Chapter 4

Osseous System

→ A skeleton is a framework of joints bones that forms the supporting structure of the body It helps to stand straight to move to perform any physical activity and also aids in breathing.

→ The skeletal system comprises of bones, Cartilages, Tendons, and ligaments It closely related to the muscular system Bones and cartilages are connective tissues.

→ Bones comprises of minerals salts like calcium phosphate that sets into the inorganic matrix of the bony tissue. It gives a "dead" stone-like appearance to the bones.

Bones

➢ 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.

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.
Therefore, these bones are formed in the palms of the hands and the soles of the feet (patellae (knee caps))

→ **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.

Structure of Skeleton

The human skeleton can be broadly divided into two groups:

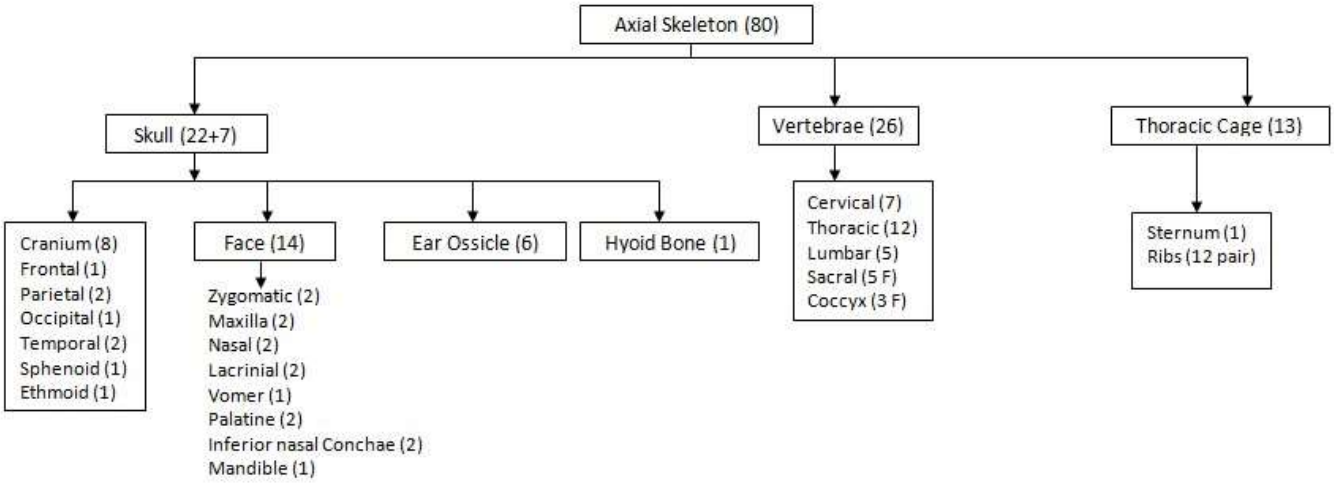
- Axial skeleton, and
- Appendicular skeleton.

Function

1) **Shape and support :** Bones act as a structural framework which provides support and keeps the body in shape
2) **Protection:** Many vital organs of the body are protected by the skeletal system as it helps in holding the organs at their places.
3) **Movement:** Bone and muscle interaction (studied in biomechanics) helps in different body movements.
   Various parts like bones, skeletal muscles, ligaments, joints, and tendons altogether generate and transfer forces to aid in physical movements of the whole body or that of some parts in three-dimensional space.
4) **Acid-Base Balance:** The alkaline salts such as calcium are either absorbed or released by the bones, which helps in buffering of the pH of blood.
5) **Mineral Storage:** Bones also act as a mineral reservoir especially for calcium and phosphorus.
6) **Blood Production:** Bones also participate in the process of haemopoiesis in which erythrocytes are produced by marrow present in the medullary cavity of long bones and interstitial spaces of cancellous bone.
7) **Detoxification:** Heavy metals and foreign elements are also absorbed by bone tissues, i.e., they are removed from the blood and thus, the impact of such foreign elements and heavy metals on other tissues is also decreased.
   These absorbed toxins can be eliminated gradually by the process of excretion.
8) **Sound Transduction:** Mechanical processes of hearing are carried out with the help of bones.

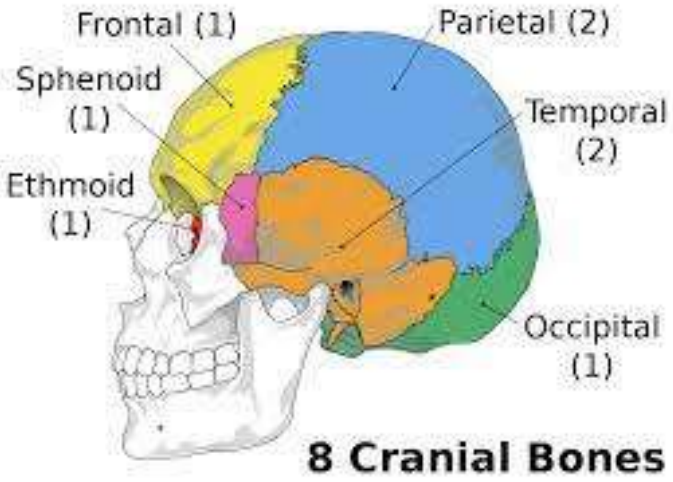
AXIAL SKELETON

➲ 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

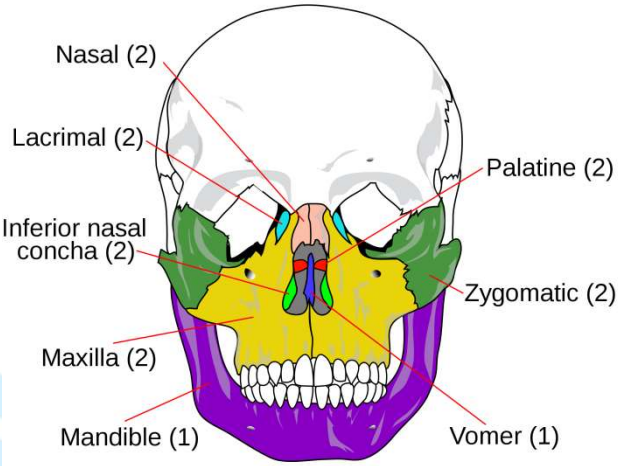
1) It protects brain.

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



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

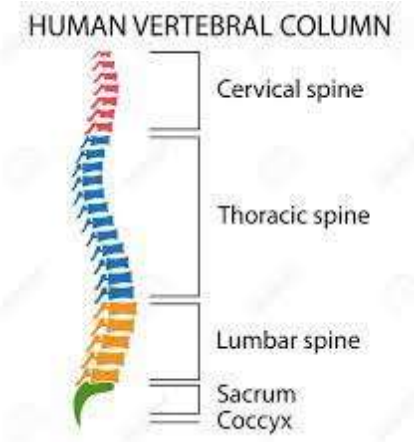
→ Hyoid bone is a horseshoe shape bone and is also known as the lingual bone. It is located at the middle of the neck, in between thyroid cartilage and chin; and forms the floor of the oral cavity.
→ Thyroid ligament holds this bone at its place.
→ Hyoid is the only skeletal bone which is not attached 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

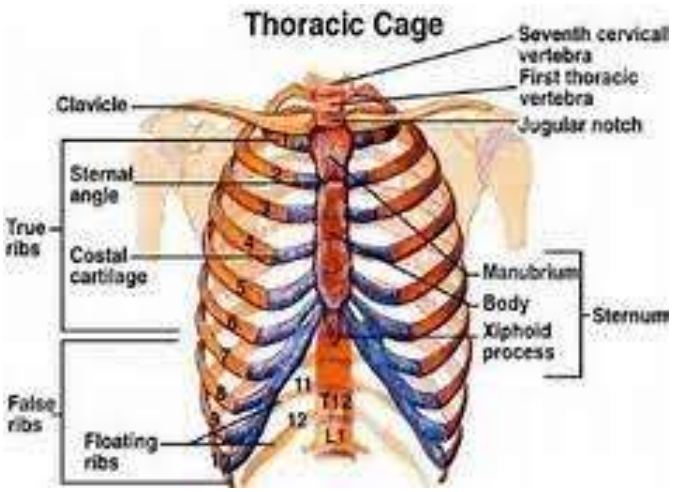
Functions of Vertebral Column

- ➲ 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

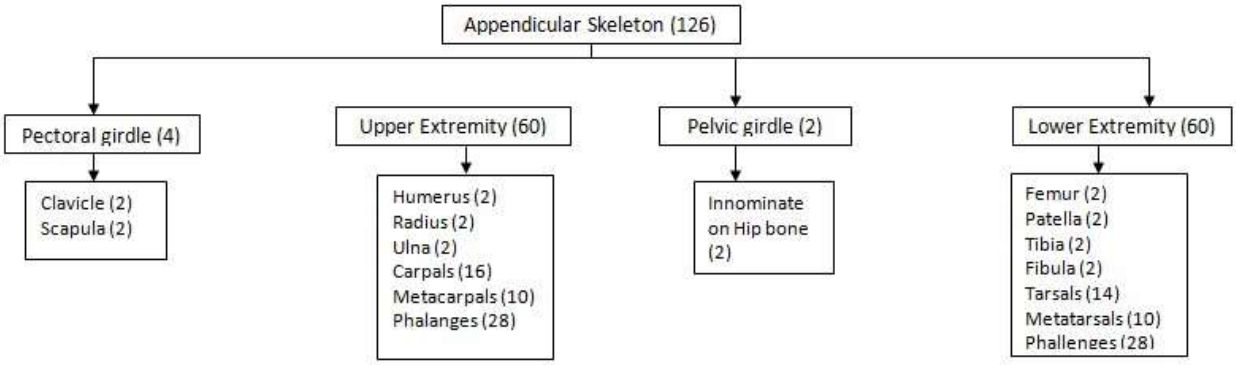
→ This rib cage protects the heart, lungs, major blood vessels, etc., from physical injury or damage.

Functions of Sternum

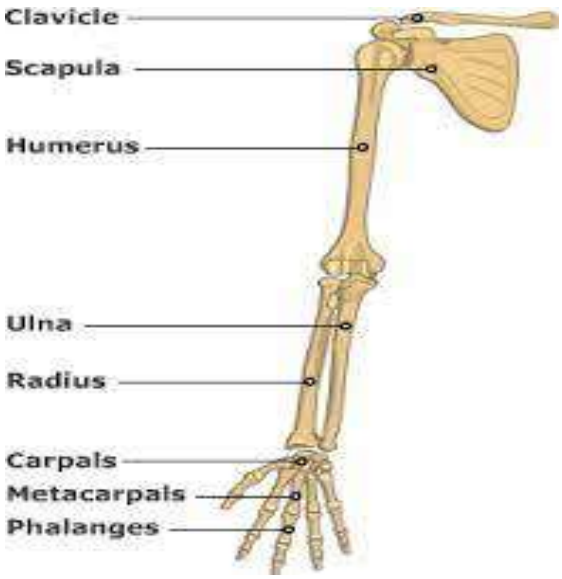
1) It completes the rib cage circle thus protects the vital organs.
2) Ribs are connected to sternum via costal cartilages, thereby providing flexibility.
3) It also protects the aorta, vena cava, and thymus.
4) It fills the space in the mid-region of the chest just above the lungs and the heart.

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



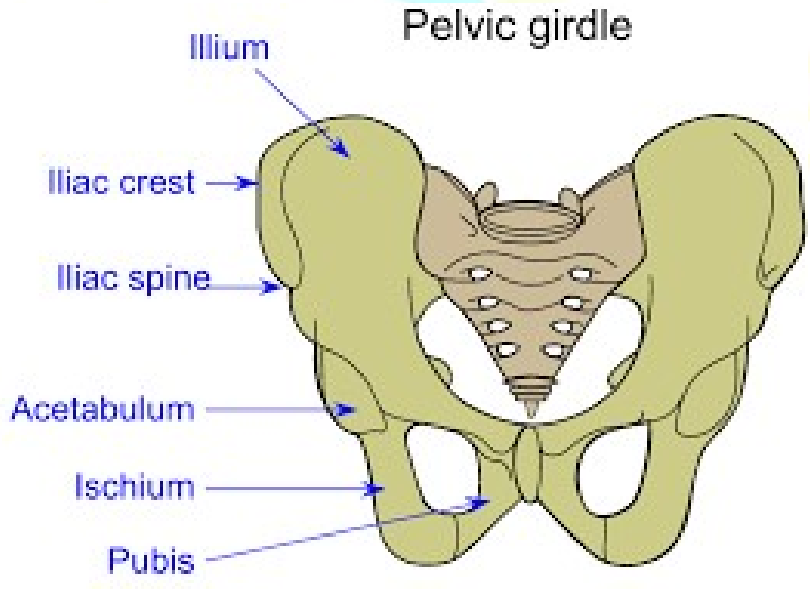
Structure and Function of Upper Extremity or Limb



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.

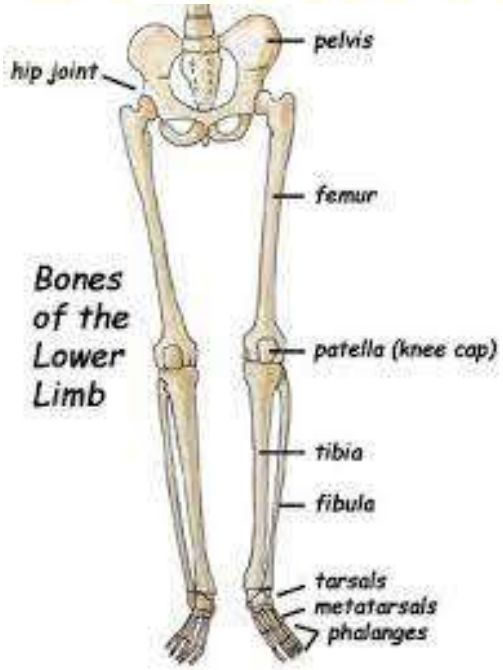
- **Greater Sciatic Notch:** It acts as a pathway through which sciatic nerve passes towards the leg.
- **liac Fossa:** It is the flat surface of the ilium.
- **Ischium:** It forms the posterior inferior region of the hip bone. It contains the body and ramus along with ischial spine and ischial tuberosity (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

Joints

- The site where more than two bones meet to carry out the movement is known as a joint or articulation', More than 100 types of joints are present in the human body.
- These Joints are attached such that they perform different movements, as required.
- There are movable and non-movable joints in the body.
- Only the movable joints allow different kinds of movements.
- The structure of the joint is the governing factor for the type, direction, and degree of movement.
- The joints serve a dual purpose, i.e., holding of bones together as well as allowing skeletal movement, The hyoid bone present in the neck is the only one which does not articulate with any of the bones.

Classification of Joints and Their Function

→ The categorisation of joints is done according to the extent of movement they show. The examples of fixed joints include joints present in the skull, showing no movement. While the joints of the vertebral column show slight movement, the synovial joints provide maximum movement to the body since they are freely movable.

Broadly, the joints are classified on the following basis:

1. **Functional Classification:** Functionally, joints are classified into three types, based on the degree of mobility of the joint:

Types of Joint	Synonyms	Mobility Degree
Synarthrosis	Immovable joints	No mobility
Amphiarthrosis	Slightly movable joints	Some degree of mobility
Diarthrosis	Freely movable joints	Maximum degree of mobility

2. Structural Classification: Structural classification of joints is done on the basis of the connecting tissue present and on the basis of the presence or absence of a joint cavity. Structurally, joints are of three types:

i) Fibrous joint.
ii) Cartilaginous joint, and
iii) Synovial joint.

Movements of Joint

There are generally four types of joint movements:

→ **Gliding:** One of the simplest motions existing between two adjacent surfaces is the gliding motion. The process of gliding takes place when the surface of a flat bone glides over the other bone, in either to and fro motion or by moving side by side, without any angular or rotary motion.

→ **Angular:** In this type of movement, the angle formed between the two adjacent bones is either decreased or increased. Some common types of angular motion

→ **Rotation:** This type of movement occurs when a bone turns along its own axis. This movement is commonly seen in the atlas and axis vertebrae, and the joints of shoulder and hip.

→ **Circumduction:** Circumduction is the movement (of a limb or eyes) in a circular direction (i.e. 360)

Disorders of Joint

Some of the common joint disorders are

1) Rheumatoid arthritis,
2) Gout,
3) Bursitis,
4) Joint dislocation, and
5) Osteoarthritis.

Rheumatoid arthritis

→ Rheumatoid arthritis is progressive a inflammatory, musculoskeletal disorder which affects multiple joints, connective tissues, muscles, tendons, and fibrous tissues Joint Dislocation

→ Joint dislocation is a condition in which a joint slips out of its place, when bone ends shift from their normal positions. Joint dislocation results in its functions loss.

→ The degree of severity depends on site of joint dislocation as different joints have different healing power.

Causes

1)Severe blow, fall, or any other trauma affecting the joint,
2) Disease or defective ligaments, and
3) Rheumatoid arthritis.

Signs and Symptoms

The affected joint will be:

1) Visibly deformed or out of place,
2) Very painful,

Osteoarthritis

- Osteoarthritis or degenerative arthritis is a common disease of joints that involves inflammation, pain, and degeneration of joints. The word osteoarthritis derived from Greek words where osteo means bone, arthro means joint, and itis means inflammation. It is also known asdegenerative joint disease or arthrosis or wear and tear (in common language). Osteoarthritis results due to deterioration of cartilage, present around joints for their protection and support.

Causes

1) Hereditary/genetic,
2) Injury,
3) Inflammatory diseases or disorders,
4) Tendonitis (inflammation of tendon sheaths) and bursitis,
5) Injury of protective caps of cartilage covering the bone ends,

Signs and Symptoms

Osteoarthritis can occur in any joint. However, the most commonly affected areas of the body include the hands, fingertips, knees, hips, spine, typically at the neck or lower back. Any joint can be affected with osteoarthritis, but thefrequently affected areas are hands, fingertips, knees, hips, spine, typically at the neck or lower back. The common symptoms of osteoarthritis are:

1) Pain,
2) Tenderness (discomfort when pressing on the area with your fingers),
3) Stiffness, and
4) Inflammation.
5)The pain and inflammation of and surrounding area increases as the condition of Osteoarthritis advances

THANK YOU