of human skull?

A. The skull is the bony framework of the head. It consists of the eight cranial and fourteen facial bones.

The cranial bones make up the protective frame of the bone around the brain called cranium.

The cranial Bones are:

(i) Frontal bone (1): It forms the forehead, anterior part of the cranial floor, and the roof of the orbits,

(ii) Parietal Bones (2): They form the major portion of the sides (left and right) and roof of the cranial cavity. They are joined to the frontal bone by a coronal suture and posteriorly to the occipital bone by lambdoid suture.

(iii) Temporal Bones (2): The left and right temporal bones form the lateral walls of the cranium as well as housing the external ear.

(iv) Occipital Bone (1): It forms the posterior part and the most of the base of cranium. It has large opening called foramen magnum. Medulla oblongata passes out through this foramen and joins the spinal cord.

(v) Sphenoid Bone (1): It is present at the middle part of the base of the skull. It is the keystone bone of the cranium, because it articulates with all other cranial bones.

(vi) Ethmoid Bone (1): It is present on the midline of the anterior part of the cranial floor.

Facial region is made up of fourteen facial bones which form upper and lower jaw and other facial structures.

The facial Bones are:

(i) Nasal bones (2): These are paired bones that form the bridges of the nose.

(ii) Maxillae (2): Two maxillae join together and form the upper jaw. Maxillae bears sockets for lodging the maxillary teeth.

(iii) Zygomatic Bones (2): These are known as cheek bones.

(iv) Lacrimal Bones (2): These are smallest bones of the face.

(v) Palatine Bones (2): They form the posterior portion of the hard palate.

(vi) Nasal Conchae (2): These are scroll like bones that form a part of lateral wall of the nasal cavity.

(vii) Vomers (1): It is a triangular bone present on the floor of nasal cavity.

(viii) Mandible (1): It is the lower jaw bone. It is "U" shaped and is the longest and strongest of all the facial bones. It is the only movable skull bone.

Skeletal structures associated with sense organs:

(i) Nasal Cavity: It is divided into left and right cavities by vertical partition called the nasal septum.

(ii) Orbits: These are bony depressions, which accommodate the eyeballs and associated structures.

(iii) Ear Ossicles: Each middle ear contains three tiny bones, namely malleus, incus, stapes, collectively called ear ossicles.

(iv) Hyoid Bone: It is a single "U" shaped bone present at the base of the buccal cavity between the larynx and the mandible. Hyoid bone keeps the larynx open.