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HUMAN ANATOMY AND PHYSIOLOGY – I

UNIT 2

TOPIC :

- **Skeletal system**

  Divisions of skeletal system, types of bone, salient features and functions of bones of axial and appendicular skeletal system

  Organization of skeletal muscle, physiology of muscle contraction, neuromuscular junction

Skeletal System

- The skeletal system is the structural framework of the human body made up of bones, cartilage, ligaments, and joints, which provides support, protection, movement, mineral storage, and blood cell formation.
- It consists of 206 bones in adults, organized into the axial and appendicular skeleton.
- The skeletal system provides support, protection, movement, and mineral storage.
- It protects vital organs like the brain (skull), heart and lungs (rib cage), and spinal cord (vertebral column).
- Joints in the skeletal system allow movement and flexibility of different body parts.
- The skeletal system maintains posture and serves as an attachment point for muscles and tendons.
- It also helps regulate calcium and phosphorus levels in the body.

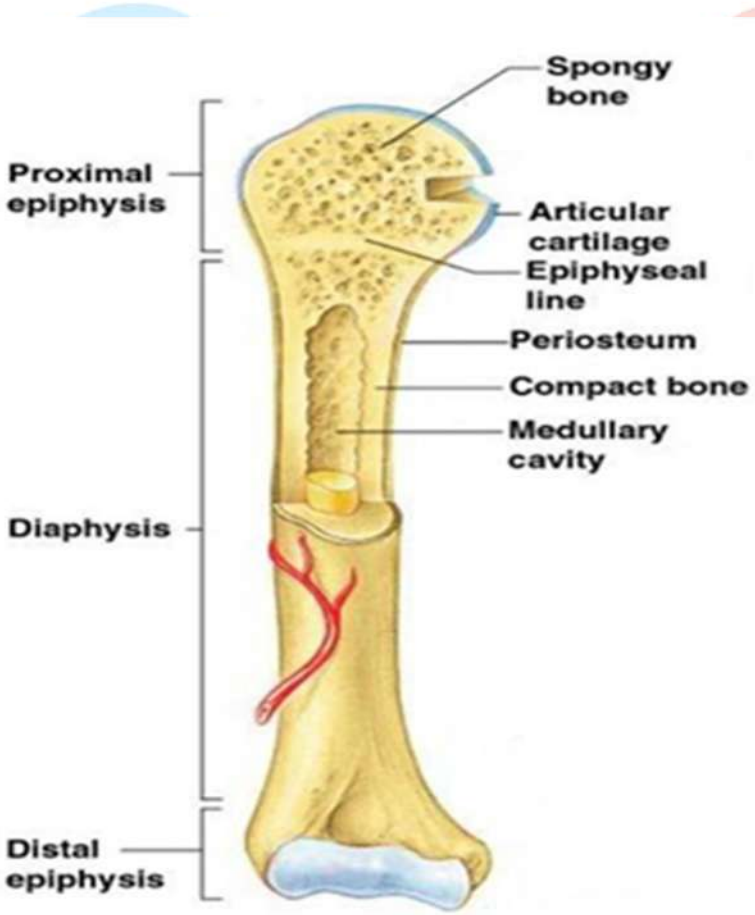
Bones

Bone is a hard, living connective tissue that forms the framework of the body. It supports body structure, protects internal organs, helps in movement, stores minerals like calcium and phosphorus, and produces blood cells in the bone marrow.

- Osteology is the study of bones and teeth.
- It is usually applicd in the fields of anthropology. forensic science, and archacology for various functions like the determination of nutritional value, health. and also to determine the position of bone within the body.

STRUCTURE OF BONE

→ Macroscopic bone structure may be analyzed by considering the parts of a long bone, such as the humerus (the arm bone). A long bone is one that has greater length than width.



Bone Tissue

A typical long bone consists of the following parts:

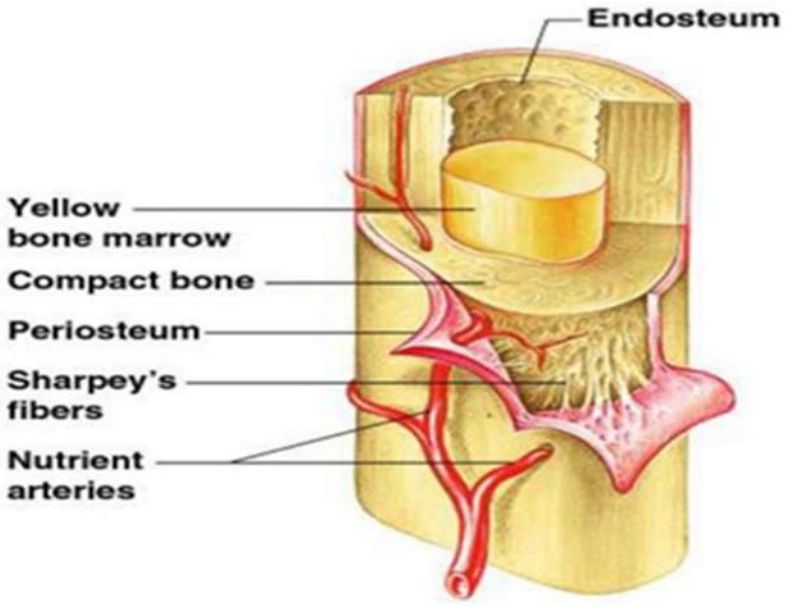
1. Diaphysis: The bone's shaft or body—the long, cylindrical, main portion of the bone.

2. Epiphyses: The proximal and distal ends of the bone.

3. Metaphyses: The regions between the diaphysis and the epiphyses. In a growing bone, each metaphysis contains an epiphyseal (growth) plate, a layer of hyaline cartilage that allows the diaphysis of the bone to grow in length. When a bone ceases to grow in length at about ages 18–21, the cartilage in the epiphyseal plate is replaced by bone; the resulting bony structure is known as the epiphyseal line.

4. Articular cartilage: Thin layer of hyaline cartilage covering the part of the epiphysis where the bone forms an articulation (joint) with another bone. Articular cartilage reduces friction and absorbs shock at freely movable joints.

5. Periosteum: Surrounds the external bone surface wherever it is not covered by articular cartilage. It is composed of an outer fibrous layer of dense irregular connective tissue and an inner osteogenic layer that consists of cells. Some of the cells of the periosteum enable bone to grow in thickness, but not in length. The periosteum also protects the bone, assists in fracture repair, helps nourish bone tissue, and serves as an attachment point for ligaments and tendons. It is attached to the underlying bone through perforating (Sharpey's) fibers, thick bundles of collagen fibers that extend from the periosteum into the extracellular bone matrix.



6. Medullary cavity or marrow cavity : Hollow, cylindrical space within the diaphysis that contains fatty yellow bone marrow in adults.

7. Endosteum : Thin membrane that lines the internal bone surface facing the medullary cavity. It contains a single layer of cells and a small amount of connective tissue.

Types

Bones are categorised into six classes on the basis of the following salient features :

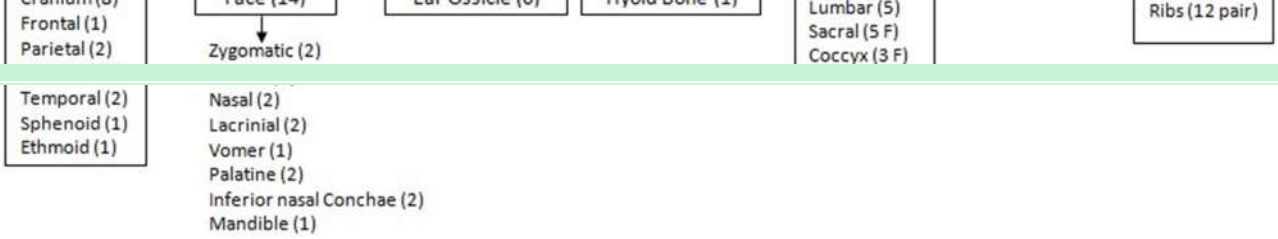
→ **Long Bones:** These bones are characterised by the presence of a shaft. They have longer lengths as compared to the widths.
They end in a number of extremities, e.g., femur, tibia, fibula, humerus, ulna, and radius. They are usually slightly curved, thus impart high strength to these bones

→ **Short Bones:** These bones are characterised by an almost equal length and width, e-g., ankle and wrist bones. They are more or less cubical in shape.'

→ **Flat Bones:** These bones are characterised by a thin shape or structure. They offer wide surfaces for muscle attachments and thus provide substantial mechanical protection, e.g, cranial bones (protecting the brain), the sternum and ribs (protecting the organs in the thorax), and the scapula (shoulder blade s).

→ **Irregular Bones:** As the name suggests these bones are asymmetrical in shape and therefore are said to have complicated shapes. They are shaped to fulfil certain specific functions within the body.
For example, the vertebrate and some facial bones; provide major mechanical support to the body while also protecting the spinal cord.

→ **Sesamoid Bones:** These bones develop in some tendons in areas where there is considerable friction, tension, and physical stress.



→ **Sutural Bones:** These bones are very small and are found within the sutural joints in between the Cranial bones They are categorised on the basis of their location and not shape.
For example, suture bones are present in the Cranium.

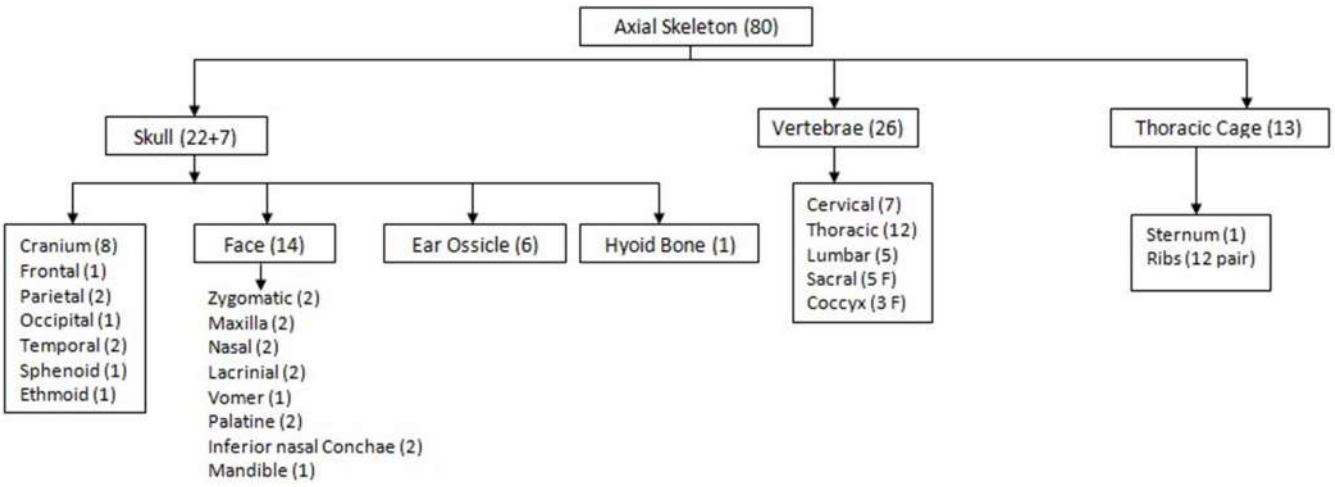
Divisions of Skeleton System

The human skeleton can be broadly divided into two groups:

- Axial skeleton, and
- Appendicular skeleton.

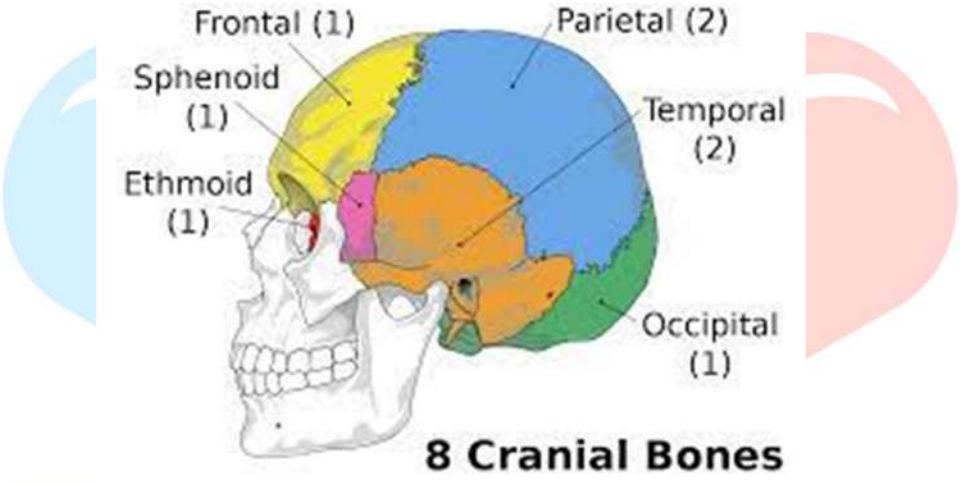
AXIAL SKELETON

➲ Axial skeleton includes those bones which help in the formation of body axis. It supports and protects the skull, neck, and the torso (or trunk) region. There are 87 bones in the axial skeleton of a child whereas an adult has only 80 bones.



Structure and function of skull

- Bones of the head region form the skull It is located over the vertebral column (along with the vertical axis). Skull of an adult human comprises of 28 bones Which are immovable, except the mandible.
- Skull is divided into two regions, i.e., cranium and facial bones. Various cavities are formed by the bones of skull and face, e.g., cranial cavity..



Cranium

→ Cranium is a spherical box-like structure which provides a protective covering to the brain.

→ The basal region of cranium consists of numerous openings from where blood vessels and nerves enter and exit the cranial cavity.

→ Bones of the Cranium

The bones present in cranium are:

1) **Frontal Bones:** The sub-division of frontal bunes includes:
   a) **Frontal Squama:** It is a thick plate-like structure that forms the forehead.
   b) **Supraorbital Margin:** This is a thick regionlocated just above the eyes.
   c) **Frontal Sinuses:** These are the cavities present in the frontal bone.
2) **Parietal Bones:** These bones form the major portion of both sides of the skul.

3) **Temporal Bones:** These bones are present along the ear and can be further divided into:

i) **Temporal Squama:** This bone forms the temple of the skull.

ii) **Zygomatic Arch:** This bone forms a part of the jaw.

iii) **Carotid Canal:** It forms the passage for carotid artery. Due to the proximity of this artery to the ear, one can feel its pulsations at the point just anterior to the ear, activities of especially during vigorous the body.

iv) **Jugular Foramen:** It provides passage for jugular vein along with 3 cranial nerves.

v) **Mandibular Fossa:** This bone takes part in the formation of Temporo-Mandibular Joint (TMJ).

vi) **Temporo-Mandibular Joint (TMJ):** This joint articulates mandible with the temporal bone.

vii) **Mastoid Process:** It is the bulging area behind the ear where neck muscles are attached.

viii) **Styloid Process:** It keeps the hyoid bone in its place with the help of neck, muscles of the tongue, and ligaments.

4) **Occipital Bones:** These bones are present at the back of the skull. Occipital bones are formed by:

I. **Foramen Magnum:** It is the site from where the spinal cord runs through and gets attached to the brain.

II. **Occipital Condyles:** It articulates with thevertebrae and helps in the nodding of head.

5) **Sphenoid:** It forms a bat-like structure present in the centre of the skull

6)**Ethmoid:** This bone is present in the anterior part of the skull and separates the nasal cavity from the brain. It forms the upper part of the nasal cavity and some parts of the orbit as well. Ethmoid bone acts as a pivot for almost all the skull bones as all the bones are connected to it:

Function of Skull

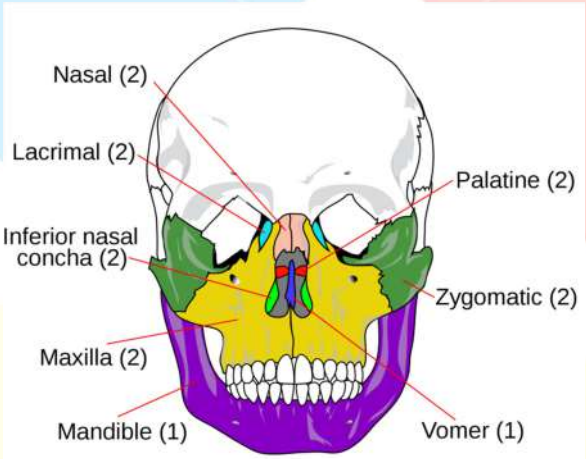
1) It protects brain.

2) The outer surface of the cranial bones provides large Surface areas for muscle attachment that move various parts of the head.

3) Its inner surface attaches to the membrane, i.e, meninges, that stabilise the position of the brain, blood vessels and nerves.

4) The bones of the skull provide muscle attachment to the muscles producing facial expressions

Facial Bones



14 facial bones

The facial skeleton also called visceral skull, forms the point of attachment for the anterior and inferior surfaces of the cranium. Different bones of the face include:

I. **Nasal Bones:** These bones are basically cartilaginous in nature and provide flexibility, and help in the formation of the nasal bridge.

II. **Nasal Septum:** The right and left part of the nose (external nares) are separated by the nasal septum, composed of ethmoid bone, vomer bone, and cartilages. Nasal cavity also contains three bony processes known as concha namely middle concha, inferior concha, and superior concha. Concha forms the walls of the nasal cavity.

III. **Maxillae:** These are the paired bones of the upper jaw. This bone is responsible for holding the upper set of teeth at their places and

acts as a roof for the mouth, and also forms the floor of the nasal cavity and eye orbits.

IV. **Cleft:** This bone forms the roof of the mouth and separates the oral cavity from the nasal cavity.

V. **Zygomatic Bones:** These are also known as cheekbones and articulate with the maxilla, sphenoid, and the temporal bones.

VI. **Mandible:** Among the facial bones mandible is the strongest as well as the largest bone. It is the only movable bone of face. The lower jaw is formed of the mandible. It also keeps the lower teeth in their places. It is unpaired.

VII. **Vomer:** It is the only unpaired bone of the face which forms the nasal septum.

VIII. **Lacrimal Bones:** Amongst the bones of the face, lacrimal bones are the smallest and the most delicate ones. The lacrimal ducts located in these bones are responsible for lacrimation.

IX. **Orbit:** It is the socket or cavity holding the eye.

Function of Facial Bones

1) They help in forming framework of face.
2) They contain cavities for special sense organs.
3) They protect the teeth.
4) They are helpful in anchoring the facial muscle of expression.

Hyoid bone

→ Hyoid bone is a horseshoe shape bone and is also known as the lingual bone. It is located at the middle of the neck, in between thyroid cartilage and chin; and forms the floor of the oral cavity.

→ Thyroid ligament holds this bone at its place.

→ Hyoid is the only skeletal bone which is not attached to any other bone of the skeleton. It acts as a point of attachment for:

1) The muscles of oral cavity and tongue ventrally, and
2) The larynx dorsally,

→ Its posterior surface is attached to the epiglottis and pharynx.

Structurally, the hyoid bone is divided into the following parts:

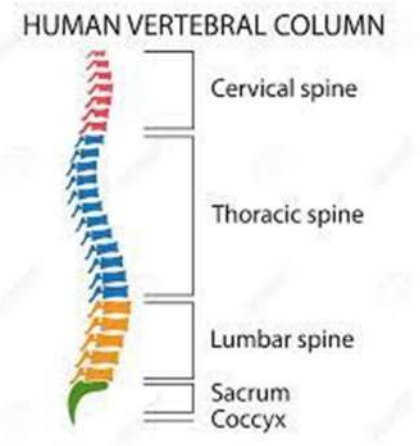
1) Centrally located part called the body, and
2) Two pairs of Cornua, i.e., greater cornu (2) and lesser cornu

Function of hyoid Bone

1)Serves as an anchoring structure for the tongue, larynx, and anterior neck muscles,
2) Aids in tongue movement,
3) Helps in swallowing, and
4) Helps in the production of sound and its variations

Structure and Function of Vertebral Column (Vertebrae)

→ The backbone (the mid back region) of human beings comprises of 33 vertebrae (in children) and 26 vertebrae (in adults), and represents the vertebral column. It is also known as the spine. This vertebral column provides protection to the spinal cord and its membranes.



Parts of Vertebrae

The human vertebral column can be further divided into the following five parts

- **Cervical:** There are 7 cervical vertebrae, externally forming the neck region.
- **Thoracic:** There are 12 thoracic vertebrae, externallyvisible as chest or thorax
- **Lumbar:** There are 5 lumbar vertebrae These vertebrae are present below the thoracic region and above the pelvic region. They are larger as well as stronger than the other vertebrae.
- **Sacral:** The fusion of 5 sacral vertebrae results in the formation of the sacral region or the part of the upper pelvis.
- **Coccyx:** It is formed by the fusion of 4 coccygeal vertebrae, in the lower part of the pelvis

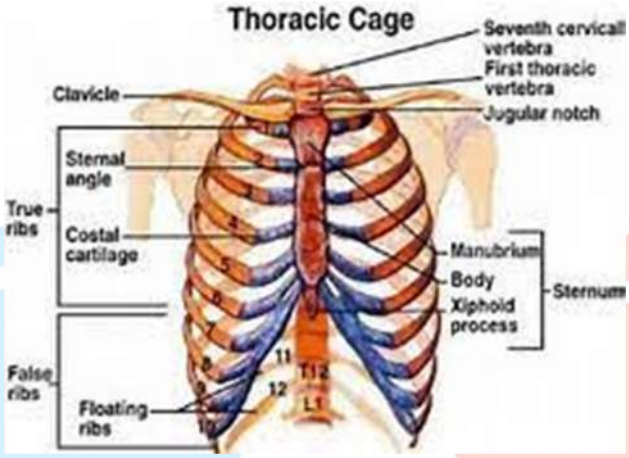
Functions of Vertebral Column

➲ It maintains the erect body posture.
➲ It maintains the body balance.
➲ The combination of vertebral column, sternum, and ribs together form a supporting framework for the trunk of the body.
➲ It supports the upper limbs and head to make them freely movable.
➲ It acts as a point of attachment for various muscles, ribs, and some organs.
➲ It protects the spinal cord, its membrane and vital organs like the kidney and liver.
➲ It forms the site of attachment for muscles, tendons, and ligaments.
➲ It maintains and balances the distribution of weight.
➲ It performs haemopoiesis in the foetus and infants.

Structure and Function of Thoracic Cage/Thorax

→ The thoracic cage or thorax is a region of the human vertebral column that lies between the head and the abdomen, excluding upper limbs.

→ Out of the 12 pair of ribs, upper 10 pairs are directly or indirectly attached to the sternum via costal cartilages from anterior end. From the posterior end, all the 12 pairs are attached thoracic vertebrae.



Functions of the Thoracic Cage

1) Motion: The bifurcation of the thoracic cage into ribs and vertebrae provides mobility to the thorax region.

2) Costal Breathing: The ribs are attached to the costal cartilages in a specific manner which helps in costal breathing.

3) Protection: Rib cage encapsulates several organs like heart and lungs, thus protecting them from damage.

Ribs

→ Long semi-circular bones forming the rib cage are known as ribs. They encapsulate the chest forming a periphery. They also allow the expansion of lungs for respiration by expanding the chest (thorax). Organs like the heart and lungs are protected by the ribs.

Basic Structure of a Rib

In humans, 12 pairs of ribs are present. A single rib is madeup of the following 3 parts :

- **Head:** This is the part that attaches a rib to the vertebrae. The neck of the rib lies just adjacent to head of the rib.
- **Shaft:** It is the length of a rib, and has costal grooves from where the blood vessels and nerves pass.

- **Tubercle :** It is the terminal (end) part of a rib which get attached to vertebrae of the thorax.

Types of Ribs

Ribs can be sub-divided into 3 categories as follows:

1) **True Ribs:** These ribs are directly attached to the sternum (via cartilages).

2) **False Ribs:** These ribs which are not directly attached to the sternum.

3) **Floating Ribs:** These ribs are not attached to the sternum.

Functions of the Rib Cage

➲ **Motion:** Since the thoracic cage is bifurcated into ribs and vertebrae, this allows the mobility to the thorax region.

➲ **Costal Breathing:** The ribs are attached to the costal cartilage in a specific manner which helps in costal breathing

➲ **Protection:** Rib cage encapsulates several organs like heart and lungs thus protecting them from damage.

Sternum

→ Sternum or breastbone is a T-shaped or dagger-shaped long flat bone, located at the centre of the thorax (chest).

→ It lies in the centre of thoracic cavity where it is joined to the ribs with the help of cartilages and forms the frontal part of the rib cage

→ This rib cage protects the heart, lungs, major blood vessels, etc., from physical injury or damage.

Functions of Sternum

1) It completes the rib cage circle thus protects the vital organs.

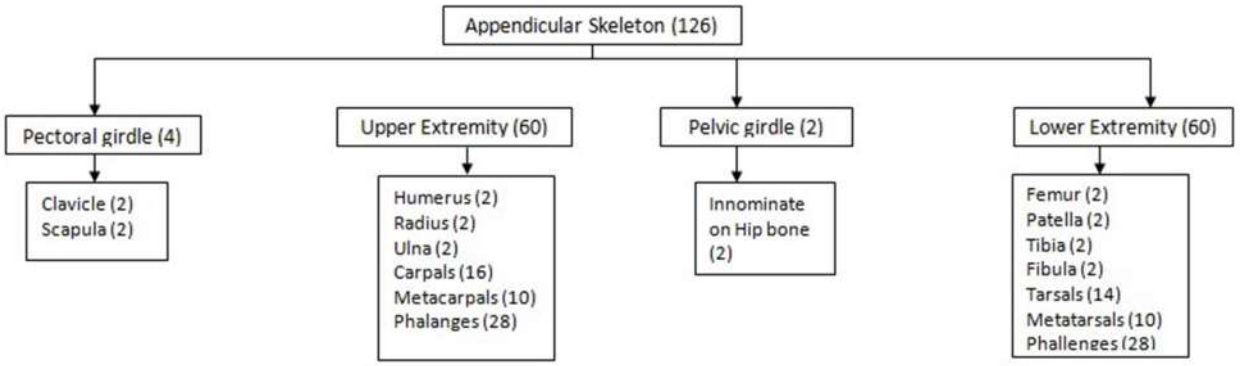
2) Ribs are connected to sternum via costal cartilages, thereby providing flexibility.

3) It also protects the aorta, vena cava, and thymus.

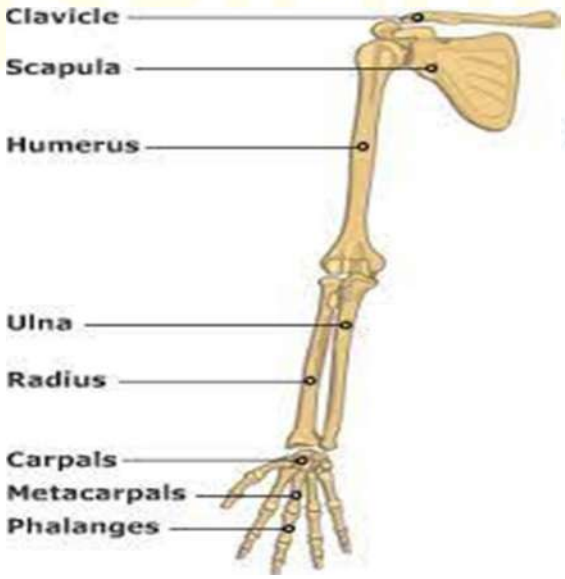
4) It fills the space in the mid-region of the chest just above the lungs and the heart.

Appendicular skeleton

- Appendicular skeleton is the bony framework of upper and lower limbs and their supporting girdles including 126 bones that anchor the appendages to the axial skeleton



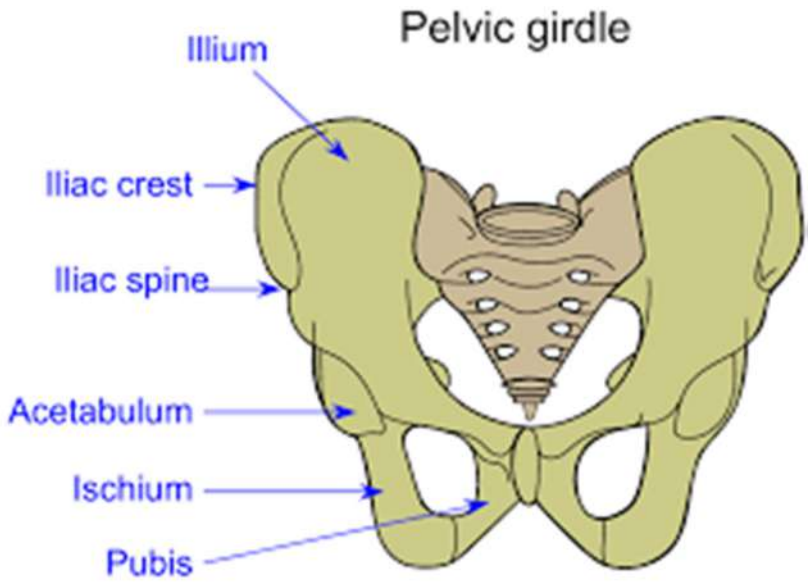
Structure and Function of Upper Extremity or Limb



Each upper limb consists of 30 bones which are divided broadly into the following 3 parts:

- **Humerus or Arm Bone:** It is the longest bone of the forelimb The head of the humerus articulates within the glenoid cavity of the scapula.
- Distally, it is joined with radius and ulna at the elbow joint. This bone enables the upper extremity to perform physical activities like pull, push, lift, and rotation of objects within the arm's length.
- **Ulna and Radius:** These bones together form the bones of the forearm
- **Ulna:** It forms the medial bone of the forelimb
- **Radius:** It is the lateral bone of the forearm. The upper surface of the radius articulates with the capitulum of the humerus, while the distal end articulates with the ulnar head
- **Carpals and Metacarpals:** 8 irregularly shaped bones known as carpals are arranged in proximal and distal rows The proximal carpals include scaphoid, lunate, triquetral, and pisiform while the distal carpals include trapezium, trapezoid, capitate, and hamate. There are 5 metacarpals which are numbered from lateral to the medial side and have the head, shaft, and a base.
- **Phalanges:** There are 14 phalanges present in a single hand, of which 2 are present in the thumb while the rest 12 phalanges are present in the 4 fingers (3 in each finger).

Structure and function of pelvic girdle



Pelvic girdle is an irregular, arch-shaped structure made up of coxae or innominate bones. The arch of the pelvic gridle is articulated by a highly flexible structure called symphysis pubis

The bones comprising pelvic girdle include

- **Ilium:** It is the upper expanded part of the hip bone having a plate-like structure.
- The external surface of the ilium acts as an attachment site for gluteus muscles such as gluteus maximus, medius, and minimus. Ilium is further divided into the following 3 parts:
- **Sacroiliac Joint:** It is the point of attachment for sacrum and ilium.
- **Greater Sciatic Notch:** It acts as a pathway through which sciatic nerve passes towards the leg.
- **liac Fossa:** It is the flat surface of the ilium.
- **Ischium:** It forms the posterior inferior region of the hip bone. It contains the body and ramus along with ischial spine and ischial tuberosity (or tuberosity)
- **Obturator Foramen:** It is a large hole through which the blood vessels and nerves pass. A fibrous membrane covers it, almost closing it completely.
- **Ischial Tuberosity:** It is the rough and thick surface of the ischial body.
- Since this is the strongest part of the hip. it supports the whole body weight at the time of sitting.
- **Acetabulum:** It is a wide socket-like cavity that holds the head of the femur or thigh bone
- **Pubis:** The anterior-inferior part of the hip bone has three parts, superior ramus, inferior ramus, and body. These 3 bones together form the pubis and meet to form a small area like a deep socket called acetabulum. This socket articulates with the femur bone. In order to

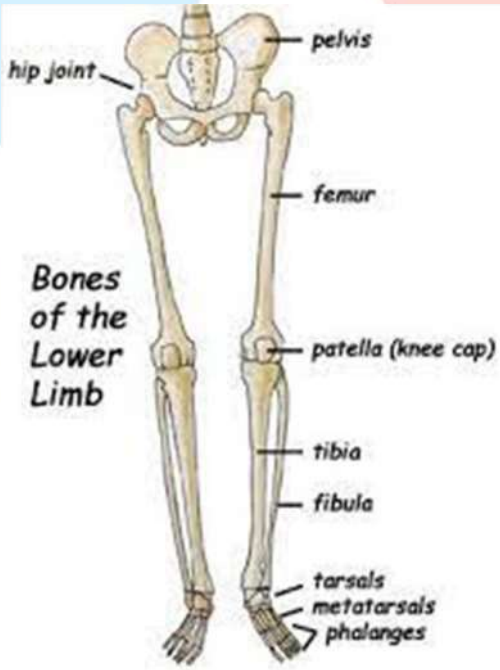
facilitate pregnancy and childbirth (parturition), the pelvis of females is extremely flexible.

Functions of Pelvic Girdle

1) Support: The weight of the body from the vertebral column is supported by the pelvic girdle.

2) Protection: It supports and protects the organs related to the reproductive and urinary system as well as the developing foetus in pregnant females.

Structure and Function of Extremity or Limb

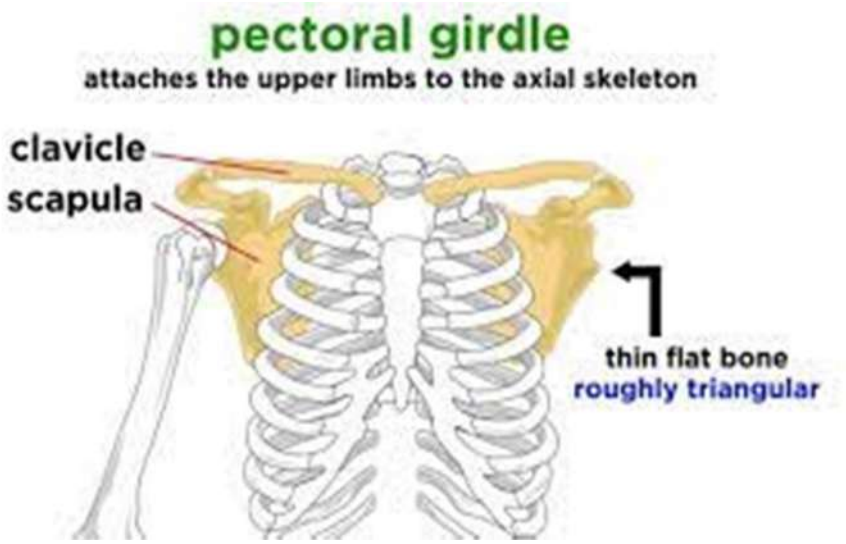


The lower limb comprises of 30 bones as given below:

- **Femur:** It is the strongest and longest bor.: of the human body The head, present at the upper end of the femur articulates with the hip bone.
- **Patella:** It is a sesamoid bone located right in front of the distal end of the femur.

- **Tibia:** It is the larger bone of the lower leg and is locatedmedially The medial condylar end of tibia articulates with the lower end of the femur.
- **Fibula:** It is the lateral bone present in the lower limb whose head of upper end snows articulation with the lateral condyle of the tibia
- **Tarsal:** Proximal and distal row of foot tarsal bones consists of 7 The proximal row consists of talus and calcaneus, while the distal row of consists medial cuneiform, intermediate lateral cuneiform, cuneiform, cuboid, and navicular bone
- **Metatarsals:** These bones articulate uniform and cuboid proximally with bones, and distally with phalanges.
- **Phalanges:** There are total 14 phalanges in a single foot; 2 of them for great toe each, while 3 are in present the rest 4 fingers each. The hallux or the big toe has 2 phalange
- The foot contains 2 additional bones known as sesamoid bones. The muscle of big toe is known as flexor hallucis longus and contains tendons which aid in the growth of such small bones

Pectoral Girdle



Skeletal muscle

- Skeletal muscle is a type of voluntary, striated muscle tissue attached to bones by tendons. It is responsible for body movements, posture, and heat production, and is controlled by the somatic nervous system.

Organization of skeletal muscle

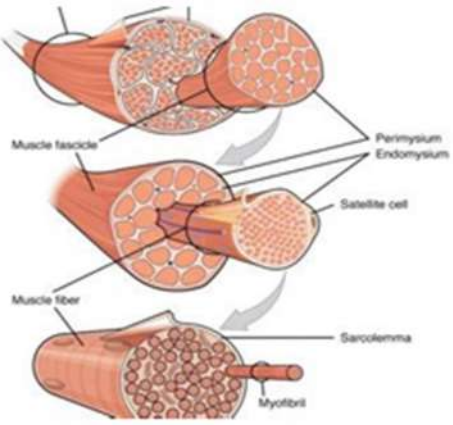
Skeletal Muscle Tissue

→ Skeletal muscles are made up of hundreds to thousands of cells which are called as muscle fibres.

→ The muscle fibres are of elongated shapes. The outermost layer encircling the entire muscle called as epimysium. Perimysium surrounds a group of 10 to 100 or more muscle fibres separating them into bundles called as fascicles.

→ Endomysium is a sheath of areolar connective tissue that penetrates the interior of each fascicle and separates individual muscle fibres from one another.

→ The epimysium, perimysium and Endomysium binds the fibres into highly organized structure and blends together at the end of muscles to form tendons which are rope shaped but sometimes it takes sheet like structure called as aponeurosis. The tendon attaches the muscle to bones.



Components of skeletal muscle

Skeletal Muscle Fiber

→ It is roughly cylindrical in shape. They lie parallel to one another with alternate dark and light strips.

→ Individual fibre may be very long, upto 25 cm in the longest muscle.

→ Each cell has several nuclei which are situated just under the cell membrane called as sarcolemma.

→ The cytoplasm of muscle cells is called as sarcoplasm. Skeletal muscle fibres contain many mitochondria which are used for production of ATP from glucose and oxygen.

→ Sarcoplasm also contains red coloured, oxygen binding protein called as myoglobin which stores oxygen within the molecule

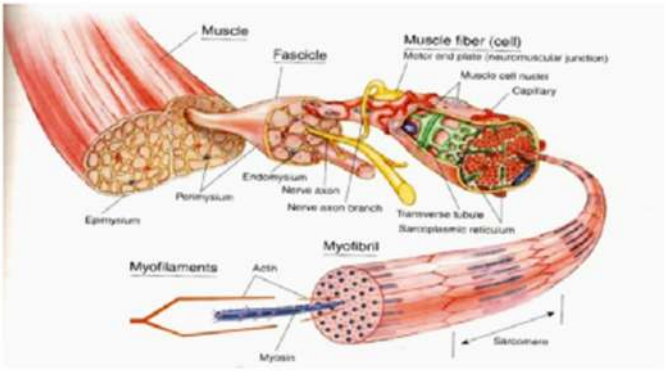
Myofibrils and Sarcoplasmic Reticulum

→ At higher magnification, the sarcoplasm appears stuffed with little threads.

→ These small structures are called as myofibrils. Myofibrils are about 2 um in diameter.

→ A fluid-filled system of membranous sacs called as sarcoplasmic reticulum or SR encircles each myofibrils. In relaxed muscle fibre, the SR stores calcium ions.

→ Release of calcium from the terminal cisterns of the SR triggers muscle contraction.



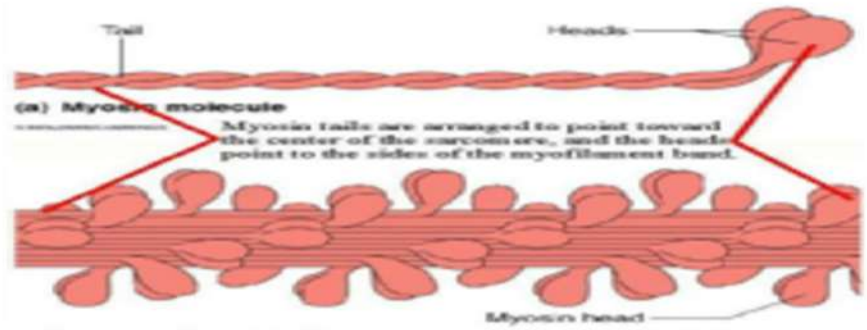
Components of skeletal muscle fibre

Filaments and Sarcomere

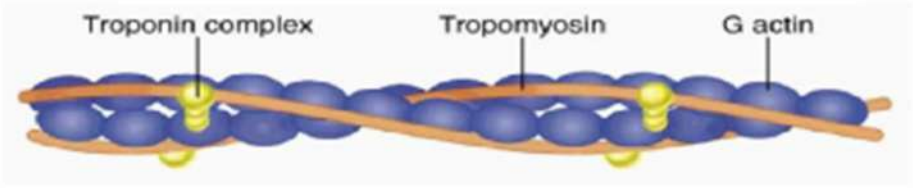
→ Within myofibrils are smaller structure called as filaments.
→ Two types of filaments are present:

- ✓ Thin filament
- ✓ Thick filament

→ Thin filaments are 8 mm in diameter and 1-2 um long.
→ Thick filaments are 16 mm in diameter and 1-2 µm long.
→ Both these thin and thick filaments are involved in contraction.
→ The filaments in the myofibrils do not extend the entire length of a muscle fibre.
→ Instead they are arranged in compartments called as sarcomere, the basic functional unite of myofibrils. Z-discs separate one sarcomere from the next.



Thick filaments of myosin molecule



Thick and thin filament

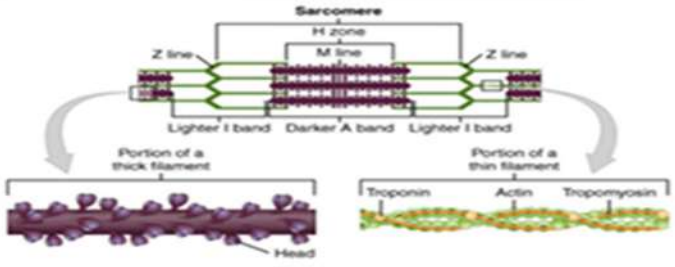
→ Sarcomere is the repeating contractile units of myofibril. It is a segment consisting of a highly organised assembly of filaments delimited by two Z lines.

→ Two important proteins namely actin and myosin form thin and thick filaments respectively.

→ The filaments partly overlap and slide past each other during contraction. Perpendicular protein plates called Z discs form the lateral boundaries of a sarcomere.

→ During contraction, the thick filaments pull the thin filaments towards the centre of the sarcomeres.

→ This movement causes the sarcomere, myofibrils and the muscle fibres to shorten.



Sarcomere

→ **Muscle protein:** Myofibrils are made up of three types of proteins.

→ **Contractile protein:** It helps in contraction process.

→ **Regulatory protein:** It regulates the contraction process by switching on or shutting the process

→ **Structural protein:** It keeps thick and thin filaments in proper alignment and is responsible for myofibril elasticity and extensibility.

→ Thick filaments are made up of protein called as myosin. Thin filaments are made up of protein called as actin. Smaller amount of two regulatory proteins, tropomyosin and troponin are also part of thin filament.

Physiology of Muscle Contraction

- The contraction of muscles is also called muscle twitch or twitch.
- Twitch takes place with change in the length of a muscle fibre, i.e., the fibre either increases or decreases in length.
- Central nervous system, comprising of brain and spinal cord, controls the process of muscle contraction.
- The muscle contractions which are voluntary in nature are controlled by the brain, while the Involuntary reflexes are controlled by the spinal cord.
- The simple implication of the term contraction is a shortening or reduction in the length of the muscle fibre.

The following steps are involved in muscle contraction

- A stimulus for muscle contraction is generated in CNS either as voluntary activity froup the brain or as a reflex activity from the spinal cord.
- The motor neuron within the ventral born of the spinal cord is activated and an action potential is produced which passes outward into the ventral root of the spinal cord A motor unit is formed by the aggregation of a number of muscle fibres. An action potential is carried to a motor end plate on every muscle fibre.
- The electrical resting potential under the motor end plate changes by the action of Ach. This generates an action potential that passes along the surface of muscle fibre in both the directions
- The action potential spreads inside the muscle fibre at the site where each transverse tubule opens onto the surface of the muscle fibre.
- Ca ions are released by the sarcoplasmic reticulum at every point where a transverse tubule comes in contact with a part of the sarcoplasmic reticulum
- The Ca+2 ions cause movement of troponin and tropomyosin on their thin filament. In be d
- This allows movement of myosin molecule head along the thin filament to generate a driving force of contraction.

Neuromuscular junction (nmj)

→ The neurons that stimulate the skeletal muscle fibres to contract are called somatic motor neurons.

→ Neuromuscular junction is the synapse between a somatic motor neuron and a skeletal muscle fibre.

→ A synapse is a region between two neurons, or between a neuron and a target cells(between somatic motor neuron and muscle fibre).

→ Synapse contains a small gap, called as synaptic cleft which separates the two cells.

→ The first cell communicates with the second cell by releasing a chemical called as neurotransmitter.

→ At the NMJ, the end of the motor neuron called as axon terminal, divides into a cluster of synaptic end bulbs.

→ Suspended in the cytosol within each synaptic end bulb contains hundreds of membrane- enclosed sacs called synaptic vesicles.

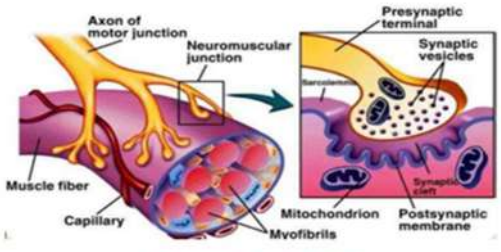
→ Inside each synaptic vesicle are thousands of molecules of acetylcholine (Ach), the neurotransmitter released at the NMJ.

→ The region of the sarcolemma opposite the synaptic end bulbs, called the motor end plate is the muscle fibre part of the NMJ.

→ Within each motor end plate are 30 to 40 million acetylcholine receptors are present.

→ These receptors are abundant in the motor end plate that provides a large surface area for ACh.

→ A neuromuscular junction includes all the synaptic end bulbs on one side of the synaptic cleft, plus the motor end plate of the muscle fibre on the other side.



Neuromuscular junction (NMJ)