SSR DEGREE COLLEGE (AUTONOMOUS)
DEPARTMENT OF MEDICAL LABARETORY TECHNOLOGY
PAPER –I HUMAN ANATOMY
UNIT WISE IMPORTANT QUESTIONS

Unit–I: HUMAN BODY, LOCOMOTION & SUPPORT

Short Questions (4 Marks)

1. Define Anatomy and mention its subdivisions.
2. Explain fundamental anatomical planes.
3. Write a short note on vertebrate structure of man.
4. Define and classify joints.
5. Write the differences between axial and appendicular skeleton.

Long Questions (10 Marks)

1. Describe the structure and classification of bones with examples.
2. Explain the types of joints and movements with examples.
3. Discuss the organization of the body cells and tissues in detail.
4. Write about the divisions of the human skeleton and name all bones.

Unit–II: ANATOMY OF THE DIGESTIVE SYSTEM

Short Questions (4 Marks)

1. Name the components of the digestive system.
2. Write a short note on the alimentary tract.
3. Write about the salivary glands.
4. Mention the functions of the liver.
5. Write the anatomy of the pancreas.

Long Questions (10 Marks)

1. Describe the anatomy of the digestive system with a neat labeled diagram.
2. Explain the anatomy of mouth, pharynx, salivary glands and esophagus.
3. Write in detail about the liver, biliary apparatus, and pancreas.
4. Explain the anatomy of the intestine and pancreas.

Unit–III: ANATOMY OF THE RESPIRATORY SYSTEM

Short Questions (4 Marks)

1. Name the organs of the respiratory system.
2. Write a short note on nasal cavity.
3. Mention the anatomy of larynx.

4. What is the respiratory membrane?
5. Write about trachea or bronchi (any one).

Long Questions (10 Marks)

1. Describe the anatomy of the respiratory system with neat labeled diagram.
2. Explain the structure and functions of lungs.
3. Write the anatomy of larynx, trachea, and bronchi.
4. Describe the respiratory membrane and its importance.

Unit–IV: ANATOMY OF THE CIRCULATORY SYSTEM

Short Questions (4 Marks)

1. Write the parts of circulatory system.
2. Write short notes on arteries, veins, and capillaries.
3. Define pulmonary and systemic circuits.
4. Mention the components of blood.
5. Write a short note on lymphatic system.

Long Questions (10 Marks)

1. Describe the anatomy of heart with a neat labeled diagram.
2. Explain the structure and functions of blood vessels.
3. Write in detail about circulatory system circuits (pulmonary, systemic, coronary).
4. Explain the lymphatic system and its functions.

INTRODUCTION

Skeletal system, the structure of the bones of the body, consists of 206 bones, 80 of the torso and 126 of the arms and legs. Bones support the body, give it shape and they protect the body parts. Apart from these, some big bones of the body like the femur of the leg produce blood.

Movements occur at the joints of one or more bones. These movements occur as a result of the skeletal muscles being excited and contracting by the nervous system, that is, with the co-operation of the nervous system, the movements take place in the joints, which prove that no single institution can function alone.

Bone organization consists of bones, cartilages and some membranes.

FUNCTIONS OF BONE

1. **Assist in Movement:** It provides the ability to move the bone joints freely with the help of muscles.
2. **Protection:** Bones protect many internal organs from injury.
3. **Storage of Energy:** A soft organic material that fills bone cavities is a store of energy.
4. **Site of Blood Cell Production:** Bone marrow found in bones helps in the production of red blood cells. This process is called Hemopoiesis.
5. **Support:** It helps to connect all the bones and cartilages of the body.
6. **Mineral Homeostasis:** It is a pool of minerals especially calcium and phosphorus etc. Bones maintain balance inside the body with the help of these minerals.
7. It acts as a framework and supports the soft tissues.

OSSIFICATION

There are two types of bone development:

1. **Intramembrane Ossification:** In intermembranous bone development, calcium salts accumulate in place of dense connective tissue and form bone. This is how the bones of the skull are formed.

2. Most of the bone development takes place through the inter-cartilaginous process. In this, bones are replaced by cartilages.

SHAPE OF THE BONES

According to the structure and shape in the human body, there are the following types of bones:

1. Long Bones
2. Short Bones
3. Flat Bones
4. Irregular Bones
5. Sesamoid Bones

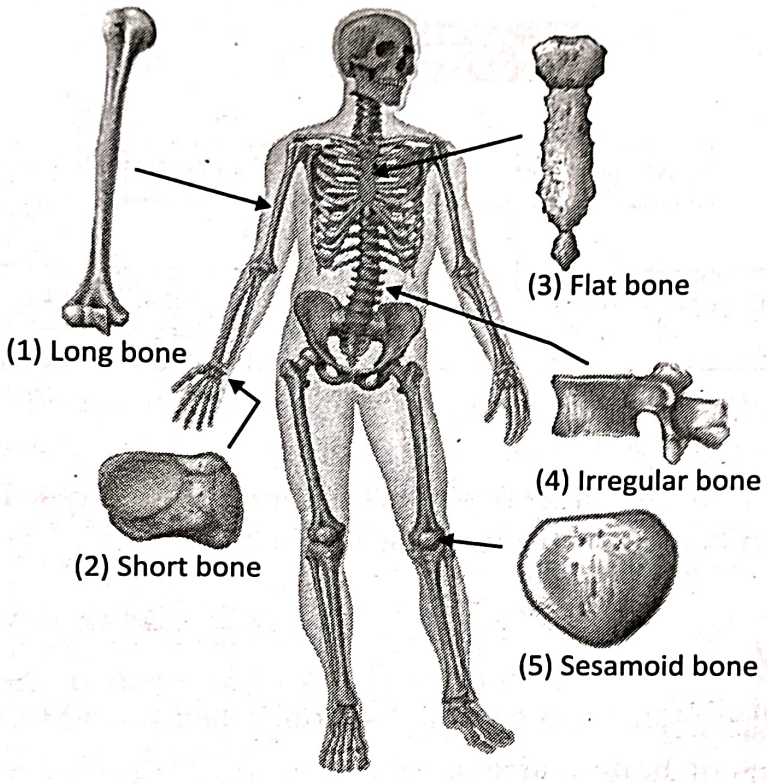


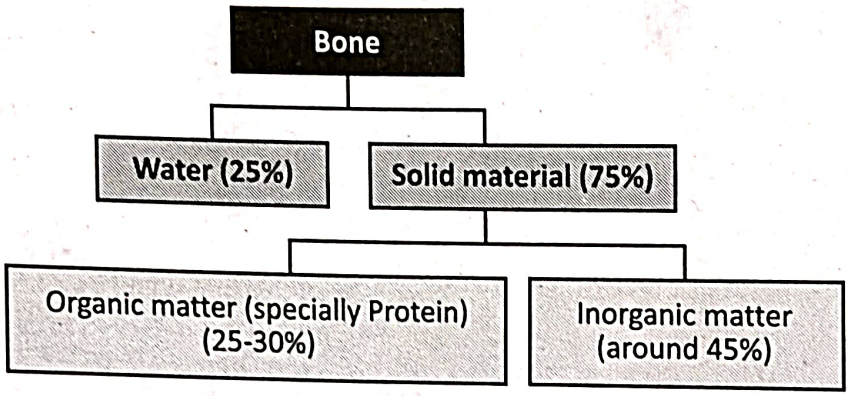
Fig. 6.1: ***Shape of the Bone***

1. **Long Bones:** In this type of bone, its length is more than the width. These types of bones are found in the arms. Examples of this are the femur tibia of the thigh, the fibula toes, some smaller than these, the humerus of the upper arm, the radius and ulna of the forearm. This type of bone has a variable number of Extremities (external organs). There is a shaft in it. These types of bones are slightly bent so that they can bear the load. It consists mainly of compact bone and parts of spongy bone tissue.
2. **Short Bones:** These types of bones are almost equal in length and width. They are cube shaped. Most of them are made up of spongy bone tissue, which is covered with a thin dense bone tissue. Examples of this are the bones of the wrist and knee where only limited movement is required.
3. **Flat Bones:** In flat bones, there is spongy bone tissue between two thin plates of compact bone in which red bone marrow resides. These types of bones are found in the body where the bones need to be protected. For example, the bones of the chest, bones of the skull, are found in the trunk and in the girdles of the shoulders and hips.

4. **Irregular Bones:** The structure of this type of bone is complex. They do not have a definite shape, such as the bones of the back and the bones of the face. They are made of spongy bone and are covered by a thin layer of compact bone.
5. **Sesamoid Bones:** These are small bones. Their number is variable. These types of bones are the bones that develop in the tendon and pass over a joint such as the patella.

COMPOSITION OF BONES

A fully developed bone contains the following substances:



1. The organic matter is ossein, mucoprotein and keratin etc. These keep the bones flexible.
2. Inorganic matter consists mainly of calcium and phosphorus. These inorganic substances maintain hardness and firmness in the bone.

BONE MARROW

Bone cavities are filled with a soft organic material called Bone Marrow.

There are two types of bone marrow:

1. **Red Bone Marrow:** Red bone marrow is involved in the formation of red blood cells and the haemoglobin present in them. Red bone marrow is found in the capillary tissue of the bone.
2. **Yellow Bone Marrow:** Yellow bone marrow which is found in the interstitial cavity of long bones is made up of fat cells and connective tissue. It does not participate in the formation of blood cells and haemoglobin.

THE SKELETON SYSTEM

The structure of bones and cartilages which protect the organs and helps in movement is called Skeletal System. It gives a definite shape to the body and keeps it straight. There are 206 bones in an adult Skeleton System.

It can be divided into two main parts:

1. Axial Skeleton
2. Appendicular Skeleton

1. AXIAL SKELETON

Under this, the bones located in a straight line of the body are included. It consists of the head and trunk which includes the skull, vertebral column, sternum and ribs.

There are 80 bones in axial skeleton, which are as follows:

1. **Skull 22 bones**
   Cranial bones (8) + Facial bones (14)
   (a) **Tranium Bones** ____ 8
   Frontal Bone ____ 1
   Parietal Bones ____ 2
   Temporal Bones ____ 2
   Occipital Bone ____ 1
   Sphenoid Bone ____ 1
   Ethmoid Bone ____ 1
   (b) **Facial Bones** ____ 14
   Zygomatic Bones ____ 2
   Maxilla Bones ____ 2
   Nasal Bones ____ 2
   Lacrimal Bones ____ 2
   Vomer Bone ____ 1
   Pelatine Bones ____ 2
   Inferior Conchae ____ 2
   Mandible ____ 1
2. **Hyoid Bone (Shaped like 'U')** ____ 1
3. **Ossicles of Ear** ____ 6
4. **Vertebral Column** ____ 26
   Separated Bones
   24 + 1 Sacrum + 1 Coccyx ____ 26
   Cervical ____ 7
   Thoracic ____ 12
   Lumbar ____ 5
   Sacrum ____ 1
   Coccyx ____ 1
5. **Thorax** ____ 25
   Sternum ____ 1
   Ribs ____ 24

2. APPENDICULAR SKELETON

There are 126 bones in Appendicular Skeleton.

1. **Pectoral Shoulder Girdle** ____ 4
   Clavicle ____ 2
   Scapula ____ 2
2. **Upper Extremities** ____ 60
   Humerus ____ 2
   Ulna ____ 2
   Radius ____ 2
   Carpals Bones ____ 16
   Metacarpals ____ 10
   Phalanges ____ 28
3. **Pelvic (Hip) Girdle** ____ 2
   Pelvic Hip and Coxial Bone ____ 2
4. **Lower Extremities** ____ 60
   Femur ____ 2
   Tibia ____ 2
   Fibula ____ 2
   Patella ____ 2
   Tarsals ____ 14
   Metatarsals ____ 10
   Phalanges ____ 28

Axial (80) + Appendicular (126) = 206 Bones

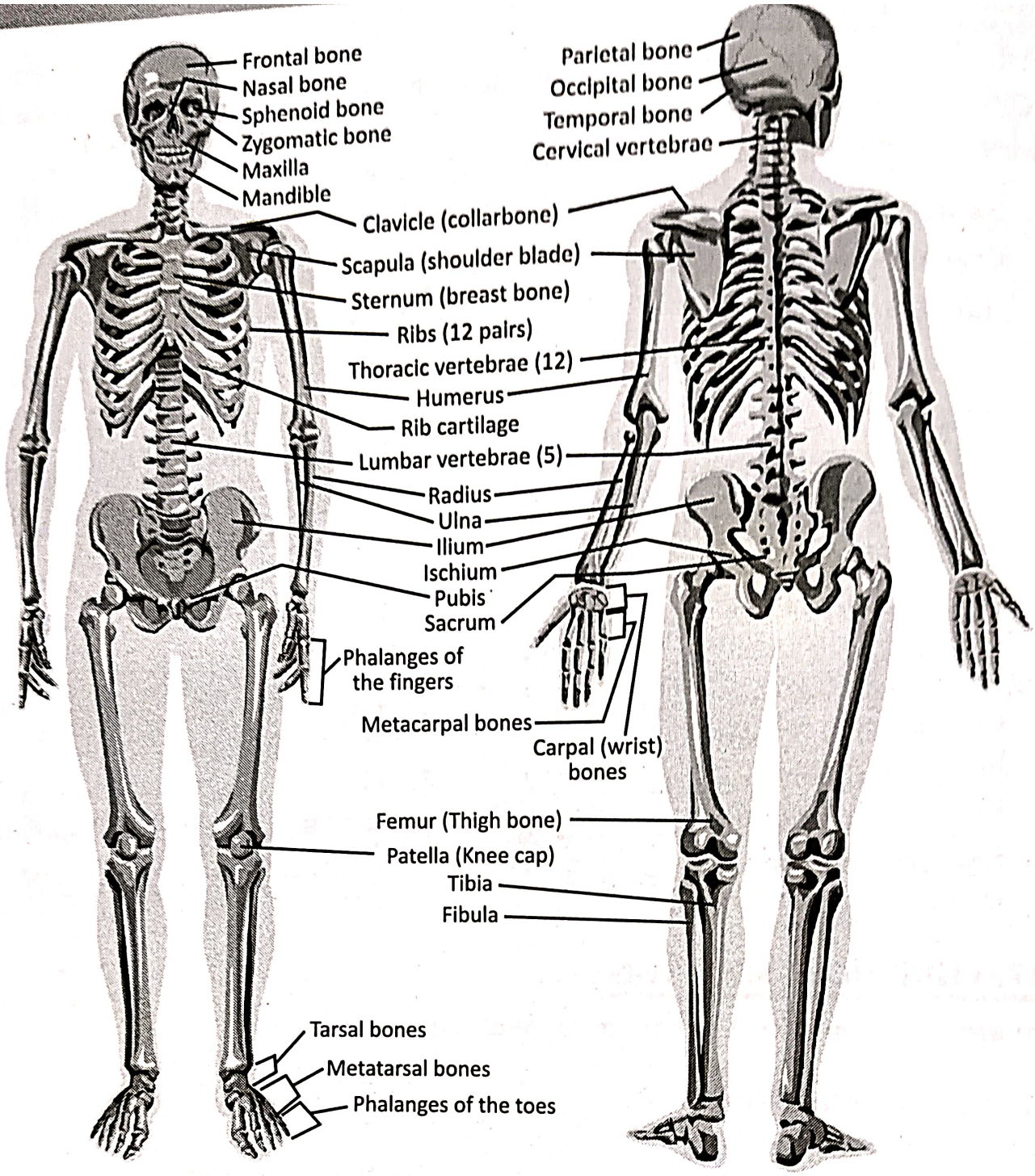


Fig. 6.2: ***The Skeleton***

AXIAL SKELETON

SKULL

The structure of the bones of the head which is made up of 8 cranial bones and 14 facial bones and teeth is called skull. It is the part of the skeleton that rests on the upper end of the vertebral column and its osteal structure is divided into two parts, the cranium and the face.

CRANIUM

The part of the skeletal system within which the brain remains closed is called the cranium. It is made up of flat and amorphous bones. It protects the brain.

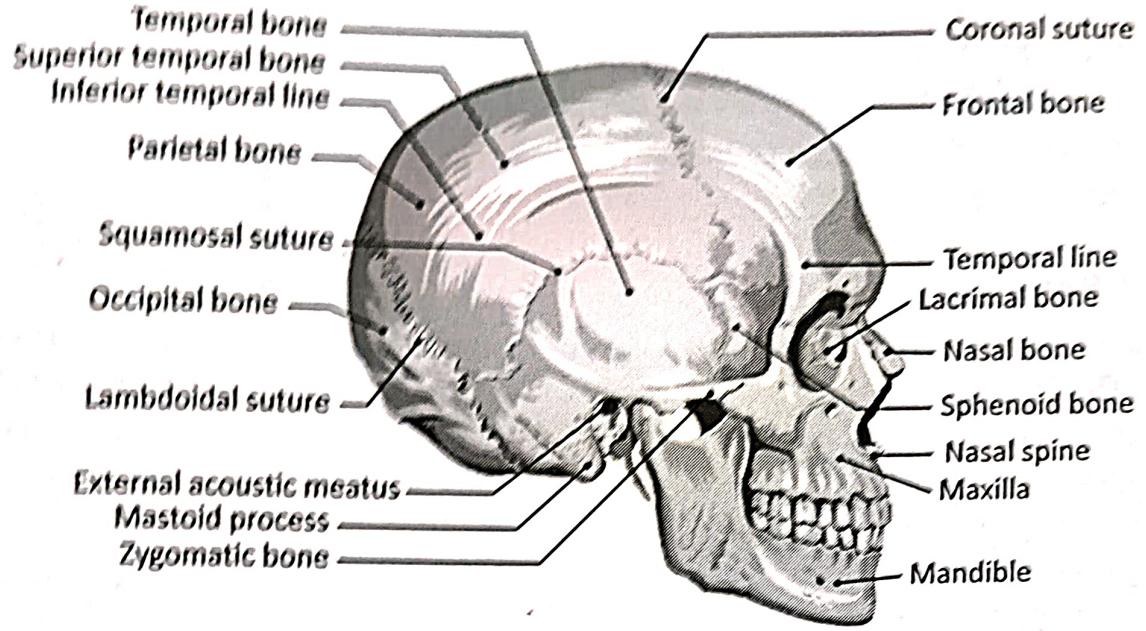


Fig. 6.3: Skull

The joint found inside the cranium is a fixed joint called a suture.

There are four types of suture:

1. **Coronal Suture:** This suture connects the forehead bone and the two parietal bones.
2. **Lambdoidal Suture:** This suture occurs between the parietal and occipital bones.
3. **Sagittal Suture:** It is located between the parietal bones.
4. **Squamons Suture:** This suture is visible in the parietal and temporal bones.

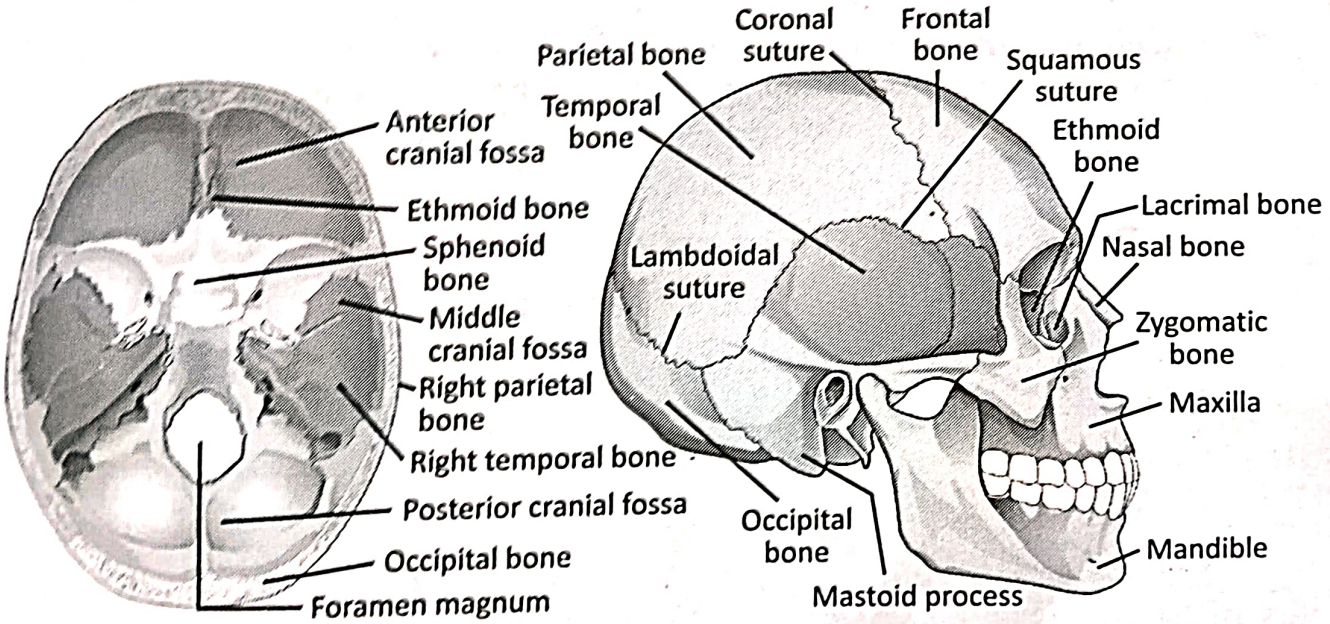


Fig. 6.4: The Bones of the Skull and their Joints or Suture

Bones of the Cranium

The cranial bones are as follows:

1. Frontal Bone of Forehead _____ 1
2. Parietal Bone _____ 2

3. Temporal Bones _____ 2
4. Occipital Bone _____ 1
5. Sphenoid Bone _____ 1
6. Ethmoid Bone _____ 1

Frontal Bone

It is a large flat bone that forms the roof of the forehead and eye-cavities. This bone two bulges. The first two have bulges on each side of the forehead, which are called frontal tuberosities and the other two are supra orbital ridges on each side of the eyes. In this bone there are asymmetrical shaped cavities called frontal sinuses which are located above each eye cavity towards the midline. They contain air which enters through small holes located in the venous cavities.

Parietal Bone

The parietal bones on both sides together form the roof of the skull and its right and left sides. Its inner surface is concave and contains the brain and blood vessels. This Coronal suture forms the sagittal suture, the lambdoid suture and the squamous suture.

Temporal Bones

One temporal bone is situated on both the sides of the head. Both the temporal bones make up the lower part of the skull. Each temporal bone has the following main three parts:

1. **Squamous Part:** From this part the front and upper part of the bone is formed, it is thin and flat. A long sloping, protruding bone, called the **Zygomatic Process,** continues to protrude from its lower part.

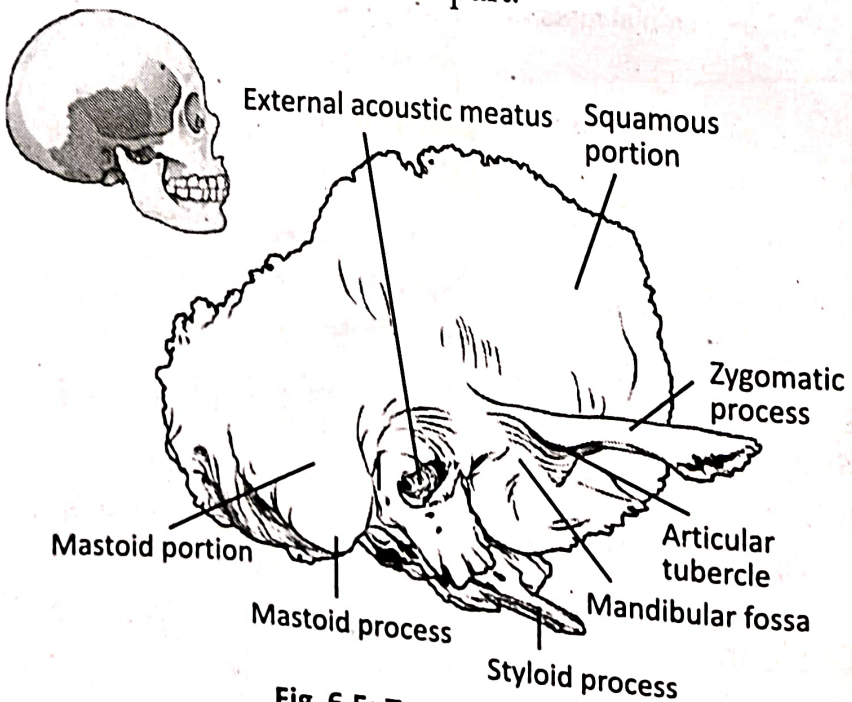


Fig. 6.5: *Temporal Bones*

2. **Mastoid Part:** It is a thick part behind the ear on either side, which extends down in the form of the mastoid zone. It consists of a large number of very small air sacs, which are related to the middle ear and which are lined by **squamous epithelium.** These air openings of the mastoid zone are called mastoid air sacs.
3. **Petrous Part:** This forms part of the base of the skull and the hearing aids are present in it. A pointed formation emerges from its descending surface, which is called **Styloid Process.**

Occipital Bone

It forms the back part of the skull. There is a raised part on it which is called external occipital. It provides space for the muscles to join. There is a large oval hole in it which is called **Foramen magnum.** Through this comes the medulla oblongata, the part of the brain that merges with the spinal cord as soon as it emerges from the foramen and there is a bulge or bony protrusion on either side of the Condyle, with the first cervical vertebrae (Alas) of the vertebral column. Together they form the atlanto-occipital joint. In this joint it is possible to move in only one direction.

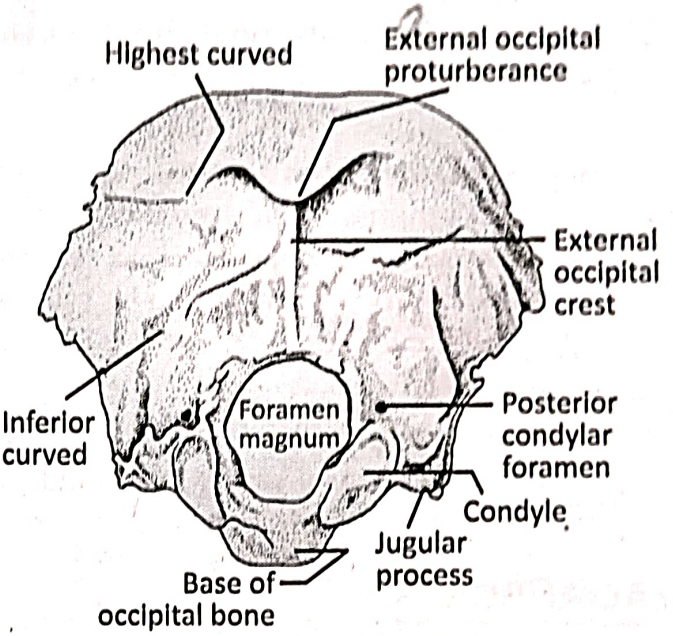


Fig. 6.6: ***Occipital Bone***

Sphenoid Bone

It lies in front of the temporal bone at the base of the skull. Its shape is like a bat with outstretched wings. In its main part there are two large air chambers, which are related to the nasal cavity.

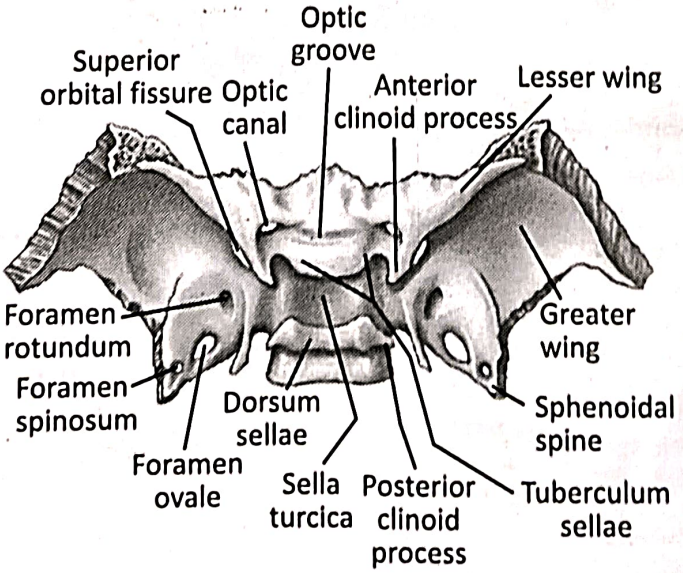


Fig. 6.7: ***Sphenoid Bone***

On the upper surface of the body there is a cavity called Sella Turcica or Hypophyseal fossa. In its large and small wing parts, there are many pores of nerve and blood vessels.

Ethmoid Bone

It is a light, sponge-like bone, which forms the roof of the nasal cavity and part of the floor between the anterior cranial fossa and the eye cavity. It is made up of three parts.

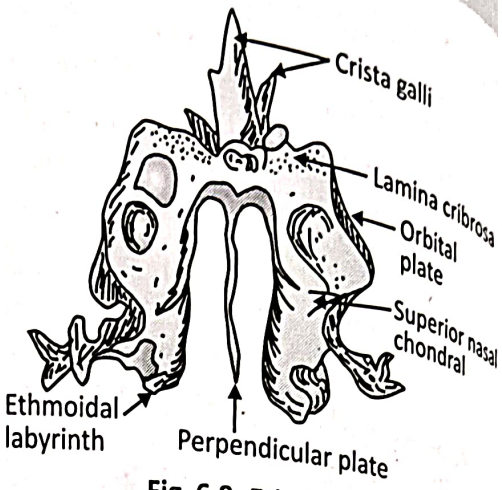


Fig. 6.8: *Ethmoid Bone*

1. Small cross plate, which is like a sieve with fine holes. It forms the upper part of the nose and through its pores, the Olfactory nerves come out.
2. Two Labyrinths (lateral nodules) each composed of several thin walled ethmoidal alveoli attached to the nasal cavity and may also be infected. Two thin plates of bone, called upper and middle nasal bone, protrude from the Labyrinths (spongy lateral body) into the nasal cavities.
3. The Perpendicular Plate moves down from the cribriform plate. Here, the upper part of the nasal cavity is formed. It divides the nasal cavity into two parts.

FACIAL BONES

There are mainly 14 bones in the bone structure of the face:

1. Zygomatic or Cheek Bones: 2
2. Maxillary Bones: 2
3. Nasal Bones: 2
4. Lacrimal Bones: 2
5. Vomer Bone: 1
6. Palatine Bones: 2
7. Inferior Conchae: 2
8. Mandible: 1

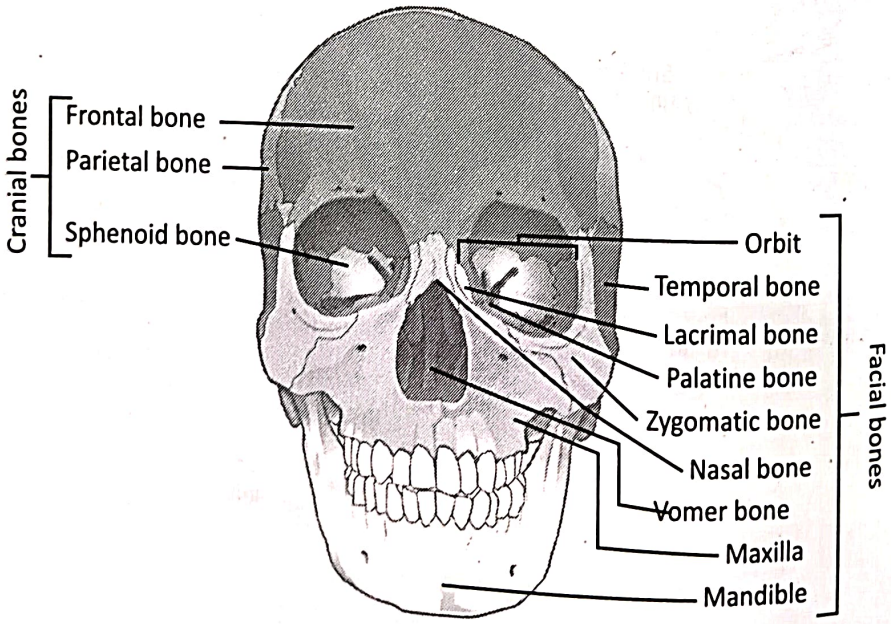


Fig. 6.9: *Facial Bones*

Zygomatic or Cheek Bones

These are irregular quadrangle-shaped bones located under the cheekbones on the face, which make the face appear full and the cheeks appear protruding. They form the floor of the eye cavities and part of the lateral walls. From these emerge the temporal region, which joins with the zygomatic region of the temporal bone to form the zygomatic arch.

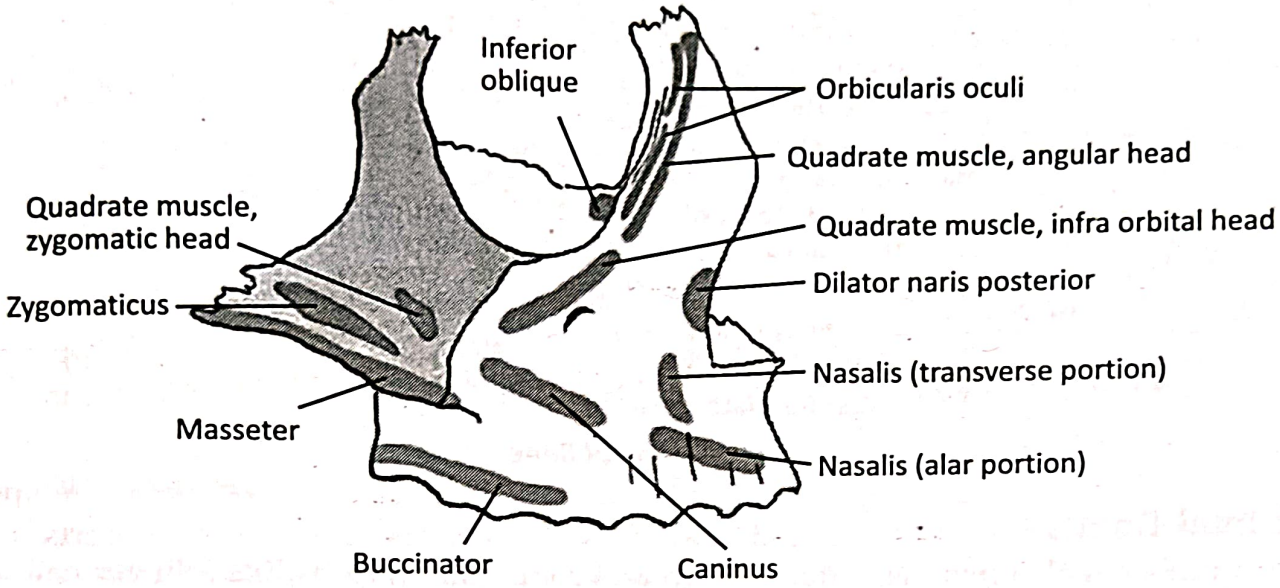


Fig. 6.10: ***Zygomatic or Cheek Bones***

Maxillary Bones

These are the largest bones of the face, which join each other in the midline to form the upper jaw. Among them there is a raised part of the alveolar process, the mandible and that part of the Maxillae in which the dental-troughs are located.

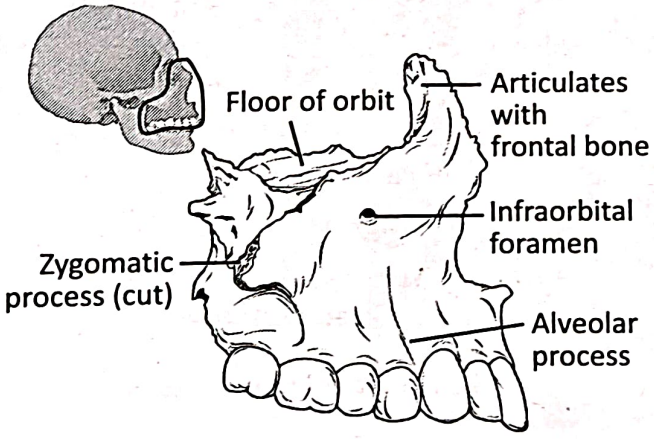


Fig. 6.11: ***Maxillary Bones***

Nasal Bones

Their number is also two. These are flat bones. It forms the bridge of the upper part of the nose.

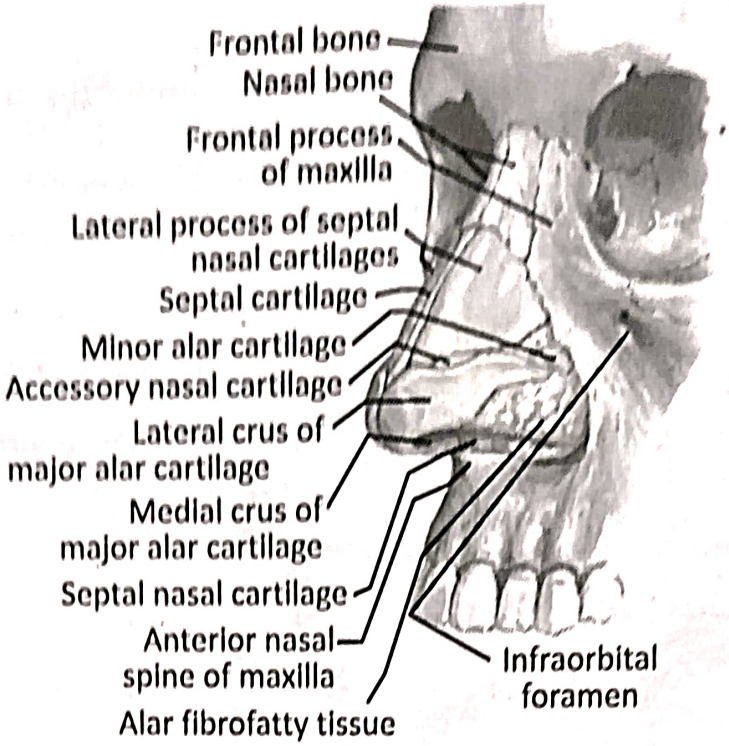


Fig. 6.12: ***Nasal Bones***

Lacrimal Bones

Their number is also two. Its surface is thin and rough. Its shape is like a finger nail. It is situated behind the nasal bone. The lacrimal gland has a lacrimal foramen through which a lacrimal duct passes.

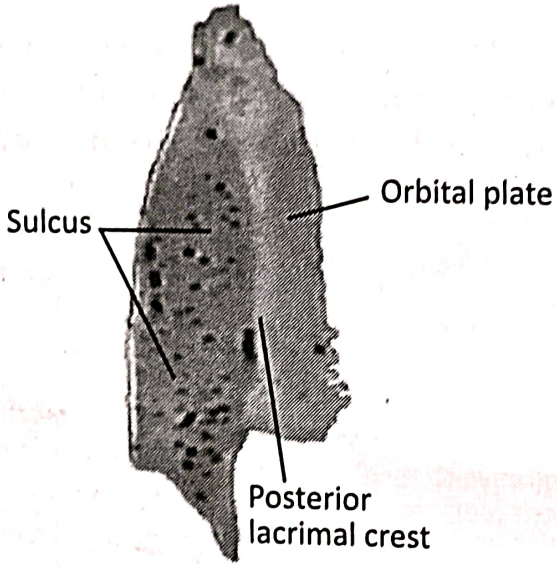


Fig. 6.13: ***Lacrimal Bones***

Vomer Bone

It is a thin flat amorphous quadrilateral bone rising above the middle of the hard palate. It forms the lower and posterior part of the nasal septum. Above Ethmoid bone it is attached to the vertical plate of the bone.

Palatines Bones

Their number is two. This flat part of the bone meets to form the back part of the hard palate. The vertical part of the palatine bones is extended upwards. It forms part of the walls of the nasal cavities.

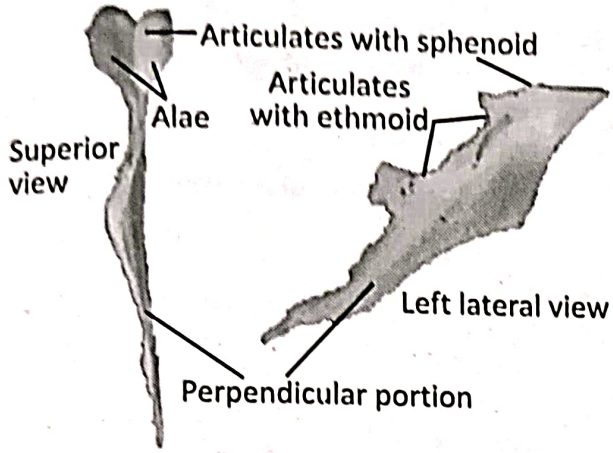


Fig. 6.14: *Vomer Bone*

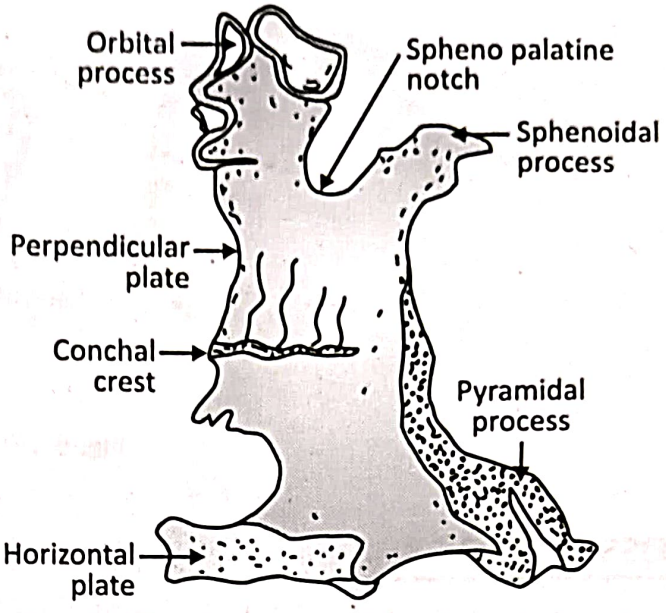


Fig. 6.15: *Palatine Bones*

Inferior Conchae

These are also two in number. The shape of these bones is like a scroll-like paper. This vein forms part of the lateral wall of the cavities. It enhances circulation. It filters and heats the air before it enters the lungs.

Mandible

It is a U-shaped bone. This is the only bone of the skull that is mobile. In this, there is a body, which is the central curved horizontal part of the bone, also there is a Alveolar process, in which the lower teeth fit in 16 cavities and bone is formed from the body.

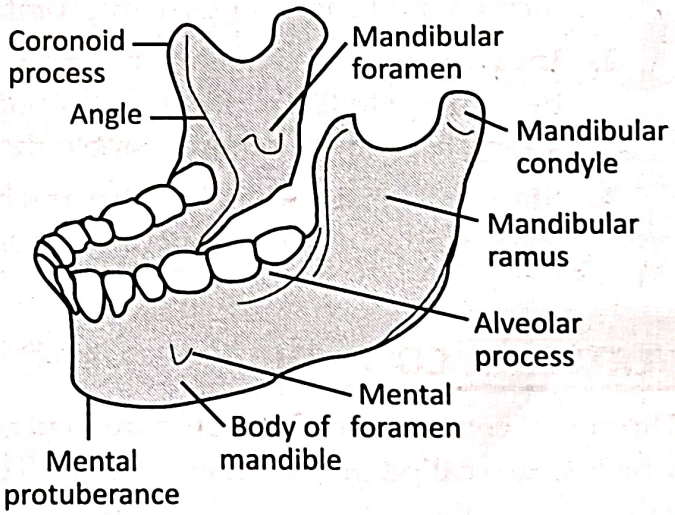


Fig. 6.16: *Mandible*

The bone of the lower jaw has a curved flat part. The trunk (body) and the vertical part, Rami, the upper end of the forelimb branch, divides into the Condylar process, which joins with the temporal bone. It forms the Temporomandibular joint and the Coronoid process which connects the muscles and ligaments, the place where the lower jaw meets the body is called angle.

HYOID BONE

It is a small bone in the shape of the letter U, which is located in the palatine of the tongue and provides a place for the muscles of the tongue to join, it is not attached to any other bone, but it is attached to the Styloid process of the temporal bone.

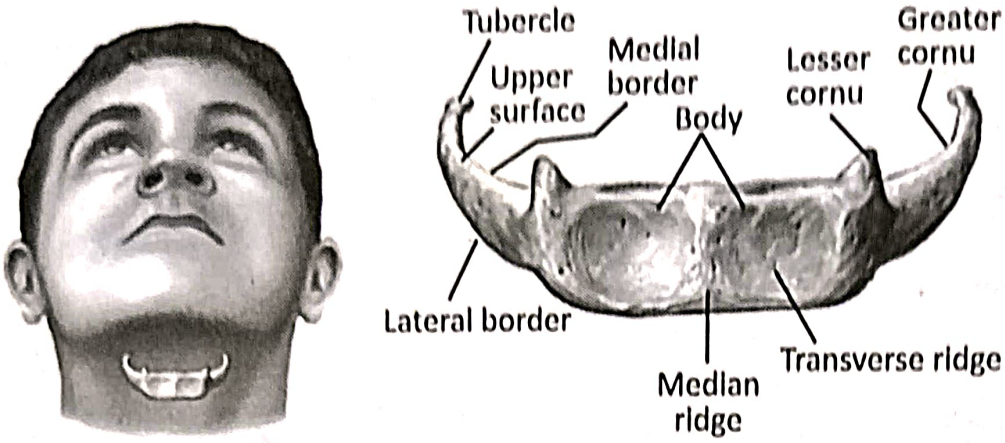


Fig. 6.17: *Hyoid Bone*

OSSICLES OF THE EAR

These are three very small bones in the cavity of the middle ear from the eardrum to the oval aperture on the medial wall, which join with each other to form a chain of mobile joints by joining the medial wall of the oval aperture. The bones of the ear are:

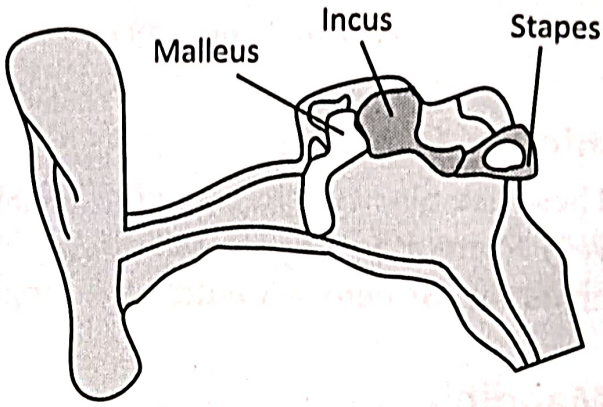


Fig. 6.18: *Ossicles of the Ear*

1. **Malleus:** It is a hammer shaped parietal bone whose handle is in contact with the eardrum and the apex joins with the incus bone to form a dynamic joint.
2. **Incus:** The anvil-shaped bone in the middle is called the incus, which is connected by its body to the malleus on the outside and the stapes bone on the inner side by a long septum. It remains stable through small amplification.
3. **Stapes:** The stapes is the stirrup-shaped innermost (intermediate) bone whose apex is attached to the incus and the base fits into the oval opening.

VERTEBRAL COLUMN

The spinal cord is a flexible structure made of 33 bones that supports the trunk and neck, which is also called the vertebral column. The bones of the spine are also called vertebrae.

The vertebral column (spinal cord) consists of the following types of vertebrae:

1. **Cervical Vertebrae:** There are the 7 vertebrae of the cervix.
2. **Thoracic Vertebrae:** There are 12 vertebrae present in the thoracic region, which are attached to the ribs.
3. **Lumbar Vertebrae:** It contains 5 vertebrae labeled L1 to L5.
4. **Sacral Vertebrae:** It consist of 5 sacral vertebrae bones.
5. **Coccygeal Vertebrae:** 4 vertebrae that join together to form the scrotum or rectum.

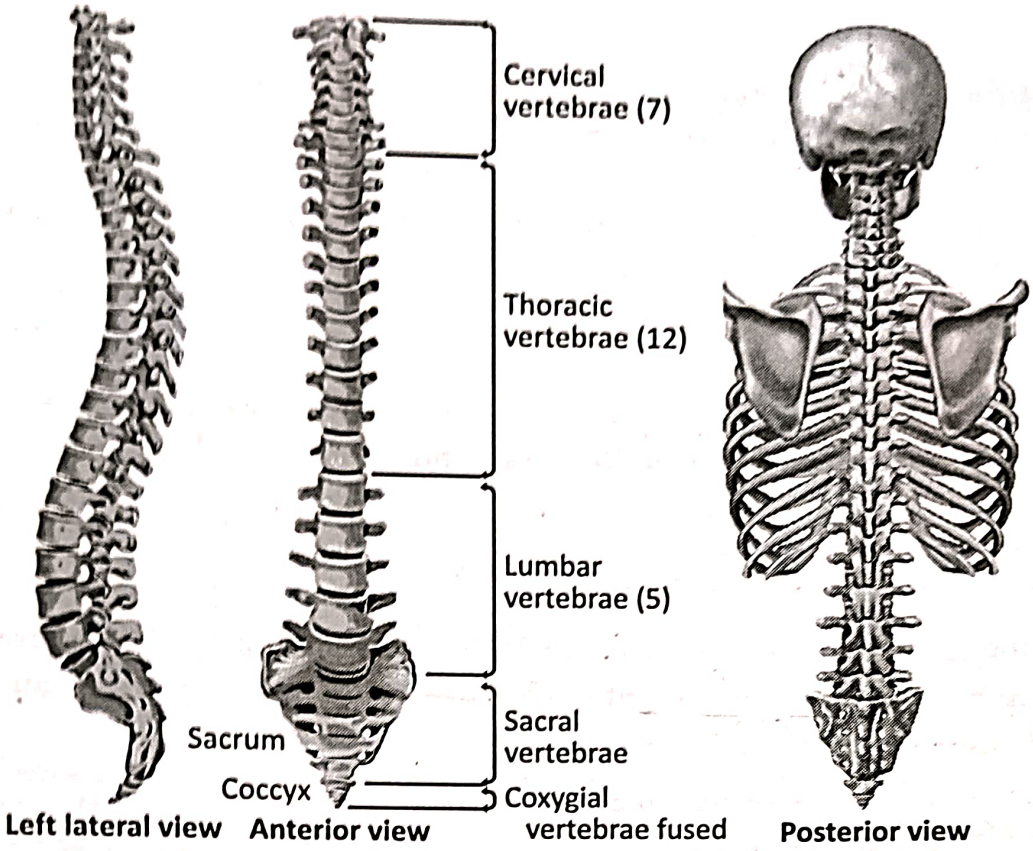


Fig. 6.19: *Vertebral Column*

Characteristics of a Typical Vertebrae

The vertebrae have two main parts, a body and an arch. The body of each vertebra is located at the front. Its size varies according to its location. The bony segments of the neck are the smallest and they get bigger as they move towards the waist.

Vertebral Arch

It closes the large vertebral hole from all sides. The bone is surrounded by two pedicles. It extends backward from the body, where the pedicle or laminae meet, the posterior and oblique stems extend to the side. A stellate spur is formed at the back of the midline where two membrane faces meet.

Atlas

The first cervical vertebra is called the Atlas. It does not have a main body and no spine, but a ring of bone in which there are two pits for joining the occipital bone. A ligament called the transverse ligament divides the ring into two parts.

In the event of death by hanging, this transverse ligament is torn and the dens crushes the lower part of the medulla oblongata and spinal cord.

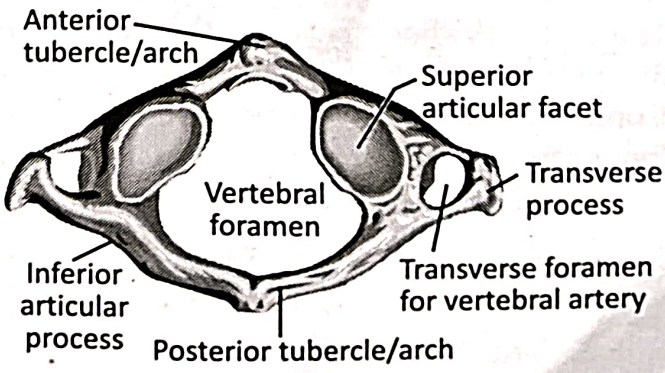


Fig. 6.20: *Atlas*

Axis

The body of the axis or second cervical vertebrae is small and it is called the odontoid process growing upwards, it is raised from the main part and through the rings of the Atlas forms a pivot on which Atlas rotates and hence the head rotates too. To maintain the position of this process and to prevent pressure on the spinal cord, there is a transverse ligament of the head between the Danes and the spinal cord.

Sacrum

A triceps or a triangular bone formed by the fusion of five vertebrae just above the anus, which forms the base of the vertebral column and together with the coccyx, forms the posterior border of the true pelvis.

Coccyx

Vertebrate, the lowest bone of the sacrum which is made up of 3 to 5 vertebrae and joins the sacrum bone above to form a joint. The fusion of the bones of the auricle occurs between the ages of 20 and 30.

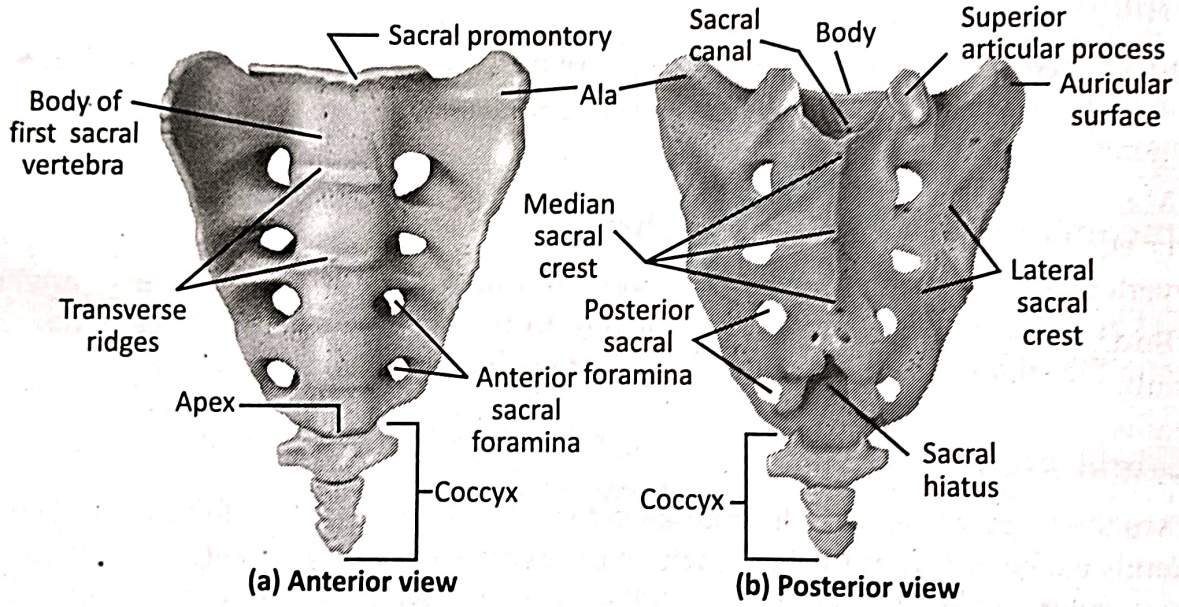


Fig. 6.21: ***Sacrum and Coccyx***

THORAX

The part of the body between the base of the neck and the diaphragm, which is surrounded by the ribs, is called the Thorax. The thoracic cage is roughly angular. The thorax is a Cone-shaped cavity whose lower part is wider than the upper part and the back part is longer than the front part. The thoracic cage protects the heart, lungs and some abdominal organs. The bones of the thorax or thoracic cage are as follows:

1. Sternum
2. Ribs
3. Thoracic Vertebrae

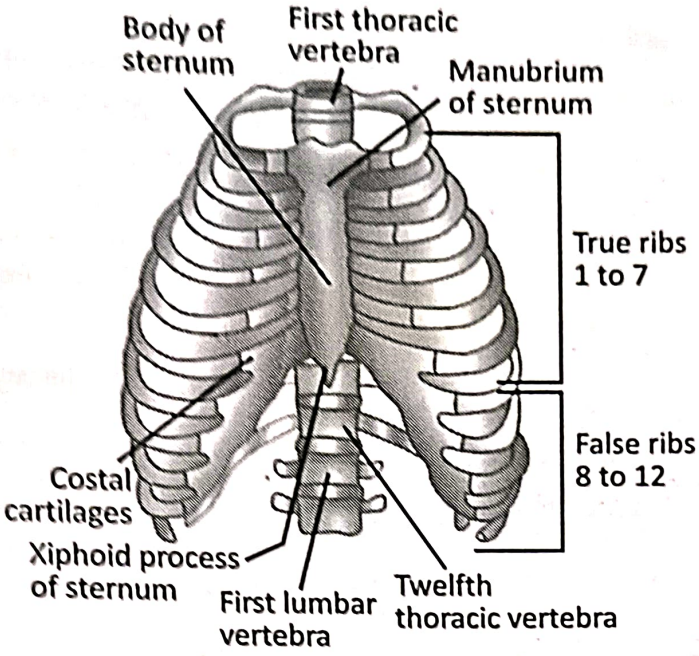


Fig. 6.22: *Thoracic cage*

Sternum

A long, flat bone located in the front middle line in the thorax or chest, which is made up of three segments:

Manubrium: It is triangular in shape and its lower edge is covered by a thin layer of cartilage. To this connects the upper edge of the main part.

Body: It is longer and narrower than the manubrium. Where it joins the manubrium, there remains a pit. At the same time the cartilage of the other rib is attached.

Xiphoid Process: The xiphoid protuberance is a small and variably shaped bulge which may not be completely ossified.

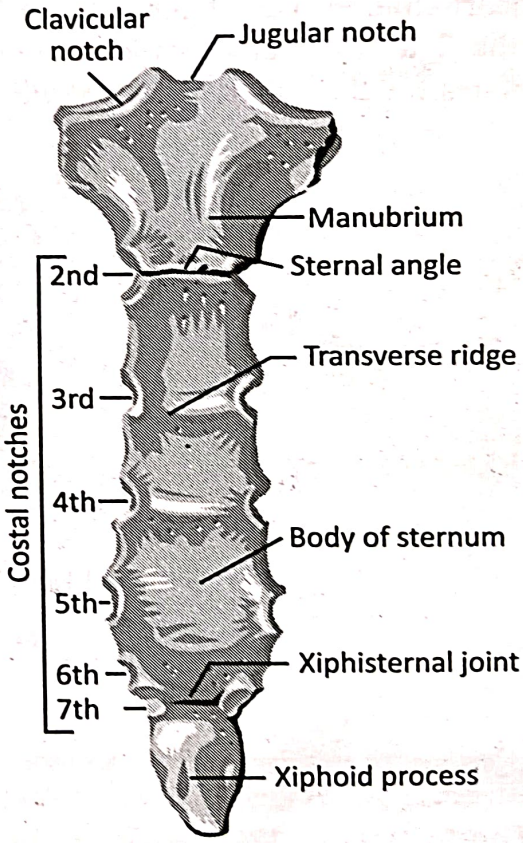


Fig. 6.23: *Sternum*

Ribs

12 tight and bent bones that come out from the sides of the thoracic vertebrae on each side and spread laterally and forward are called ribs. The length of the first to seventh rib increases and the length of the eighth to the twelfth rib decreases. The space between the ribs is called the interstitial space, in which the intercostal muscles are present. The first seven vertebrae are called real ribs. The remaining five joints are called false ribs. There are muscles in the space between the ribs which help in respiration.

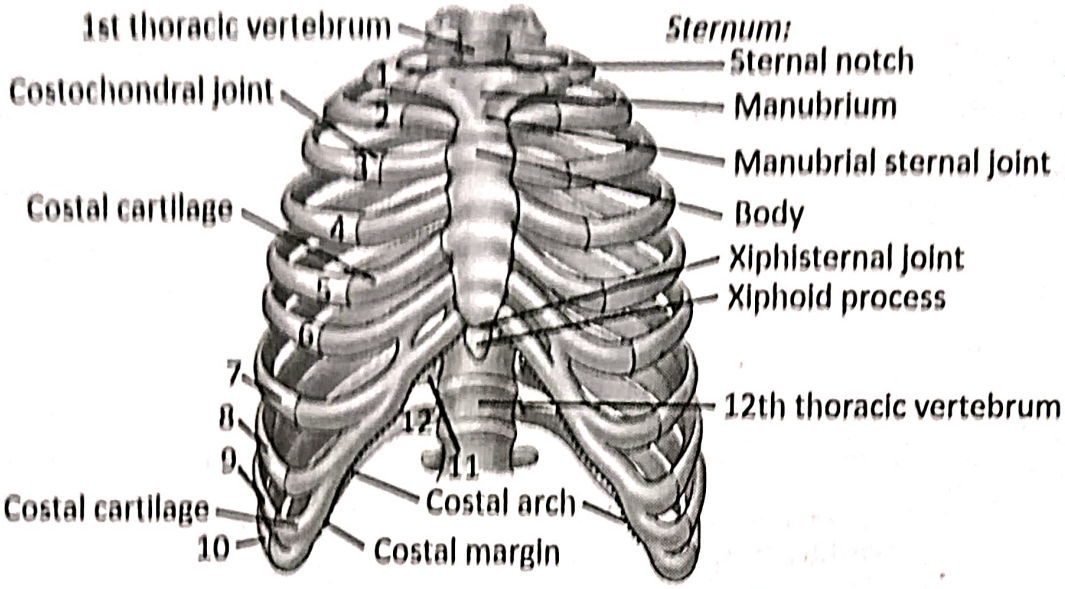


Fig. 6.24: *Ribs*

Thoracic Vertebrae

There are 12 vertebrae present in the thoracic region which are attached to the ribs. Their size gradually increases from top to bottom. In a typical thoracic vertebra, the body is heart-shaped, with lateral articular facet (surfaces) forming joints with the heads of the ribs. The transverse tendons which support the ribs are firm and bulky and have joint plates for the tubercles of the ribs.

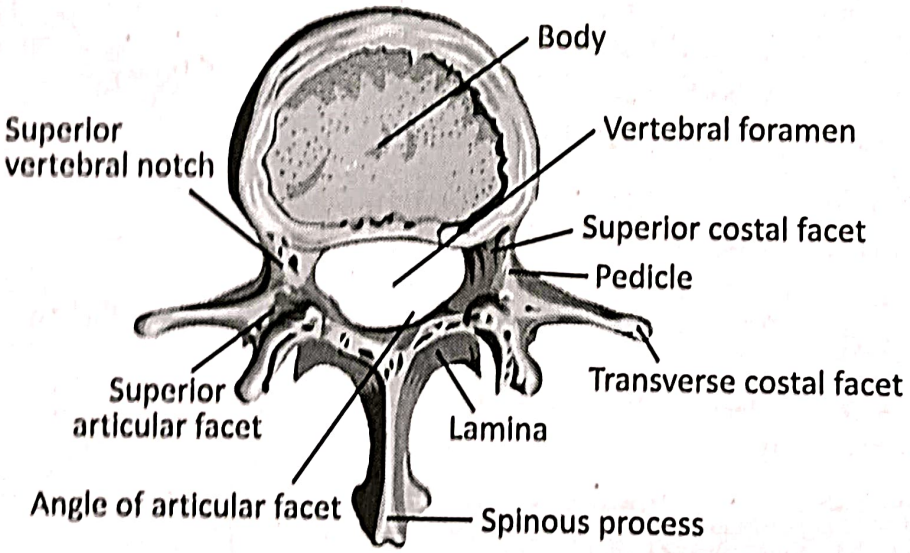


Fig. 6.25: *Thoracic Vertebrae*

APPENDICULAR SKELETON

The following 126 bones are included under the appendicular skeleton:

UPPER EXTREMITIES (64 BONES)

Scapula

A large, flat, triangular bone that makes up the back part of the shoulder, which joins the clavicle and humerus bones to form a joint is called the scapula. It is located on the back

side of the thorax, between the seventh ribs on the other side. The side end of this bone is flattened, whose enlarged region is called Acromion. On the lower surface of the acromion, there is a pit called the glenoid cavity. The septum located next to the upper edge is called coracoid process. All the muscles here are attached to this part.

Clavicle

In common language it is called Clavicle bone. It is also called collar bone. It is a long, shaped bone of the English letter 'S'. It is bent in two places.

One bend is convex and the other bend is concave. Between which is the Shaft. Its medial or sternal end is attached to the manubrium of the sternum bone and the sternum-clavicular joint is formed and the scapular end of the lateral or scapula bone side joins with the scapular region of the scapula bone to form the Acrimioclavicular joint.

Humerus

The upper arm bone, which runs from the shoulder joint, where it is attached to the scapula bone, goes to the elbow joint and there it joins the radius and ulna bones. Its upper end connects to the glenoid cavity of the scapula. The greater tuberosity and the Lesser tuberosity are the phases of this period. They are located away from the upper end and are rough.

Between the two tubercles is the Intertubercular sulcus, in which one of the tendons of the biceps muscle is located. The humerus bone narrows further between the bulges. This part is called surgical neck because the possibility of fracture is more at this place.

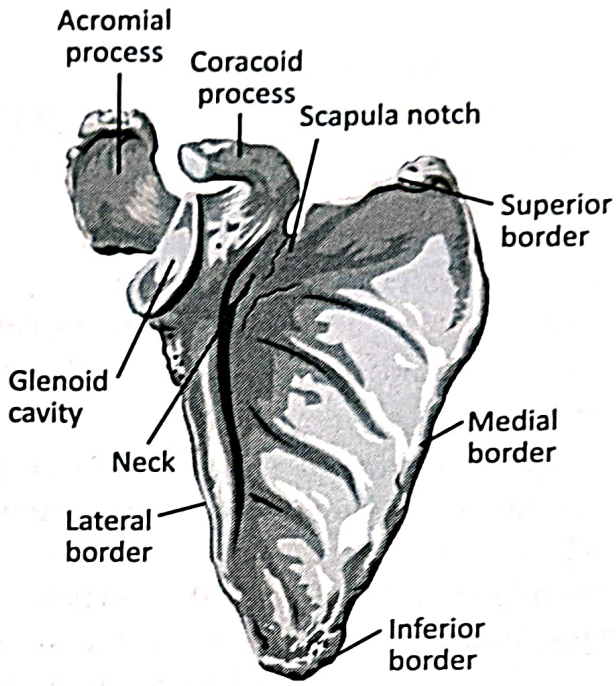


Fig. 6.26: *Scapula*

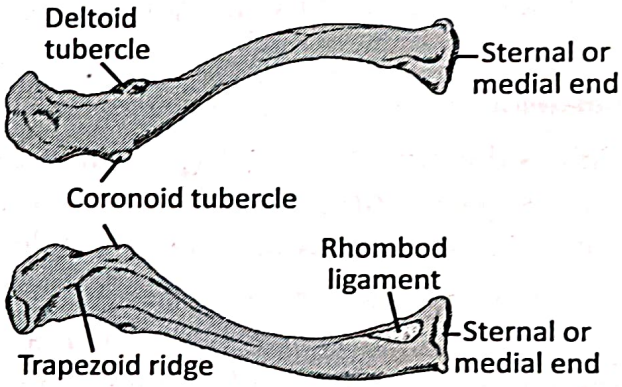


Fig. 6.27: *Clavicle Bone*

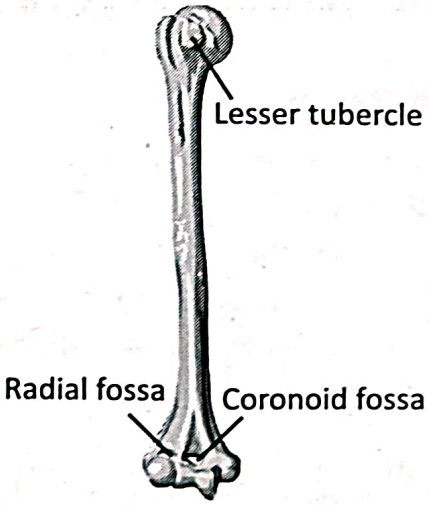


Fig. 6.28: *Humerus*

Ulna

The inner and large bone of the forearm, which is on the opposite side of the thumb, is also called the interosseous. Its upper end is hooked. In this, there is an upper and lower

two ends and in between them there is an ossicle. The ulna bone is longer than the radius bone and its apex is at the lower end. Its upper end is wide which takes part in forming the elbow joint. In this, there are two types of processes: Olecranon and Coronoid. The Olecranon fossa extends from the back to the top and, with the elbow straight, it fits into the Olecranon fossa of the humerus bone. The coranoid phalange faces forward.

It is smaller than the Olecranon fossa and fits into the coronoid fossa of the humerus bone when the elbow is flexed. There are two grooves-trochlear and radial in the vertical end. The trochlear groove joins the trochlea of the humerus bone at the elbow joint and the radial groove joins the superior radioulnar joint to form the vertical extremity joint.

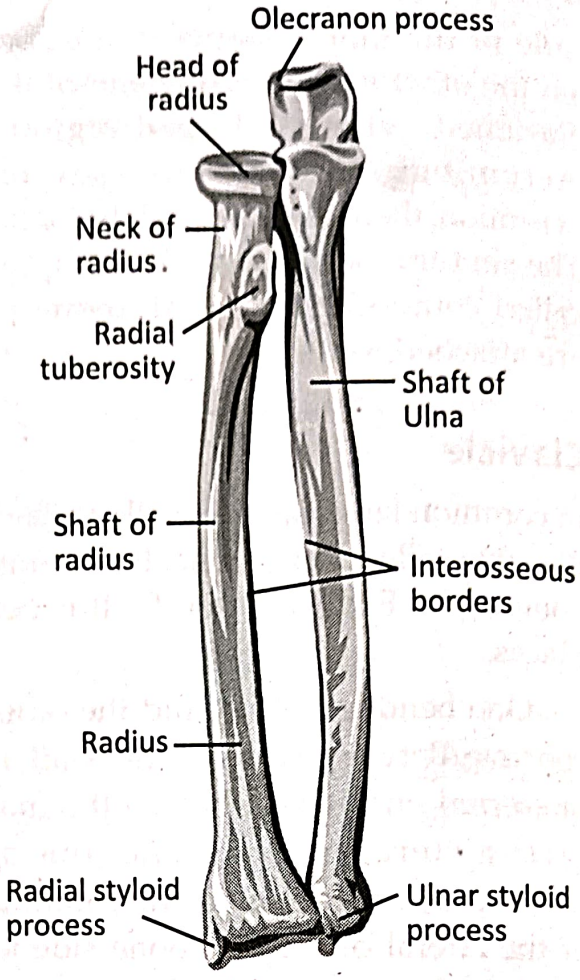


Fig. 6.29: ***Radius and Ulna***

Radius

This is the outer bone of the forearm. Its upper end is short and has a circular head, which connects above with the outer condyle of the humerus and on the inside with the ulna.

Below the upper end is the neck and on the front side of the bone there is a range called the radial tuberosity, to which the biceps muscle attaches. There is a sharp edge on the shaft towards the ulna. From this edge a strip of fibrous tissue is attached to the interosseous membrane. Its lower part forms the posterior edge of a long triangular region where the pronator quadratus muscle is inserted.

Carpal Bones

These are eight small amorphous bones, which are in rows of four. The upper row is near the radius and the ulna, so this is called proximal row, the second row which is near the palm, is called the distal row.

1. **Proximal Row:** In this row, there are four bones Scaphoid, Lunate, Triquetral and fisiform in the outer side.
2. **Distal Row:** It consists of trapezoidal trapezoidal amygdala and annular bones.

The eight carpal bones are identified as follows::

1. **Scaphoid:** It is a boat shaped bone with a tubercle on its side.
2. **Lunate:** It has a neo-moon shape in appearance. The scaphoid and lunate, these two bones are attached to the lower end of the radius above to form the wrist joint, below they are attached to some of the carpal bones of the distal row.

3. **Triquetral:** It is a pyramid shaped bone.
4. **Pisiform:** It is a pea sized bone.
5. **Trapezium:** It is a quadrangular bone with a crest and a groove on its anterior surface.
6. **Trapezoid:** It is like a child's shoe.
7. **Capitate:** It is the largest carpal bone with a round head.
8. **Hamate:** It is a nail shaped bone with a hook at its base.

All the carpal bones are held together by ligaments and held in place. These movements are carried between them to a certain extent by the ligaments.

Metacarpal Bones

These are five short and long bones, which are spread in the palm. The bases of these bones are attached to the lower bones of the carpus and the apex joins with the Phalanges.

The first metacarpal, which joins the fingers that make up the thumb, can move easily. It can also appear in front of each finger. This have strengthens the grip. The fingers are short and long bones. Their number is two in the thumb and three in each finger.

Phalanges

The fingers and thumb of the hand are formed from a total of 14 long bones, which are called Phalanges. Their number is 3 in each finger and 2 in the thumb.

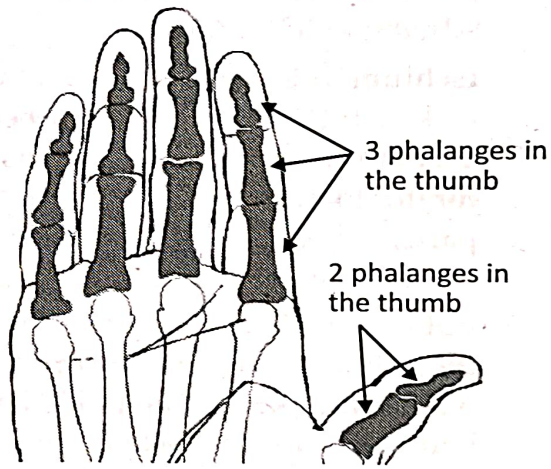


Fig. 6.30: ***Phalanges***

Pelvic Girdle

It is an arc formed by Innominate bones. The pelvic girdle is made up of the following two types of bones.

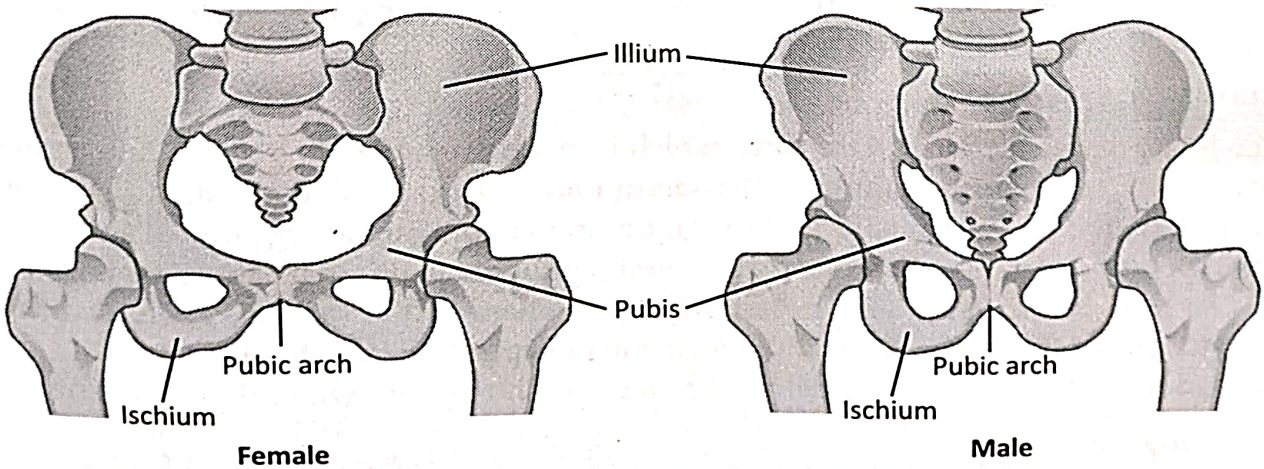


Fig. 6.31: ***Diagram showing the difference in shape of the male and female pelvis***

The two Innominate bones are made up of three of the following bones:

1. Ilium
2. Ischium
3. Pubis

1. **Ilium:** Located in each half of the pelvis, the upper and widest part of the hip bone, is called the iliac phalanx. There is some rough bulge on its entire upper edge which is called iliac crest. This crest provides space for the muscles of the abdominal wall to attach. The upper edge is called the iliac crest, from its front side, the vertical superior iliac spine and the posterior part is called the posterior superior iliac spine. There is a schiatic notch under it.
2. **Ischium:** It is the lower part of the buttock or hip bone, which attaches to the 2/5 of the acetabulum and limits the obturator foramen from behind. It has two parts, a Body and a Ramus, in which there is a main osseous Ischial spine.
3. **Pubis:** It is the front and lower part of the buttock bone, which forms the front wall of the pelvis. The pubic bones on both sides are connected to each other in the midline by a thick cushion of fibrous cartilage. This joint is attached to the pubis bone on the other side at the Symphysis pubis. The front part of the body is called the pubic crest.

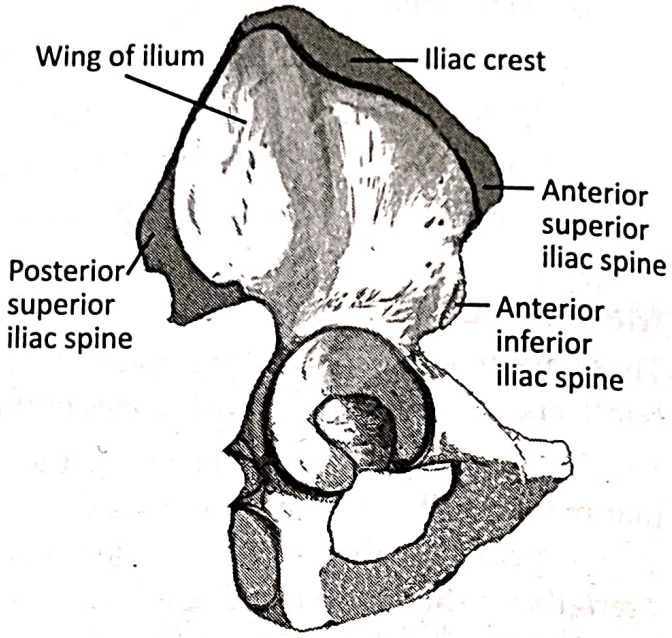


Fig. 6.32: *Ilium*

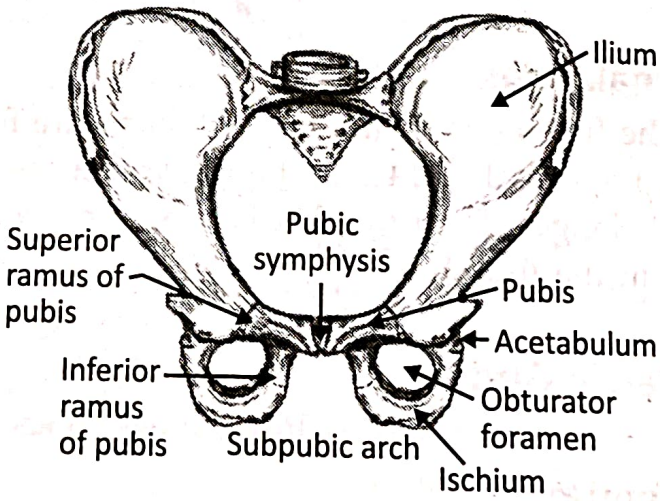


Fig. 6.34: *Pubis*

Pelvis

The lower bony structure of the torso which is made up of the hip bones (ilium, ischium and pubis) in front and side and the sacrum and coccyx behind is called pelvis. It is divided by the linea terminalis and the end of the sacrum into a large unreal and a small (real) pelvis. The large pelvis is the elongated part of the pelvis that is fixed on both sides by the base of the ileum and posteriorly by the base of the sacrum. There is a small curved groove in the small pelvis which runs deeper towards the back. In males it is shaped like a heart. While the pelvis of females is shorter and wider than that of males.

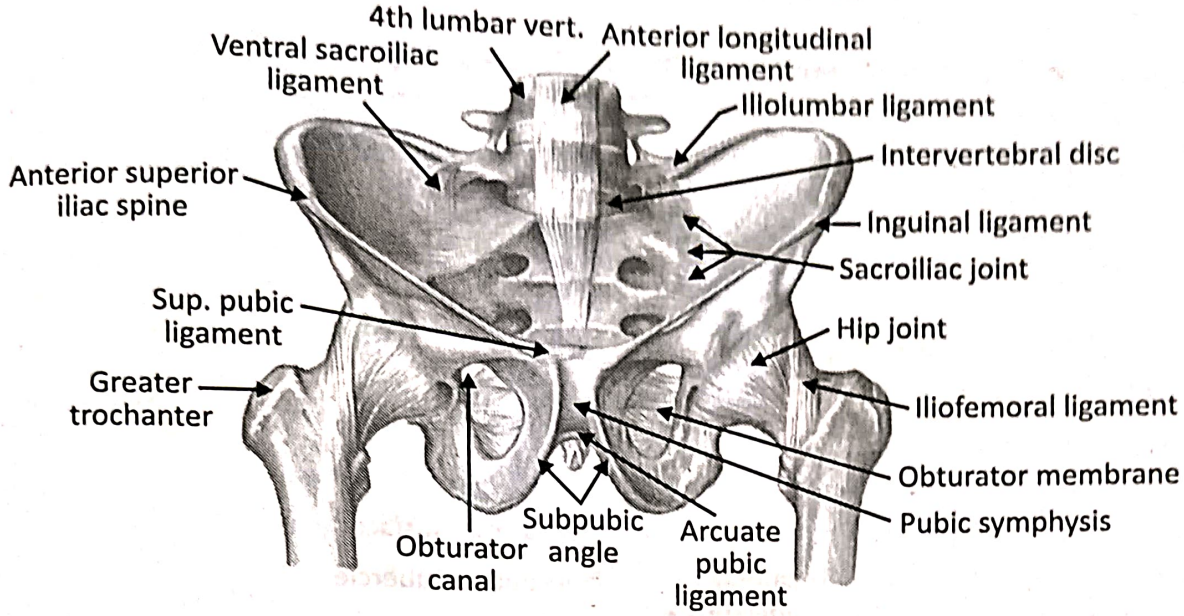


Fig. 6.34: ***Male Pelvis***

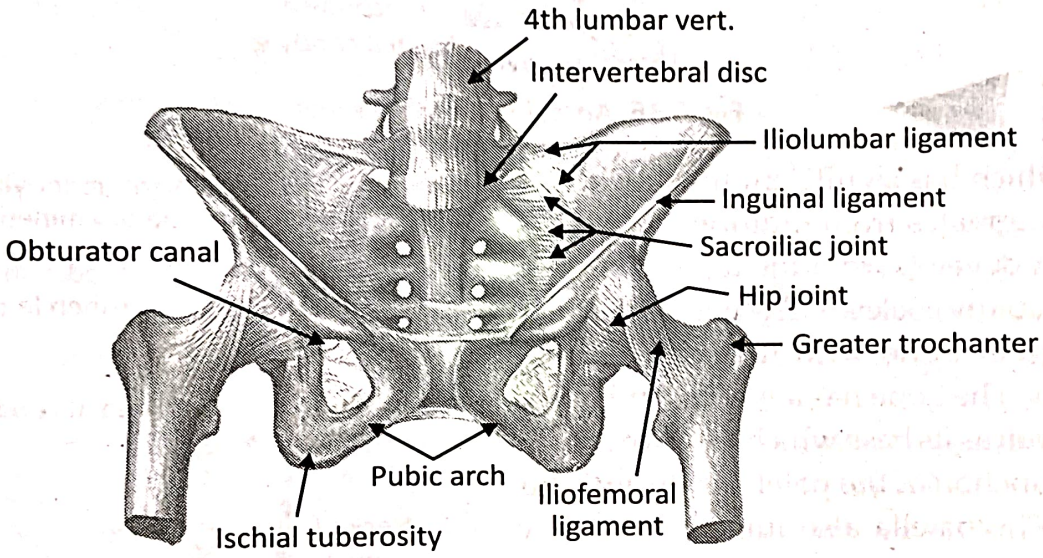


Fig. 6.35: ***Female Pelvis***

Femur

The thigh bone is attached to the hip bone above and the tibia and patella below. It is the longest, heaviest and strongest bone. There is a small nodule in its upper end so that the upper end of the femur can be attached. Greater and lesser are trochanter amplification.

They act as a point-of-attachment for connecting some muscles of the thigh and buttocks. It forms a flattened triangular area on the back surface of the lower third which is called the Popliteal surface. The distal edge of the femur is protruded. It has two articulars, i.e., secondary and lateral archs.

Patella

The patella is also known as the kneecap. It sits in front of the knee point and protects the joint from damage. It is the largest sesamoid bone in the body and lies within the quadriceps tendon in front of the knee joint. The kneecap is an example of a bone we are all familiar

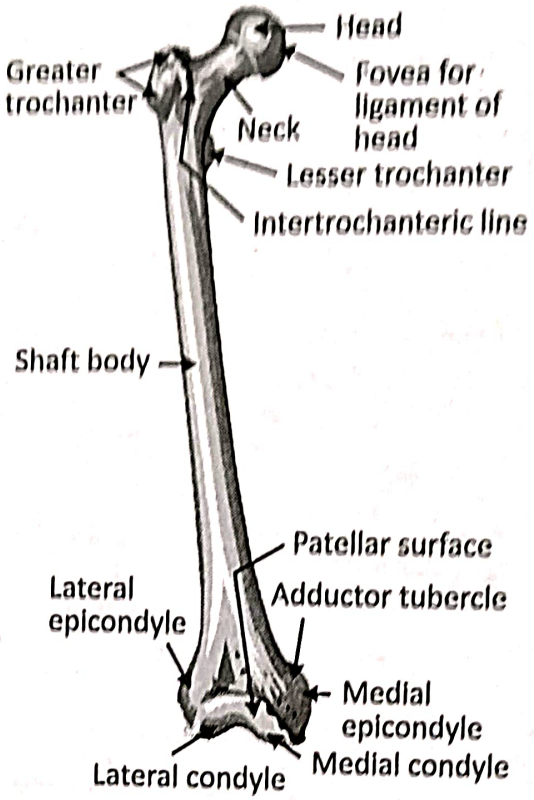
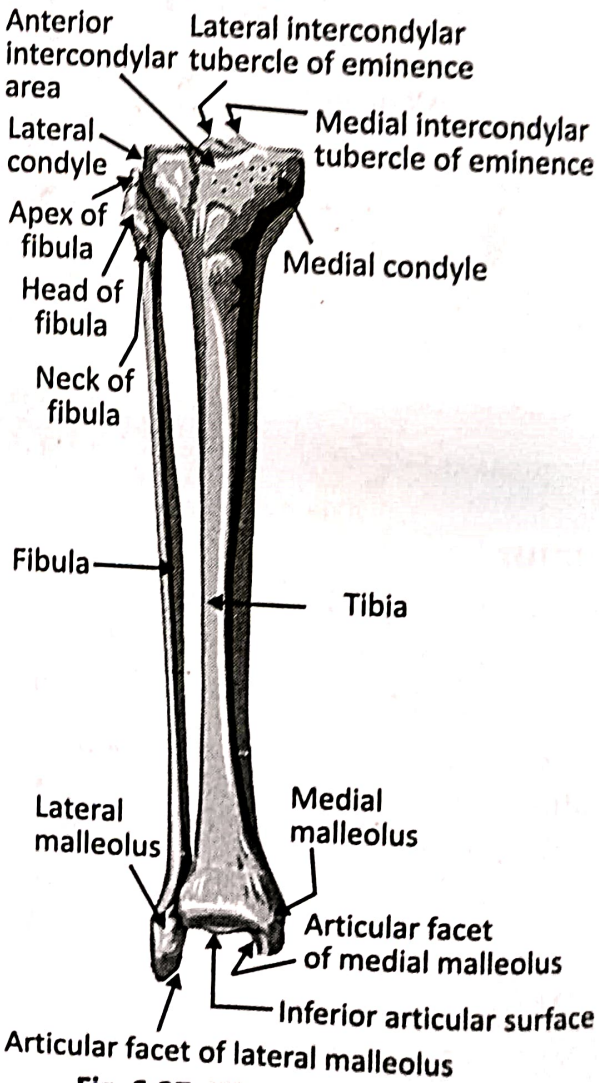


Fig. 6.36: ***Anterior View of Femur***

with and which has significant functional role. The bone originates from multiple ossification centres that develop from the ages of three to six, which rapidly coalesce. The patella is a thick, flat, triangular bone with its apex pointing downwards. The bone has a medial and lateral border, as well as its base which lies proxilmally. The main function of the patella is during knee extension. The patella also functions to allow for smooth movement of the knee in flexion and extension and also protects the anterior surface of the knee joint.

Tibia Bone

The inner and large bone of the leg between the knee and the ankle, joins the femur above and the talus bone below, forming a joint. The proximal end of the tibia meets in the medial and lateral arch. The medial edge of the tibia is more rounded and it starts from the medial condyle and reaches the medial malleolus below. It is mostly subcutaneous and is a good place for tibia to be ossified (Bone graft).



Fibula Bone

This bone is the outer and thin bone of the foot from the knee to the ankle, which forms the joint with the tibia bone above and with the tibia and the talus bone below. At the distal end of the fibula is the lateral malleolus. It continues below the tibia and attaches to a bone called the talus.

Tarsal Bones

The number of these bones is seven. It forms the back part of the foot. These are small bones made of bone tissue and are covered with compact tissue outside them. These bones support the weight of the body in a standing position.

Their description is as follows:

- Talus: 1
- Navicular: 1
- Cuboid Bone: 1
- Calcaneus or Calcaneum: 1
- Cuneiform Bones: 3

Metatarsal Bones

Their number is five. They are counted from one to five from the middle to the side. Their bases are attached to the cuneiform and cuboid bones. They are attached to the tarsal bone at the proximal ends and to the Phalanges at the distal ends.

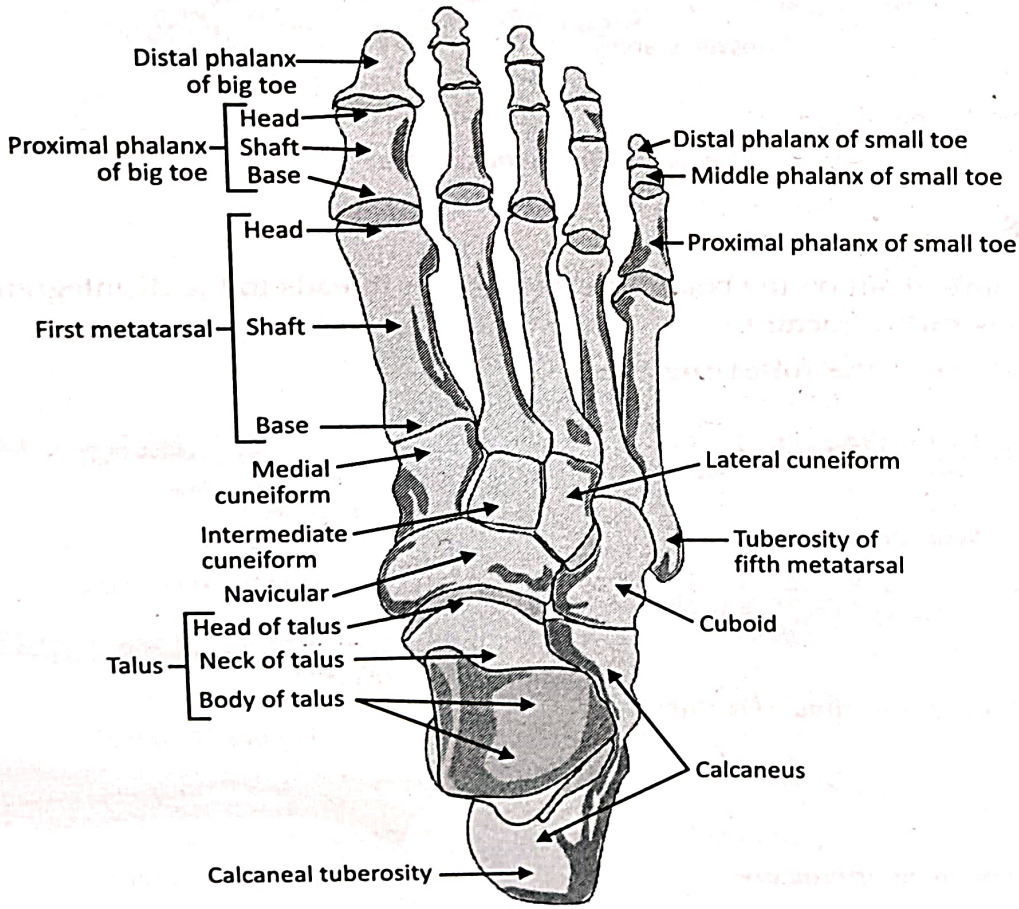


Fig. 6.38: ***Metatarsal Bones***

Phalanges

These bones are 14 in number and are arranged like the phalanges of the hand, but they are relatively smaller. It provides stability as well as support in walking.

ARCHES OF THE FOOT

The foot has to act as a lever to support the weight of the body while standing upright and to propel the body forward in walking, running or jumping. There are two longitudinal arches in the foot to accomplish these functions. The medial arch is particularly flexible and the lateral arch is strong, providing limited movement. The arch of the foot provides buoyancy to the foot while walking. Strong ligaments, tendons and muscles passing through the sole assist in this task.

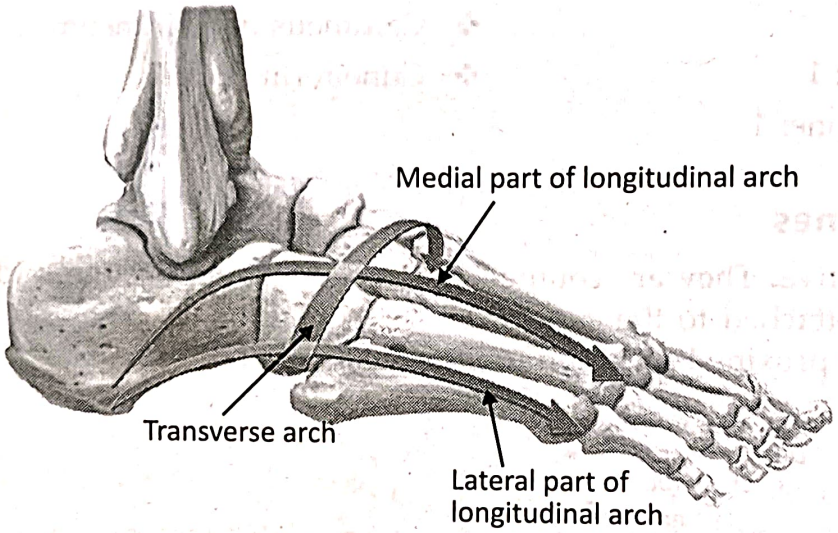


Fig. 6.39: ***The Arches of the Foot***

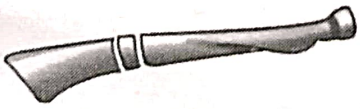
FRACTURE

If more pressure is put on the bone than its capacity, it leads to the disintegration of the bone, which is called fracture.

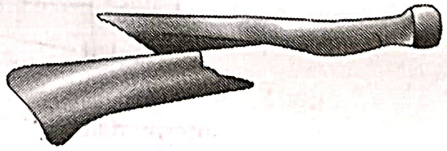
Fractures are of the following types:

Avulsion Fracture

Closed Fracture or Simple Fracture



Comminuted Fracture

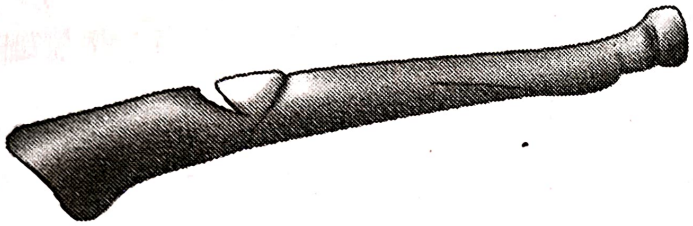


Displaced Fracture

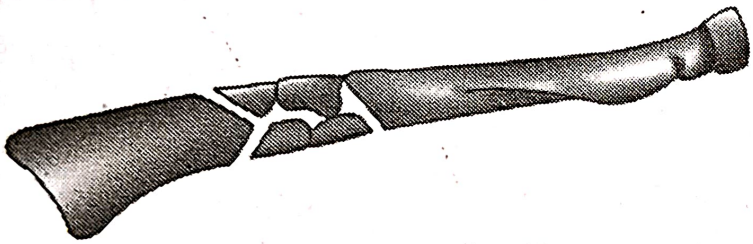
Fissured Fracture

Greenstick Fracture

Impacted Fracture

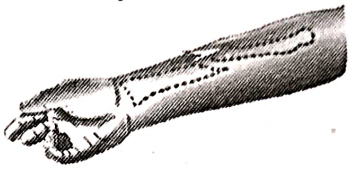


Incomplete Fracture



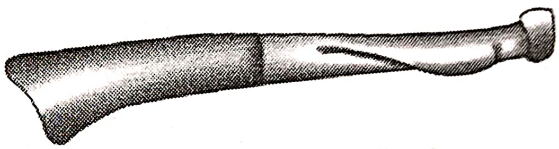
Multiple Fractures

Oblique Fracture



Open Fracture; Compound Fracture

Spiral Fracture



Transverse Fracture

7

CHAPTER

Joints

The places in the body where two or more bones meet each other are called joints.

Joints are classified on the basis of structure and speed. On the basis of composition, joints are divided into three classes:

1. Fibrous Joints
2. Cartilaginous Joints
3. Synovial Joints

They have been classified according to the movements occurring in the joints, as some joints are immovable joints, that is, they do not move at all, they remain fixed. Some joints are short-lived joints, that is, they have some movement. The rest of the joints are movable joints, that is, they move freely.

FIBROUS JOINTS

It is a joint in which bones are attached to fibrous tissue. A fibrous joint is a fixed joint. The bones are tightly bound by the fibers. These are tightly joined together, so the fibrous joints are generally immovable in adults. There are three types of fibrous joints.

1. Sutures
2. Syndesmosis
3. Peg and Socket Joint

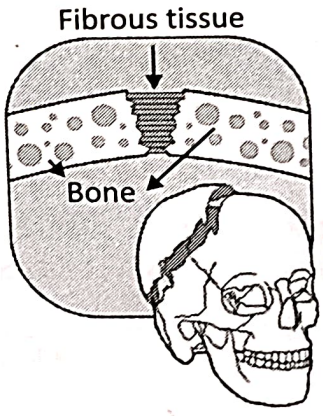


Fig. 7.1: ***Fibrous Joints***

SUTURES

This joint is made up of two bones with saw-like edges and its edges fit into each other. At first these bones are joined by a line of fibrous tissue, but eventually osteogenesis occurs and bone to bone joins to form a permanent joint, which does not allow any movement. These joints are found in the skull and are called Sutures.

At birth, there is a clear line of fibrous tissue between the bone and the bone, which allows the edge of the bones to slide slightly over each other, allowing moulding the infant's head as it passes through the pelvic tract.

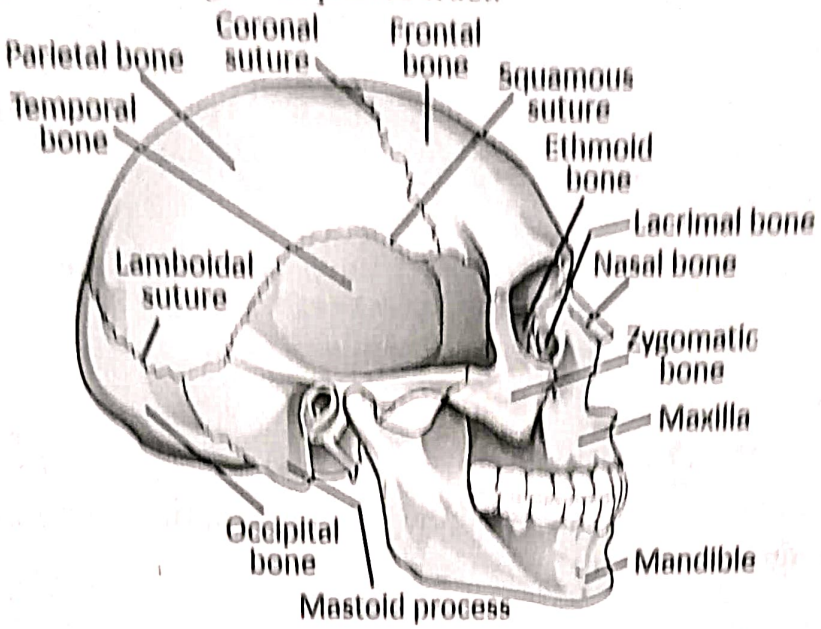


Fig. 7.2: *Sutures of the Skull*

SYNDESMOSIS

A joint in which bones are bound by ligaments is called Syndesmosis. It is an immovable junction in which the joint planes are joined together by a Syndesmosis or membrane, as in the Inferior tibiofibular joint.

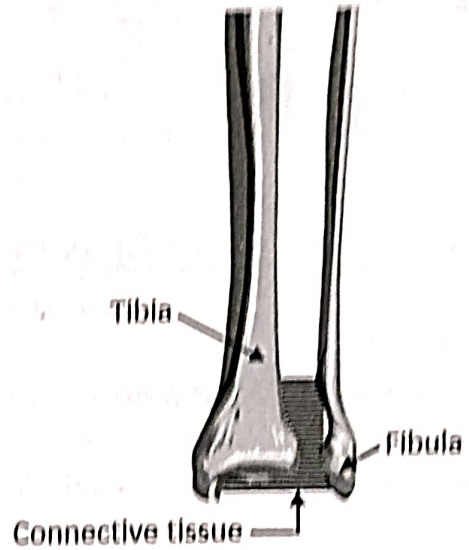


Fig. 7.3: *Syndesmosis*

PEG AND SOCKET JOINT

It is a type of fibrous joint, which is made of a nail or peg and socket. This type of joint is the joint formed by the fit of the dentin of the root into its bony socket.

CARTILAGINOUS JOINTS

It is a joint in which bones are connected by cartilage. There is little movement in these joints or no movement at all. There is a lack of joint cavity in such joints. The following types of joints are cartilaginous joints.

SYMPHYSIS PUBIS

In this, the pubic bones on both sides are joined together by a cushion of cartilage.

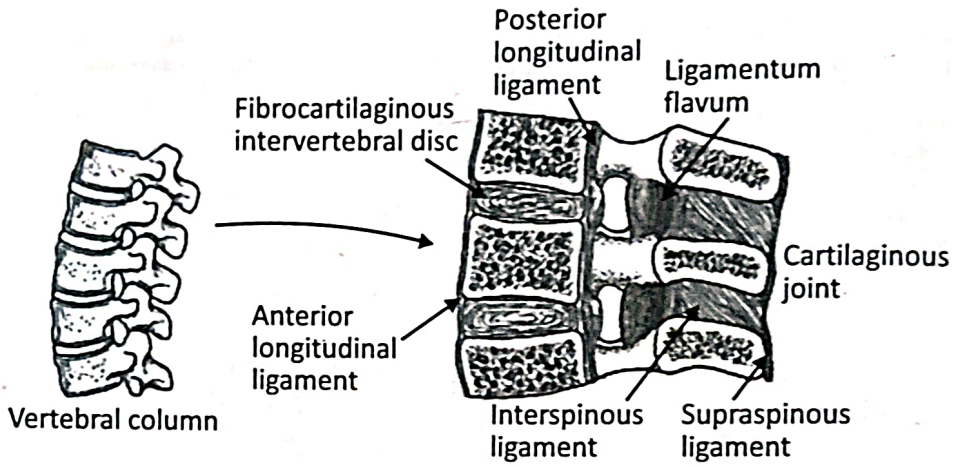


Fig. 7.4: *Cartilaginous Joint*

INTERVERTEBRAL JOINTS

The joints between the bodies of the vertebrae are interconnected by intervertebral discs made of fibro-cartilage.

SYNOVIAL JOINTS

Such a joint in which a cavity lined by a synovial remains closed in which a synovial-fluid is filled, is called a synovial joint. Examples of these types of joints are shoulder joints, elbow joints, buttocks (hip joints) and knee joints etc.

TYPES OF SYNOVIAL JOINTS

The synovial joints are divided into the following classes according to their movements:

- **Hinge Joint:** According to the movements in the synovial joints, such a elbow joint in the lower classes rotates only forward and backward.
- **Pivot Joint:** A synovial joint in which a segment of a cylinder of one bone fits into a corresponding cavity on another bone as seen in the proximal radioulnar joint.
- **Condyloid Joint:** A joint that can have all kinds of angular motions other than axial rotation.
- **Ball and Socket Joints:** In this, the hemispherical head fits into a cup-shaped socket, for example, the shoulder and hip joint.
- **Plane Joint:** A synovial joint in which the opposite bony surfaces are flattened or slightly curved in which only sliding movements can take place.
- **Saddle Joint:** A joint in which the surface of the end of one bone is convex while the opposite side is concave.
- **Gliding Joint:** A joint in which the ends of bones slide or slide over each other.

TYPES OF MOVEMENTS AT JOINTS [See Fig. 7.5 (a) & (b)]

1. **Flexion:** The angle between the surface of the bones of the joint decreases.
2. **Extension:** The angle between the surface of the bones of the joint decreases.
3. **Hyper Extension:** Being of extension beyond the state of anatomy.

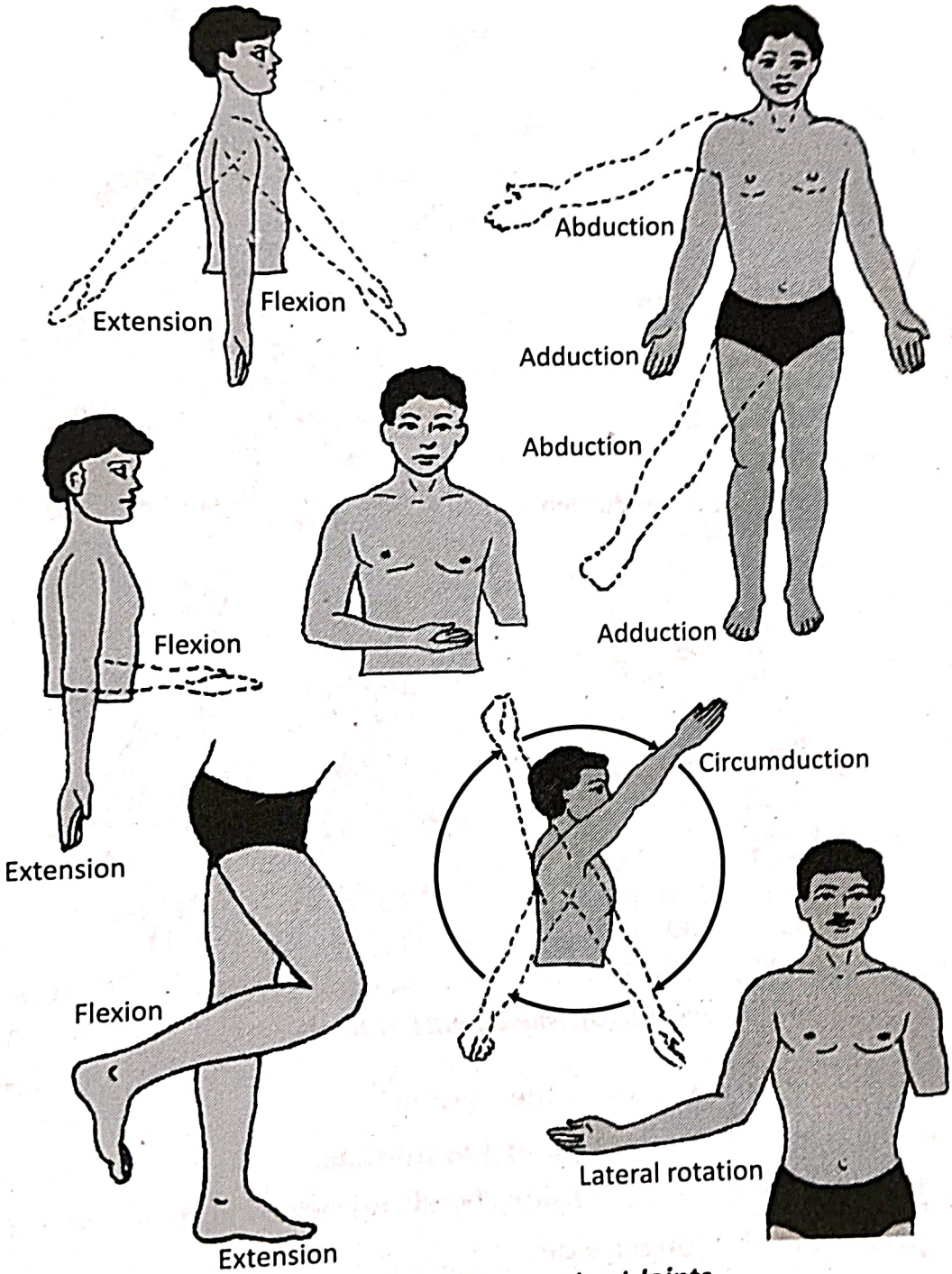


Fig. 7.5 (a): *Movements at Joints*

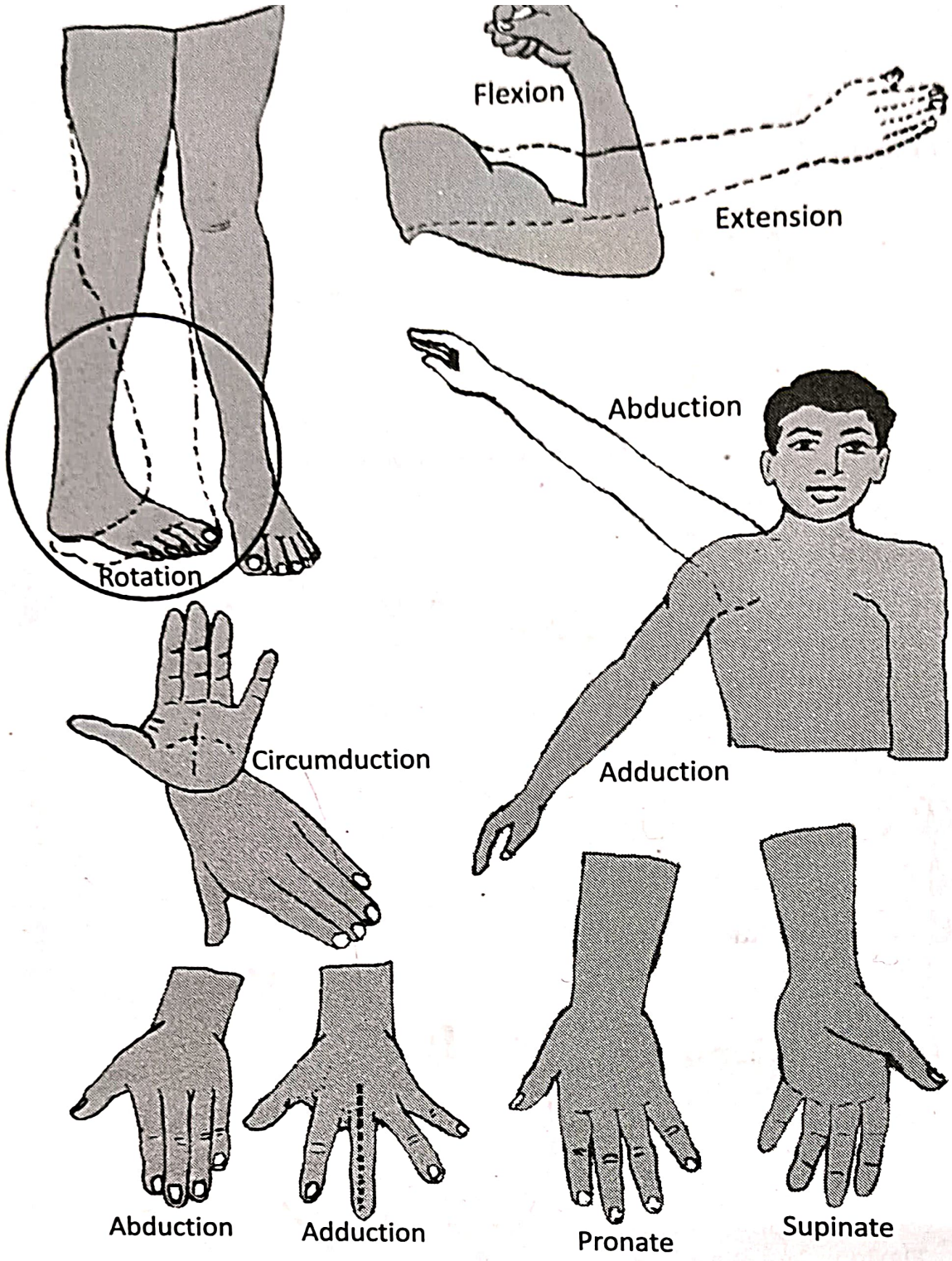


Fig. 7.5 (b): *Movements at Joints*

4. **Abduction:** Bone action away from the midline.
5. **Adduction:** The action of the bone near the midline.
6. **Circumduction:** A mixture of extension, bend, refraction and incidence.
7. **Rotation:** Speed from the longer side.
8. **Inversion:** Turn the soles of the feet inward so that they are facing each other.
9. **Eversion:** Turn the soles of the feet outwards so that they are facing outwards.
10. **Dorsiflexion:** Bend the legs backwards.
11. **Planter flexion:** Bend the foot towards the soles.
12. **Protraction:** Forward movement of the lower jaw or shoulder girdle parallel to the ground.

13. **Retraction:** Backward movement of the lower jaw or shoulder girdle parallel to the ground.
14. **Supination:** Wrist movement in which the palm is turned forward or upward.
15. **Pronation:** Wrist movement in which the palm is turned back or down.
16. **Elevation:** Lifting the shoulder upwards.
17. **Depression:** Turn the shoulder down.
18. **Opposition:** It is an angular motion in which the pad of the thumb touches the pad of the outstretched finger at the palm joint of the thumb.
19. **Reposition:** In this type of movement the thumb returns to its normal position.

THE JOINTS OF THE HEAD

TEMPOROMANDIBULAR JOINT

This joint is between the temporal bone and the tip of the mandible. This is the only moving joint of the head. Its movement can be in three directions up and down, back and forth and side-to-side.

The suture of the head have already been described. The membranous area without osteoblasts at the angles of the parietal bones is called the carotid gap or Fontanelle. It is mainly of the following types:

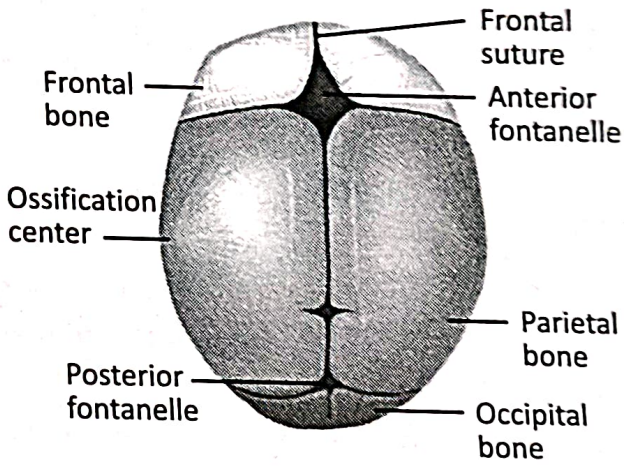


Fig. 7.6: ***Fontanelles***

1. **Anterior Fontanelle:** Fontanelle is located at the confluence of the frontal and anteroposterior sutures. It is shaped like a diamond. Delay in its closure is a symptom of a disease called 'rickets'.
2. **Posterior Fontanelle:** Fontanelle is located at the confluence of the anteroposterior and lamdoid sutures. It is triangular and closes after some time of birth. Delay in its closure can lead to a disease called hydrocephalus in which the accumulation of fluid inside the skull causes the head to enlarge.

THE JOINTS OF THE UPPER EXTREMITY

1. **Sternoclavicular Joint:** The sternum bone of the clavicle bone, the side edge of the thoracic bone, joins the articular facet located in the manubrium of the sternum to form the sternoclavicular joint.
2. **Acromioclavicular Joint:** It occurs between the acromion of the clavicle and the acromion of the scapula and is commonly associated with movement of the shoulder.

3. **Shoulder Joint:** It allows more free movement than all the joints of the body. It is a ball-and-socket type joint formed by the fitting of the vertex of the humerus into the Glenoid cavity of the scapula, forming a third circle.

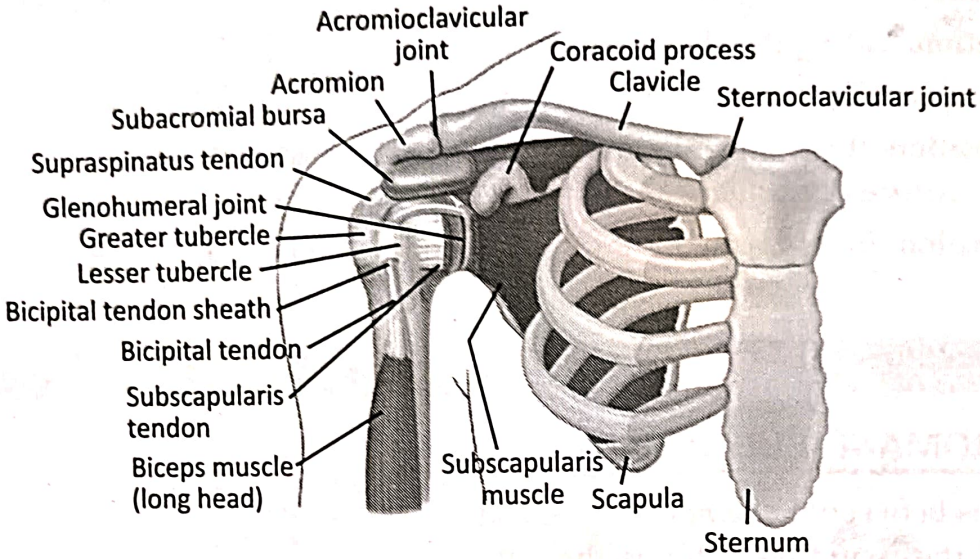


Fig. 7.7: ***Shoulder Joint***

ELBOW JOINT

It is a synovial joint, composed of the small rounded end of the humerus and the upper end of the radius. Extracapsular structures include the anterior, posterior, middle erectile and flexor muscles.

1. **Wrist Joint:** It is a Synovial joint between the lower end of the radius and the umbilical cord and triangular carpal bones of the proximal row, between which is an articular disc of fibrous cartilage. As it thickens, the lower end of the ulna remains completely separate from the carpal bones and does not participate in the formation of the wrist joint.
2. **Metacarpophalangeal Joint:** This joint can also make movements like the wrist joint, but the interphalangeal joints are the core joints that allow only flexion and dilation.
3. **Carpal Joints:** In this, there are joints between the carpal bones of the proximal and distal rows. In this, the Hinge core joint positions are very close to each other, so there are slight contraction and expansion movements between them.

OTHER TYPES OF JOINTS

1. **Amphiarthrodial Joint:** A joint that is both a core joint and a synapse joint.
2. **Biaxial Joint:** A joint in which the two chief axes are in motion at right angles to each other.
3. **Bicondylar Joint:** A synovial joint in which the two rounded surfaces of one bone fit into the shallow grooves on the other bone to form the joint.

4. **Bilocular Joint:** A joint that is divided into two segments by the interarticular cartilage.
5. **Bleeder's Joint:** Treating a patient with hemophilia in which there is bleeding.
6. **Cochlear Joint:** Lateral joint.
7. **Compound Joint:** A joint formed by two or more parts.
8. **Condyloid Joint:** A joint that can have all kinds of angular movements other than axial rotation.
9. **Diarthrodial Joint:** A joint in which there is a cavity within the capsule separating the bones from which the joint can move freely.
10. **False Joint:** A joint formed after a fracture.
11. **Fibrous Joint:** A joint in which bones are attached to fibrous tissue.
12. **Flail Joint:** High speed joint.
13. **Ginglymoid Joint:** A synovial joint in which there is only forward and backward movement.
14. **Immovable Joint:** Such a joint that cannot move at all, like a joint between the vertebrae in the spine.
15. **Mixed Joint:** A joint in which different types of joints are combined.
16. **Uniaxial Joint:** A joint rotating on one axis only.
17. **Unilocular Joint:** A joint that has only one cavity.

CHAPTER

Digestive System

INTRODUCTION

Digestion is the process in which food is broken down mechanically and chemically into smaller components so that they can be absorbed, for example, into the bloodstream. Digestion is a type of catabolism in which large molecules of food are broken down into smaller molecules. When food is taken in the mouth and chewing it through the teeth, a chemical process begins with the chemicals present in the saliva released from the salivary glands. This food then travels through the Oesophagus to the Abdomen, where hydrochloric acid kills the most contaminating microbes, initiating mechanical breakdown of some portions of food (e.g., denaturation of proteins) and chemical transformation of some portions. Hydrochloric acid has a low pH value, which is good for fermenters. After some time (an hour or two) the food residues pass through the small intestine and large intestine and are expelled during excretion.

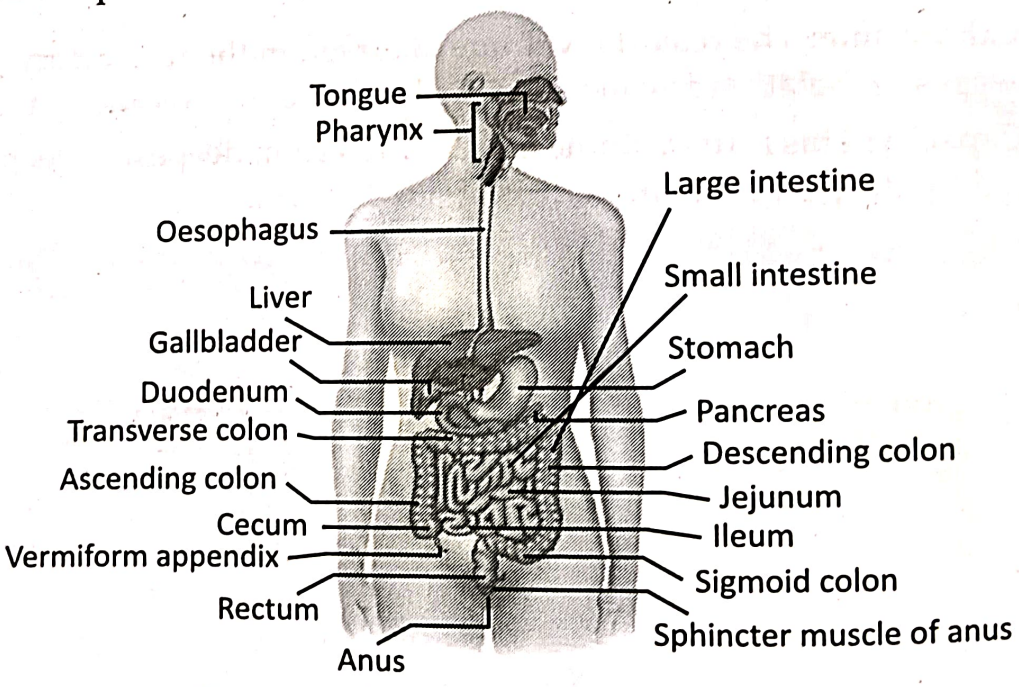


Fig. 16.1: ***Anatomy of the Gastrointestinal***

In a healthy human, this process can take 24 to 72 hours. The digestive organs mainly consist of the digestive tract, which is also called the alimentary canal. It is a tube about 9

eters (30 feet) long starting from the mouth, passing through the thorax, abdomen and lvis and ending at the anus. The wall of this tube is made up of involuntary muscles.

ORGANS OF DIGESTIVE SYSTEM

- Mouth and Oral cavity
- Oesophagus
- Small intestine
- Rectum
- Anus
- Pharynx
- Stomach
- Large intestine
- Anal canal

In addition to the above, the digestive system also includes the following accessary rgans related to digestion:

- Teeth
- Tongue
- Salivary glands
- Liver
- Lips
- Cheeks
- Pancreas
- Gallbladder

STRUCTURE OF THE ALIMENTARY CANAL

The structure of the digestive tract is the same beyond the level of the Oesophagus, which is different from the structure of the mouth and pharynx or throat. The wall of the digestive tract extends from the Oesophagus to the anus. Normally, the walls of the digestive tract are made up of the following four layers of tissue from the inside to the outside respectively.

1. **Outer Covering or Adventitia:** It is the outermost layer of the digestive tube, which is made of loose fibrous tissue in the part located in its thorax and in the part located in its abdomen is of serous art, which is called **Peritoneum.** It is the largest serum membrane of the body which covers all the abdominal organs. The part that covers the Viscera is called the **Visceral Peritoneum.** The double-layered part of the serous arteriosus, which is called the **Mysentery,** connects the intestines to the posterior wall of the abdomen. The two layers of the peritoneum are intertwined, but due to the presence of a small amount of serous fluid in between the cells of the peritoneum, they do not rub against each other.
2. **Muscular Layer:** Underneath the outer covering or the adventitia is the muscular lining. It is made up of three layers of involuntary or smooth muscle-external Longitudinal, central circular and internal oblique muscles. Skeletal muscle fibers are present in the constrictors of the upper Oesophagus and Sphincters of anus. This muscular layer of the digestive tract moves food down the digestive tract by waves of muscular contractions called **Peristalsis.**
3. **Submucous Layer:** It is a layer of loose connective tissue consisting of some elastic fibers between the innermost muscular layer and the innermost mucosal layer. Many nerves and lymphatic nodules are located in certain areas in this layer. Arterioles are Venules and capillaries in blood vessels. The Submucosal glands are

present in the Oesophagus and duodenum. Nerve pexuses is called **Meissner's plexus** that contains sympathetic and parasympathetic nerves which supply nerves to the mucosal articular lining.

4. **Mucous Membrane:** It is the innermost layer of the digestive tract, in this layer the layer of Lamina propria supporting the epithelium containing lymphatic nodules and lymphocytes and the muscularis mucosa in which the nerve plexus resides. The surface area of the epithelium is enlarged by large folds of pits, crypts and glands. This layer performs the function of Lubrication, secretion and absorption and due to this the food material becomes greasy and slips down. In this way, the mucous membrane is not damaged by solid particles of food and many chemical substances. Absorptive cells and secretory cells are present in this layer, which produce mucous enzymes etc. From the stomach to the beginning of the anal canal, the mucous membrane is not damaged. Digestion and absorption of food takes place through the mucous membrane from the stomach to the beginning of the anal canal. Therefore, in this part of the digestive tract, especially in the stomach and small intestine, the mucous membrane is made up of columnar epithelial cells, between which Goblet cells are found. The walls of the digestive tract remain smooth by the mucus released from them, which protects them from digestive enzymes.

ORGANS OF DIGESTIVE TRACT

MOUTH

The mouth or oral cavity is the initial wide part of the digestive tract. Its roof (upper part) is made up of hard and soft palate. The front two-thirds of the tongue surrounds the floor (lower part) of the mouth. The walls are made up of the muscles of the cheeks. The mucous membrane lining the mouth is attached to the skin of the lips and the mucous membrane of the pharynx. Arbicularis oris muscles are present in the lips which keep the mouth closed. The inner opening of the oral cavity is called the **Fauces.** A fleshy part hangs in the middle of its upper part, which is called **Uvula.** In the oral cavity, near the pharynx, in the walls of both sides, a gland is buried inside the muscles, which is called **Tonsil.** The entire oral cavity is covered with a Stratified Squamous Epithelium. It contains small mucous-secretory glands. The oral cavity is divided into two parts. External small part, Vestibule or Buccal cavity, which is limited by the lips and cheeks on the outside and by the teeth and gums on the inside. The remaining large part of the oral cavity is called the **Oral cavity proper.** It is lined on the sides by maxillary bones and teeth and merges behind the Oropharynx.

Lips

It is the upper or lower fleshy edge of the mouth which forms the opening of the mouth or the oral cavity. They are mainly composed of fibroelastic connective tissue and skeletal muscle fibers. The upper and lower lips are fused at the face angles. Their outer lining is of the skin and the inner lining of the mucous membrane, which is in continuation of the

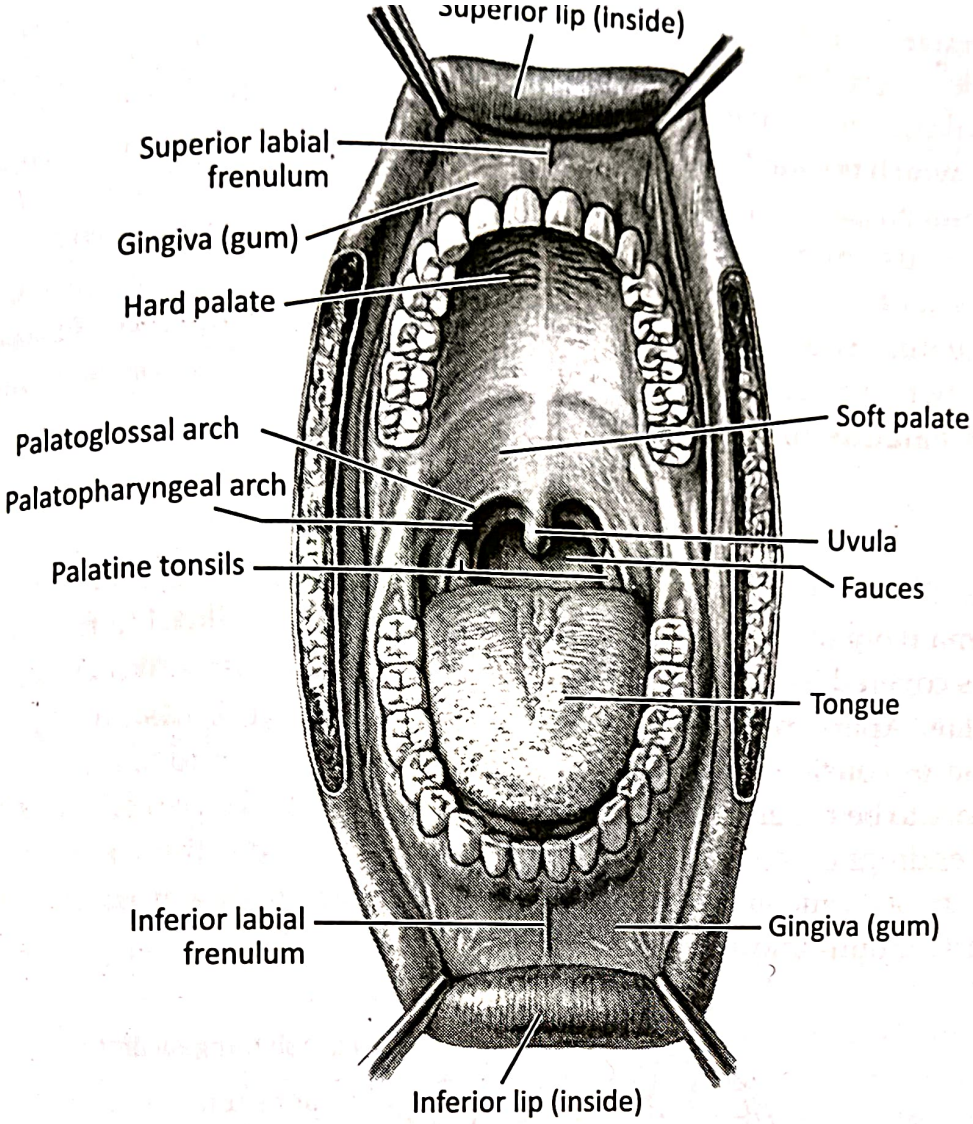


Fig. 16.2: ***Structure of Mouth***

mucous membrane of the oral cavity. They rise up by the levator anguli oris muscle and press down the face angle by the depressor anguli oris muscle.

Each lip is attached to the gums in its midline by a fold of mucous membrane, the Labial **Frenulum.** The small band under the tongue is called the **Lingual Frenulum.**

Cheeks

The fleshy sides of the face below the eyes, which form the lateral walls of the mouth, are called **Cheeks.** They are attached to the lips and the buccinator muscle is found in them. The cheeks are lined with a mucous membrane which contains small mucous glands.

Palate

The roof of the mouth, the horizontal division separating the nasal and oral cavities is called the Palate. It is of two types:

1. **Hard palate:** This is the front hard part of the palate. The hard palate is made up of the maxilla and palatine bones and is surrounded by the upper teeth. Forming a curve on the posterior edge of the hard palate, descends and merges laterally into the walls of the pharynx.

2. **Soft palate:** The soft palate is the soft fleshy part of the palate. The soft palate is a muscle covered with mucous membranes. From the middle of the free end of the soft palate, a muscular conical membrane covered with mucous membrane hangs down which is called the **Uvula.** The cochlear prevents food from passing through the nasal passages during swallowing. From the upper end of the uvula, two folds of mucous membrane come out on both sides and go down forming an Membranous arch. These are the **Pillars of fauces.** The anterior folds are called the **Palatoglossal Arch** and the posterior folds are called the **Palatopharyngeal Arch.** Between the arches on each side there is a collection of lymphoid tissue called **Palatine tonsils.**

Tongue

The tongue is a freely moving muscular organ located on the ground floor of the mouth, which is the main organ of taste and helps in chewing and swallowing food and speaking. The tongue is covered in some areas by a modified membrane on which there are bulges called **Papillae.** Apart from this, in particular areas, **Taste Buds,** are spread over the whole tongue in considerable quantity. Due to these taste buds, the back part of the tongue appears to be rough. It is from these taste buds that we perceive taste, because on these are the endings of the nerves of the senses of taste. Under the free part of the tongue is a crescent-shaped mucous membrane. It extends from the lower layer of the tongue to the floor of the mouth and is called the **Frenulum.**

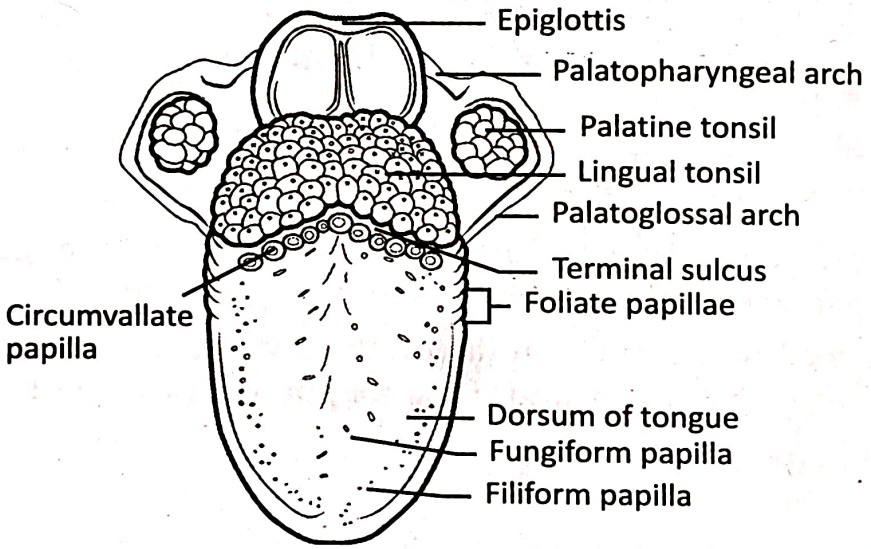


Fig. 16.3: ***Papillae of the Tongue and Related Structure***

There are three types of papillae:

1. **Filliform or Threat-like Papillae:** These are angular structures found in the front two-thirds of the tongue. They do not have taste buds.
2. **Fungiform Papillae:** These are broad flat shoots appearing like fungi on the tongue, mainly located on its ends and sides, which are much more in number than the circumscribed shoots. Most of them have taste buds.
3. **Vallate Papillae:** These are usually 8 to 12 and are found in the shape of an inverted V towards the base of the tongue. These are the largest and easily visible Papillae.

Functions of the Tongue

- It helps in speaking.
- On the surface of the tongue are taste buds. With the help of these taste buds we can taste things like sour, sweet, salty etc.
- It helps in chewing the food.
- It helps in swallowing of food items.
- Through the tongue, the food item is known to be hot or cold.

Teeth

Teeth are small, white colored structures located in the mouth. The teeth are located in the oral cavity in the bony troughs or dental cavities of the **Maxilla** and the **Mandible.** There are two sets of teeth, temporary and permanent. Teeth that erupt in the first or second year of life are temporary. They are also called **Deciduous or milk teeth.** After they fall or fall out, permanent teeth start coming in their place.

1. **Temporary or Milk Teeth:** These begin to erupt at about 6 months of age and all have erupted by the end of the second year or soon thereafter. In terms of composition, they are similar to permanent teeth, except that they are relatively smaller in size. Their neck is more narrow. There are 10 temporary teeth in each jaw and 20 in total. There are five teeth on each side of the midline of each jaw, named from the midline, two **Incisors,** one dentary or **Canine** and two **Molar** or **Chewing Teeth.** First the central incisors of the lower jaw begin to erupt and then the lateral incisors emerge. After the erupting of these teeth, at the age of 12 to 15 months, one chisel tooth each comes out on either side. Penetrating teeth erupt in the 18^{th} month. Finally, between the 20^{th} to the 24^{th} month, the remaining molar teeth (molars) erupt. A one year old child should have two central and two lateral incisors in the upper and lower jaws, thus, a total of eight teeth. A healthy 2 year old child has 20 milk teeth. Generally, the teeth in the lower jaw erupt earlier than the teeth corresponding to the upper jaw. Temporary teeth last until the age of 6, after which they begin to fall out. By the age of 12 all the temporary teeth have fallen out. Premature teething in children is a sign of their normal development. In some diseases such as Rickets, children's teeth erupt late.
2. **Permanent Teeth:** After childhood, the number of teeth in a human is 32, out of which 16 teeth remain in the upper and 16 teeth in the lower jaw. There are 8-8 teeth on either side of the midline of each jaw, from whose center there are two incisors, one dentary or penetrating, two **Pre-molars** and three **Molars.** The third final dentate teeth are called **Wisdom Tooth.**

After the erupting of the milk teeth, the first molar teeth erupt, then the incisors (central and then lateral) at the age of 7 to 8 years, the first premolars or pre-molars at the age of 9 to 10 years, 11 At the age of about 17 years, the second anteroposterior and second pectoral teeth emerge at the age of about 12 years and lastly, at the age of about 17 years, the third pectoral tooth also emerge which is known as **Wisdom tooth.** The Wisdom tooth emerges at the age of 17 to 30 years. Sometimes the third Molar gets Impacted inside.

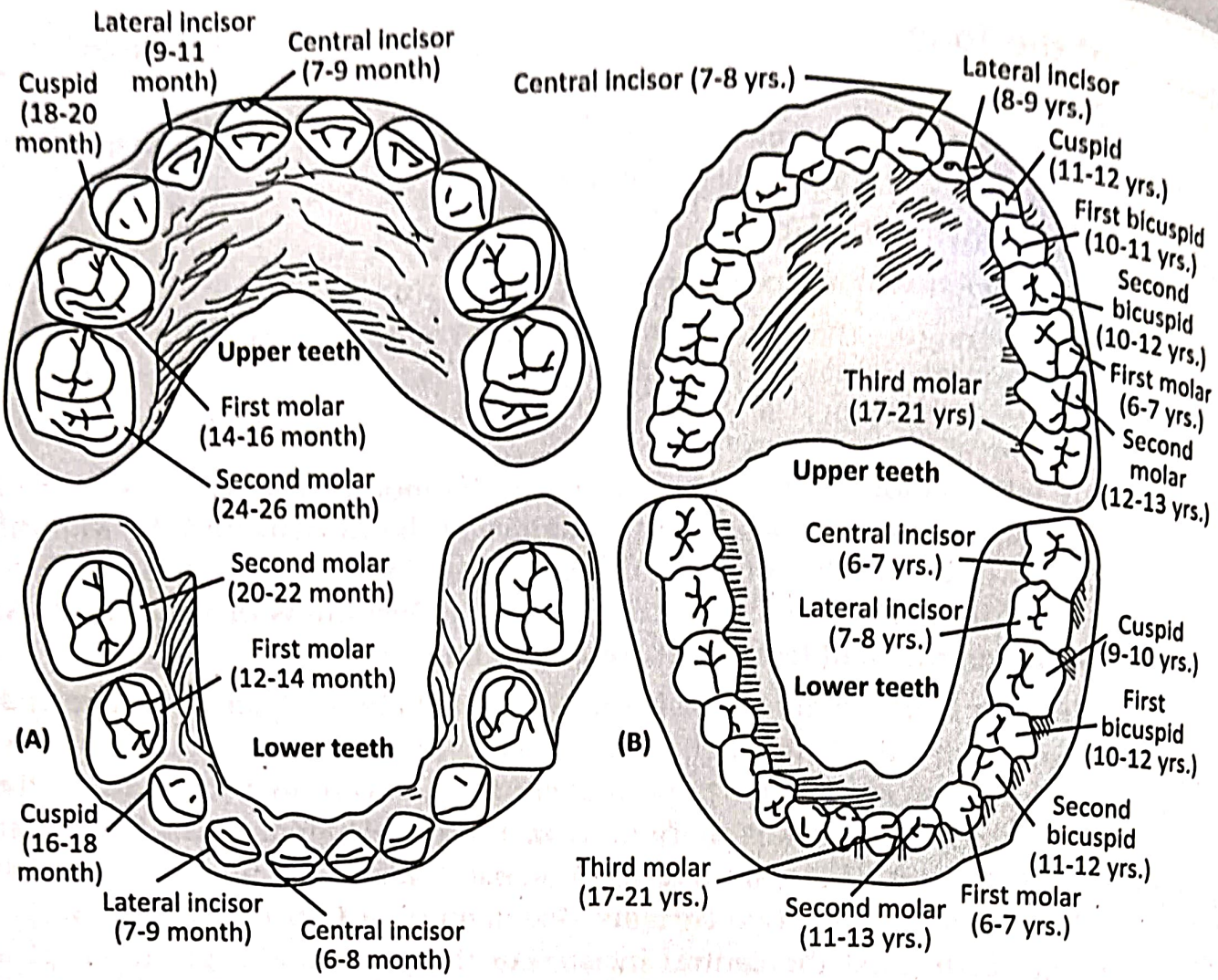


Fig. 16.4: ***(A) Deciduous Baby Teeth, (B) Permanent Teeth***

Structure of Teeth

Teeth differ in shape, yet they have the same structure and each tooth has the following three parts:

1. **Crown:** This is the protruding part of the tooth that is visible from the gums. It moves upward into the oral cavity.
2. **Neck:** This is the narrow part between the dental crest and the dental root, which is surrounded by gums from all sides.
3. **Root:** This is the part of the tooth that is buried in the trough of the jaw bones.

Each tooth is made of Dentin, Enamel, Cementum. Inside the tooth there is a cavity called the **Dental Cavity,** which leads to the root canal and contains a highly sensitive yellowish substance called **Dentine.** It is the main substance of the tooth, as it makes up most of the tooth. Within it exists the **Pulp cavity** containing the dentin. The **Enamel** is the hardest and toughest part of the tooth. It covers the dental crest. Its layer is thickest on the mantle and thinner near the neck. The **Cementum** is the bone-like substance covering the dental root that keeps the tooth fixed in the dentin. The blood vessels and nerves reach inside the tooth through a small opening at the top of each tooth root. Inside the tooth is a cavity called the **Root cavity,** which is filled with a substance made up of soft connective tissue called the **Pulp.**

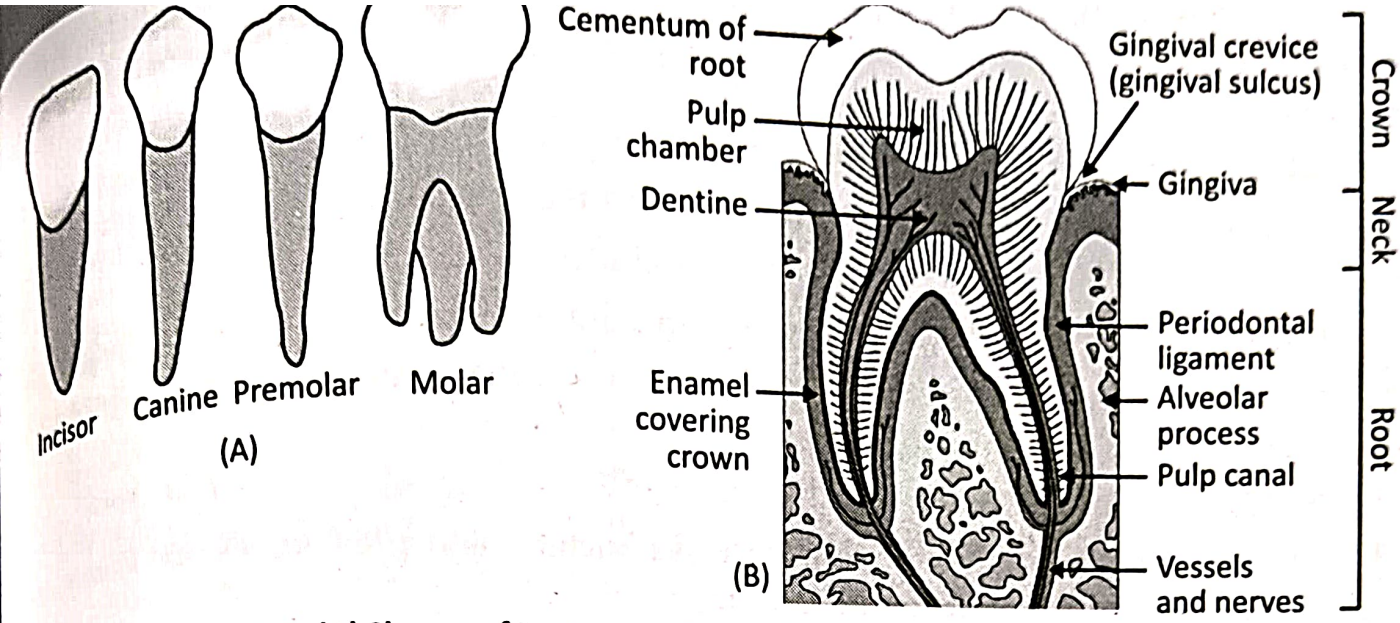


Fig. 16.5: ***(A) Shapes of Permanent Teeth, (B) Sagittal section of a Tooth.***

Nerves and blood vessels are found in the dental medulla. Rodents cut the food into pieces. The premolar and molar teeth perform the function of chewing or grinding food with their broad flat surface.

SALIVARY GLANDS

These are the glands of the mouth from which **Saliva** is secreted. These are the following three pairs of glands, that is, these glands are made up of many groups of sac-like brackets, from which small Lobules are formed.

1. **Parotid Glands:** These are pyramidal shaped glands. A mastoid gland is located on both sides of the face, under the ear and in the front. These are the largest glands. Each gland has a **Parotid duct** or **Stenson's duct** which opens inside the cheek near the other Molar. Through these ducts, the cavity of the parotid glands (containing water, salt and tylin) comes into the mouth.
2. **Sub-mandibular glands:** These glands are present on either side of the face, one each under the mandible or lower jaw. In size, it is half the size of the parotid glands. The sub-mandibular ducts come from the glands on both sides and open on either side of the gynae on the floor of the mouth. These glands secrete water, salt, salivary amylase and mucin which comes to the mouth through submandibular ducts.
3. **Sublingual glands:** These are the smallest glands. These glands are located on the floor of the mouth of the submandibular glands, one each under the tongue. There are many small vessels in them which pierce the mucous of the oral floor and pour the saliva into the oral plane through small holes. Their sacs are more viscous than the sacs of other glands.

Secretion of Saliva

The release of saliva occurs as a reflex action. As soon as food enters the mouth or on the sensation of food, which can be seen or smelled, saliva starts pouring.

Saliva has a slightly acidic pH. Saliva moistens the food, helps in its chewing and swallowing and starts the process of digestion of food. About 1.5 liters of saliva is produced per day.

Saliva contains the following substances:

- Water is 99% and acts as a solvent. Keeps the face moist.
- A protein called mucin that makes up mucus.
- Mucus mixes with food to make it lubricated so that it can go down the esophagus.
- Salivary Ptyalin acts on digested starch or carbohydrate and breaks it down into maltose and dextrin.
- Chlorides activate salivary Ptyalin.
- Lysozyme is an enzyme that destroys bacteria and prevents Dental decay and infection of the mucous membrane.
- Bicarbonates maintain pH level of saliva from 6.35 to 6.85.

Functions of Saliva

- Water present in saliva helps in the dissolution of food, which reveals the taste of food.
- When dry food enters the mouth, it gets mixed with the help of saliva.
- Saliva moistens the food and lubricates it, so that the mucous lining of the mouth does not burst.
- Saliva also cleans the mouth and teeth and lubricates the soft organs.
- Saliva helps in killing harmful microorganisms like lysozyme and immunoglobin.

PHARYNX

The pharynx is the Musculomembranous (tube) from the back of the nasal-cavities for air to the larynx and from the mouth to the esophagus for food.

This tube is about 12.5 cm (5 inches) long. Its upper broad part remains attached to the base of the skull and the lower part merges into the esophagus and the anterior part into the nasal cavity.

The pharynx is part of the digestive system and respiratory system. Since both food and air pass through the scrotum, a thin epiglottis of connective tissue closes over the trachea when food is swallowed to prevent strangulation or asphyxiation.

Parts of Pharynx

The pharynx is divided into following three parts:

1. **Nasopharynx:** The nasopharynx is related with the breathing activity. This is the posterior part of the pharynx. In this part the Eustachian tubes come and open and lymphoid tissue which is also known as the mumps or adenoids are found in the nasopharynx.

2. **Oropharynx:** The oropharynx is the central part of the pharynx located between the soft palate and the upper edge of the Epiglottis. Tonsils are located in the lateral walls of this part of the pharynx.
3. **Laryngopharynx:** The lower part of the pharynx from the upper edge of the Epiglottis which opens into the larynx and esophagus is called Laryngopharynx.

Layers of Pharynx

The wall of the pharynx consists of the following three layers:

1. **Mucous layer:** It is the innermost layer. It consists of a layered squamous epithelium. It is located along the mouth and esophagus.
2. **Submucous layer:** It is the middle layer which consists of fibrous tissue. It contains blood and lymph vessels and nerves.
3. **Muscular layer:** This is the outer layer, it contains three contractile muscles, which help in swallowing.

OESOPHAGUS

The esophagus is a narrow muscular tube about 25 cm (10 in) long and about 2 cm wide that begins at the scrotum behind the mouth, passes through the thorax through the thoracic diaphragm and ends at the heart gate in the abdomen.

The wall of the esophagus is made up of two layers of thin muscles that form a continuous layer from the esophagus to the outside and are gradually compressed over a long period of time. The inner layer of these muscles is in a curved path in the form of downward rings, while the outer layer is vertical. At the top of the esophagus is a layer of tissue called the **Epiglottis,** which closes during swallowing so that food cannot enter the trachea. The chewed food is pushed through the esophagus to the stomach by the peristalsis of these muscles. It takes only seven seconds for food to pass through the esophagus and there is no digestion during this time.

Deglutition or Swallowing

After the food has been chewed properly and has become Bolus, it is swallowed. The process of monitoring has the following three parts:

1. **First action:**
   (a) Its tendency is voluntary.
   (b) In this the mouth is closed and the voluntary muscles of tongue and cheeks push the esophagus from the back of the mouth back into the pharynx.
2. **Second action:** The second action of monitoring takes place in the pharynx. In this phase there is an involuntary or reflex action, which is triggered by stimulation of the glossopharyngeal nerve. In this, the pharyngeal muscles push the food down into the esophagus. When swallowing occurs, all other passages are closed. The soft palate rises up and closes the pharynx and separates it from the rest of the pharynx, so that the esophagus does not pass into the pharynx and further

reaches the esophagus. It is not possible to breathe and swallow food at the same time.

3. **Third action:** This is also an involuntary and reflex action. In this, the lower muscles of the pharynx contract and initiate waves of peristaltic motions, which carry the food through the esophagus into the stomach.

ABDOMEN

The abdomen is a small, English "J" shaped sac whose walls are made up of thick, flexible muscles that store food and help break it down into smaller particles. If food is broken down into smaller particles, it is more likely to be fully digested in the small intestine and the churning in the abdomen helps in the process of splitting food that started in the mouth.

Food enters the stomach from the heart gate in the abdomen where it is further broken down into smaller particles and mixed thoroughly with gastric acid, pepsin and other digestive enzymes to break down proteins. Stomach enzymes also have an optimum point, that is, they work best at a particular pH and temperature. The acid itself does not turn the food into powder, it merely provides the optimum pH for the action of the pepsin enzyme and kills the microbes that enter the food. It can also denature proteins. It is the process of shortening of polypeptide bonds and dissolving salt bridges that cause damage to the II, III and IV protein structures. The wall cells of the abdomen also secrete a glycoprotein called **Intrinsic Factor** that enables the absorption of Vitamin B_{12}. Other smaller particles, such as alcohol, are absorbed into the abdomen, passing through the abdominal membrane and entering the circulatory system. Food in the stomach is in a semi-liquid form, which when it is full is known as **Chyme.**

The transverse portion of the esophagus exposes the four clear and well-developed layers within the abdomen.

1. Thin layer of Mesothelial cells is the serous membrane, which is the outermost wall of the abdomen.
2. The muscular layer is a well-developed layer of muscles used to mobilize the ingested food, which is made up of three sets running in different alignments. The outermost layer runs parallel to the vertical axis of the stomach (top to bottom), the middle layer is concentric in the axis (circling the abdomen horizontally) and the innermost oblique layer, which mixes the ingested food and breaks it down into smaller pieces and particles and move angularly from the vertical axis. The inner layer occurs only in the abdomen, with all other digestive systems having only the first two layers.
3. Submucosa, it is composed of connective tissue connecting the inner muscular layer to the mucous membrane and contains veins, blood and lymphatic arteries.
4. The mucous membrane is the innermost layer that is often folded. It can be divided into the epithelium lamina propria and the muscularis mucosa, although some consider the outermost muscularis mucosa to be a separate layer because it develops from the mesoderm or mesoderm, rather than the endoderm or endoderm (and thus there are 5 layers in total). The epithelium and lamina are filled with connective

tissues and covered with gastric glands which may be simple or tubular branched and secrete mucus, hydrochloric acid, pepsinogen and renin. The mucus lubricates the food and prevents hydrochloric acid from affecting the abdominal walls.

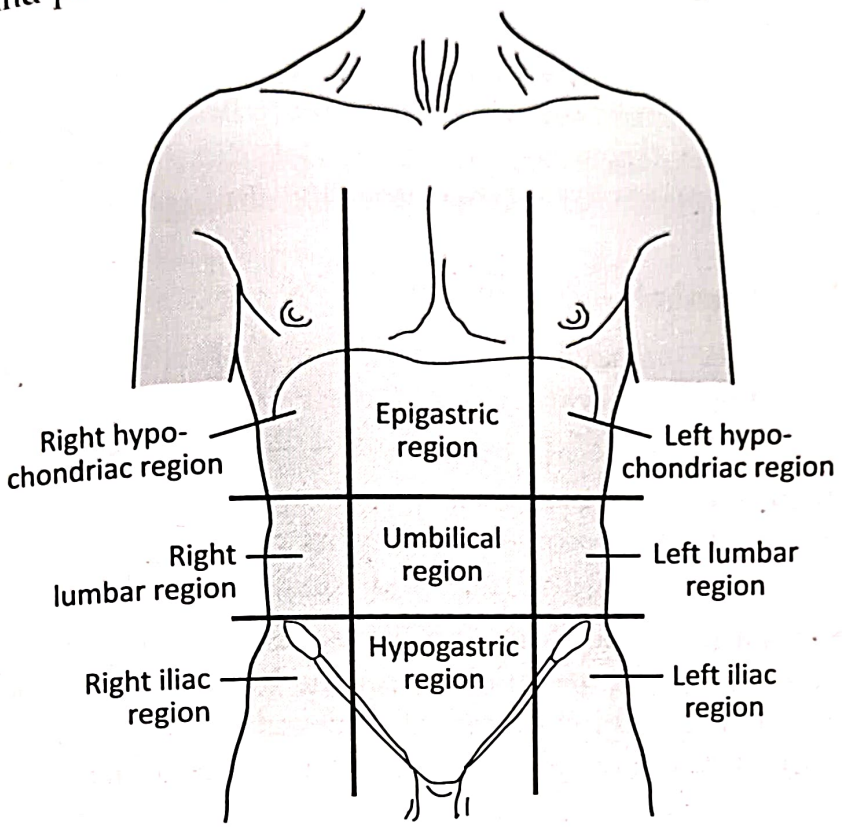


Fig. 16.6: ***Nine Regions of Abdomen***

TOMACH

tomach, between the esophagus and the duodenum, below the diaphragm, to the right f the spleen and partly below the liver, is the muscular wide sac-like portion of the limentary canal. Most of its (about 5/6) part is located on the left side of the midline of

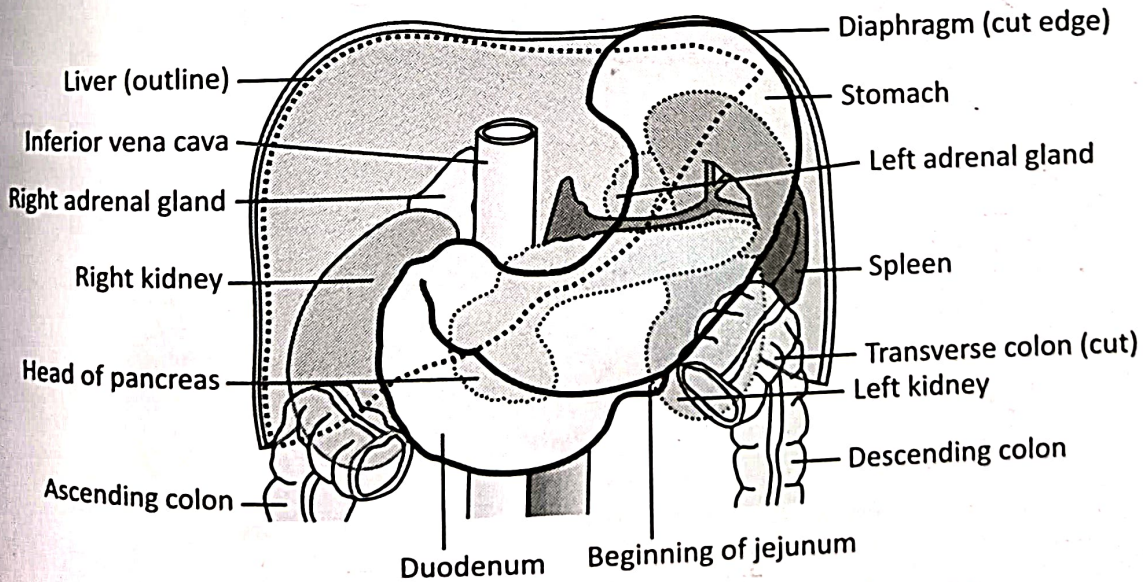


Fig. 16.7: ***Stomach and its Associated Structures***

the body and the rest on the right side. Next to it is the left segment of the liver and the anterior abdominal wall. Behind the abdominal aorta, pancreas, spleen, left kidney and adrenal gland are located. Above this is the diaphragm, the esophagus and the left section of the liver. Below is the transverse colon of the large intestine and the small intestine. On the left is the diaphragm and spleen and on the right is the liver and duodenum. It is made up of the fundus or upper rounded part, a body or middle part and the pylorus or pylorus or distal small part. It secretes gastric juice which mixes with food to form chyme, a semi-solid substance suitable for further digestion through the intestines.

Structure of the Stomach

The size and shape of the stomach varies according to its muscular activity and food. It has two curvatures: **Lesser curvature** and **Greater curvature.**

The lesser curvature is small and the greater curvature is large. The lesser curvature forms the right or back edge of the stomach and the major curvature forms an upward arch running forward. It later becomes the fundus part of the stomach on the left side. Running down it finally turns to the right and joins the Duodenum.

There are three parts of the stomach: The upper part is located above the cardiac orific, the main body between the fundus and the horizontal part below is called the Pyloric antrum or canal. This duct opens into the pyloric orifice. At this gate there is a pyloric sphincter, which does not allow food from the duodenum to return to the stomach.

Walls of the Stomach

The walls of the stomach are made up of the following four layers:

1. **External Serous Layer:** This is the outermost layer of the stomach. It is a visceral layer made up of peritoneum.

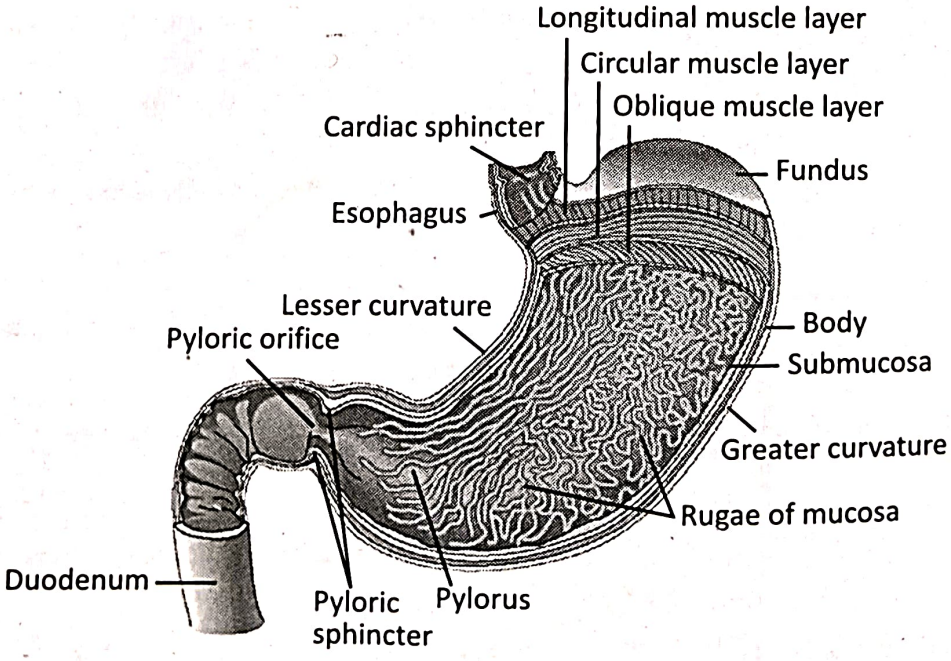


Fig. 16.8: ***The Muscle Fibres of the Stomach Layer***

2. **Muscular Layer:** Within the lining of the peritoneum is the muscular layer. It consists of three layers of smooth or involuntary muscle. The outermost layer consists of longitudinal filaments which are in continuation of the esophagus. The intermediate layer consists of circular fibers that thicken into the ventral opening where they form the Pyloric sphincter. The inner layer consists of oblique fibers which are mainly found in the fundus of the stomach and in the body.
3. **Submucosal Layer:** This layer is made up of loose connective tissue in which blood vessels and lymph vessels are found.
4. **Mucosal Layer:** This layer looks like a beehive due to the digestive glands and their pores. The mucous membrane has many folds called Rugae. They are elongated and spread when the stomach is filled. The mucus secreted by the globule cells helps to lubricate the food.

There are three types of gastric glands in the stomach:

1. Fundic Glands
2. Cardiac Glands
3. Pyloric Glands

The mouths of the micro ducts of these glands open on the mucous membrane.

1. **Fundic Glands:** These glands are found in the fundus and body of the stomach. Digestive or peptic cells are found in the bodies of these glands, which are the main cells of the glands. An enzyme called pepsinogen is produced from the particles present in them.
2. **Cardiac Glands:** These glands are located near the pyloric orifice, from which the mucus leaks; whose reaction is alkaline.
3. **Pyloric Glands:** These glands are the Pyloric sglands located near the pylorus or pylorus, from which gastric juice is secreted.

Functions of the Stomach

The stomach has the following functions:

- Churning the food so that it breaks into small particles and the digestive juices can mix well in it.
- Food enters the esophagus through the Cardiac orifice in the stomach, which stays in the stomach for some time, so the stomach acts as a temporary store of food, so that the gastric juice secreted from the walls of the stomach gets time to act on the food.
- The stomach serves as a temporary storehouse for ingested food, until it reaches the small intestine.
- The stomach secretes hydrochloric acid and enzymes that initiate the digestion of proteins and kill most microorganisms that enter the stomach with food.

Gastric Juice

This gastric gland located in the stomach, which is a thin colorless fluid, which contains pepsin (the main enzyme of gastric juice), hydrochloric acid, mucin (a glycoprotein),

inorganic salts in small amounts and interstitial agents of anti-anaemia. Gastric juice is slightly viscous and sour in taste, with a range of pH 0.9 to 1.5. The relative density is 1006-1009. A normal adult consumes 1.5 to 3 liters of gastric juice per day.

Gastric juice is made up of the following substances:

- Water, mineral salts and mucus
- Hydrochloric Acid (HCl)
- **Enzymes:**
  - Pepsinogen
  - Renin
  - Lipase

The action of enzymes is as follows:

Pepsinogen: It is converted into pepsin in the presence of hydrochloric acid. Pepsin digests the protein, which converts the protein into peptone. Peptones are simple soluble substances made up of amino acids.

Renin: An enzyme found in the gastric juice of infants that coagulates milk into curd, converts the soluble protein carcinogen into casein, an insoluble milk protein. Pepsin may act on the casein thus isolated.

Lipase: It is an enzyme that breaks down fats into fatty acids and glycerol. It is not a potent enzyme and is different from lipase found in **Pancreatic Juice.** This enzyme is found in very small amounts in gastric juice, due to which digestion of fat starts from the stomach itself. It is necessary for children. With the help of this milk gets digested completely.

Hydrochloric acid present in gastric juice has the following uses:

- It kills bacteria.
- It produces acidic medium which is essential for gastric enzymes.
- It controls the pylorus.
- It inhibits the action of ptyalin.
- It converts pepsinogen to pepsin.

Secretion of Gastric Juice

A small amount of gastric juice is always present in the stomach even if there is no food in it. This gastric juice is called **Fasting Gastric Juice.** The secretion of gastric juice is highest one hour after a meal, after that it decreases and reaches the level of fasting gastric juice four hours after the meal.

INTESTINE

It is that part of the alimentary canal or food pipe which extends from the gastrointestinal tract of the stomach to the anus. It is divided into two parts:

1. Small intestine
2. Large intestine.

SMALL INTESTINE

It is smaller in diameter than the large intestine. It extends from the pyloric opening of the stomach to the end of the ileum or ileum, a 5 to 7 meter long tube that opens into the large intestine at the **ileocecal valve.** It is longer in males than in females and due to reduced tautness, it is longer in a dead body than in a living body. It usually resides in the lower middle part of the abdominal cavity at the bend of the large intestine.

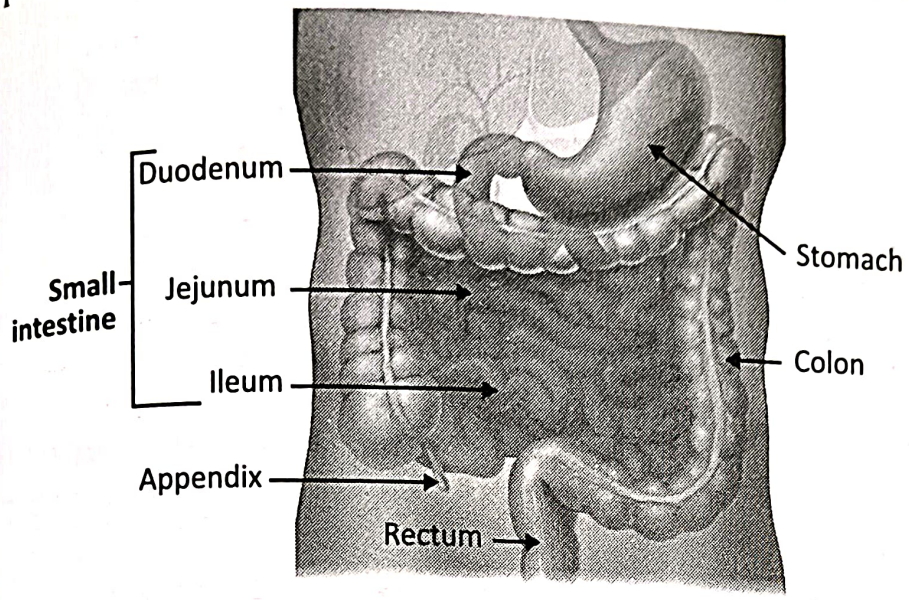


Fig. 16.9: ***Small Intestine***

It consists of the following three parts:

1. **Duodenum:** This is the first part of the small intestine which extends from the pylorus to the jejunum. It is about 25 cm (10 inch) long in the shape of a horseshoe (English letter C) that surrounds the apex of the pancreas. At a distance of about 10 cm from the pylorus, a common orifice, **Ampulla of Vater,** opens into both the **Common Bile Duct** and the **Pancreatic Duct.** It is surrounded by sphincter of oddi.

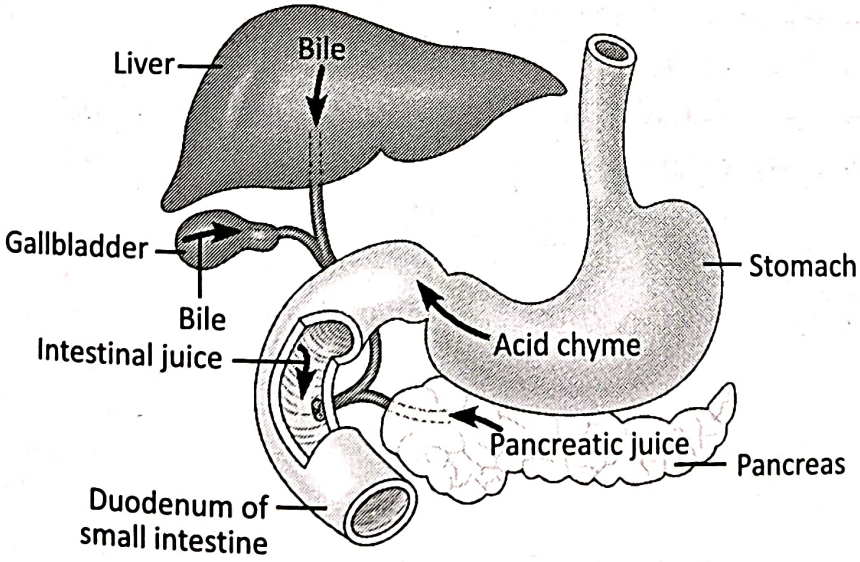


Fig. 16.10: ***Duodenum and its Associated Structures***

2. **Jejunum:** This is the upper 2/5 part of the remaining part of the small intestine and is about 2.5 meters (8 feet) long. Its upper end is attached to the duodenum.

3. **Ileum:** This is the lower midgut or part of the small intestine from the jejunum to the cecum, which is about 3.5 meters long and ends at the **Ileocecal Valve,** which controls the flow of food from the ileum to the large intestine and prevents the contents of the cecum from coming back into the ileum.

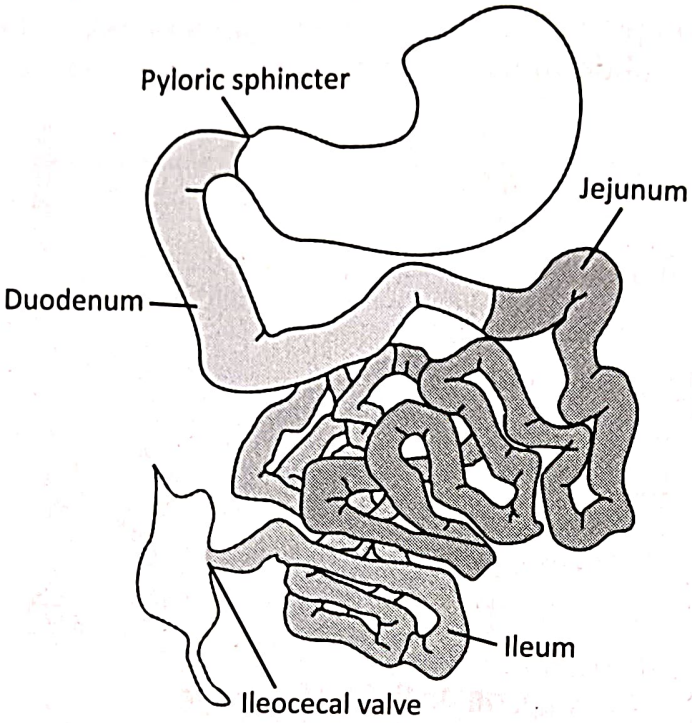


Fig. 16.11: ***Jejunum and Ileum and their Associated Structures***

There is no clear boundary between the jejunum and the ileum. Both the jejunum and the ileum of the small intestine are suspended from the posterior wall of the abdomen by a folded layer of Peritoneum called the **Mesentery.**

Structure of Small Intestine

The walls of the small intestine are made up of the same layers of tissue that make up the walls of the stomach. But some transformation takes place in them.

- The External Serous Layer is made up of the peritoneum. Its double layer, which is called the **Mesentry,** covers the duodenum from the front and attaches the jejunum and ileum to the posterior ventral wall.
- There are large blood vessels and nerves on the posterior abdominal wall, from which branches come out through both layers of the mesentery to reach the small intestine.
- The muscular layer is made up of involuntary muscles, with one outer layer of longitudinal fibers and the other thick layer of circular fibers below it. In the middle of these fibrous layers, a network of blood capillaries, lymphatic vessels and nerves are spread. The contraction of the layer of circular fibers produces wave-like motions in the small intestine, i.e., peristaltic movements.
- The submucosal layer is made up of Areolar tissue, in which many blood vessels, lymph vessels and glands are found and a network of nerves is laid. The network

of nerves is called **Meissner's Plexus.** A special type of small glands are found in the duodenum, which are called **Brunner's Glands.** These produce a viscous alkaline liquid that protects the inner surface of the duodenum from acidic substances in the stomach.

- The mucous lining (layer) is the lining of the inner mucosal layer. It has many circular folds or Villi. This gives more space for the production of digestive juices and absorption of food. Due to the presence of these rings, the food is not able to enter the large intestine immediately, due to which the digestive juices get more time to act on the food.

The lining of the mucous membrane has the following characteristics:

- It consists of Plicae circulars that surround the intestine like rings, which increase the available area of mucus for absorption. Unlike the Rugae (gastric wall), they are permanent and do not disappear when the intestine is dilated.
- Uncountable small, 0.5 to 1 mm, in its recesses from the inner surface of the small intestine. Long finger-shaped bulges come out, which are called **Villi.** Due to these the mucosa appears like velvet. The walls of the villi are made up of columnar epithelium cells (Enterocytes), interspersed with mucous membrane cells. Within these **Goblet cells** is a network of blood and lymph cells. Lymphatic vessels are called **Lacteals.** Lymphatic vessels or lacteals are important in the absorption of fats. The inner folds of the epithelium between the bases of the villi form tubular intestinal glands, increasing the surface area.

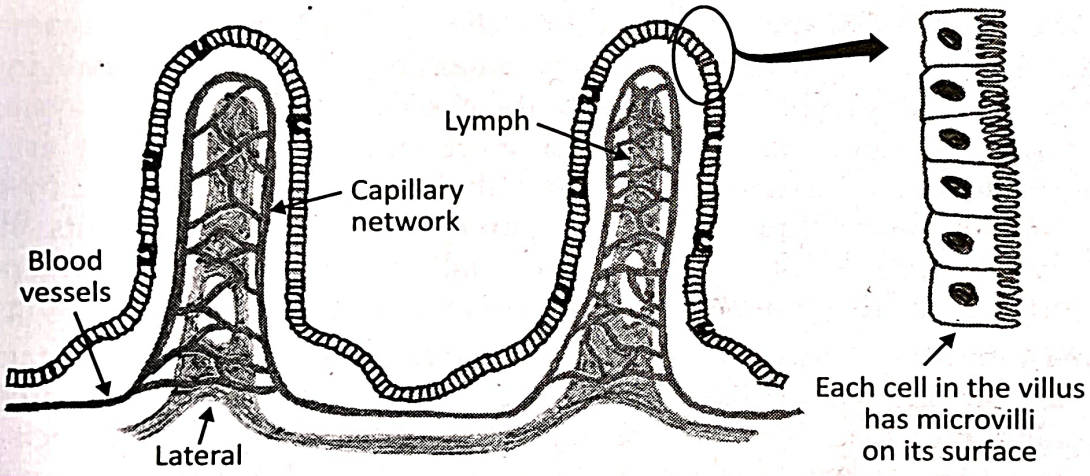


Fig. 16.12: ***Villi***

- Within the mucosa are tubular glands that secrete a variety of enzymes and help in the digestion of carbohydrates, proteins and fats. The intestinal glands or **Crypts of Lieberkuhn** are simple tubular glands found throughout the mucous membrane of the small intestine and opening on the surface of the Tubular between the shoots from which the intestinal juice secretes. These glands are covered with columnar epithelium which merges with the covering of the shoots. **Brunner's glands** are found only in the duodenum. These glands produce a viscous alkaline mucous secretion that protects the mucous membrane in the intestine from the acidic chyme of the stomach.
- **Solitary glands:** There are solitary lymphatic vesicles found throughout the mucous membrane of the small intestine. These bacteria protect the intestine

from invasion. In the ileum these follicles occur in clusters and are called **Aggregated lymph follicles** or **Peyer's patches.** These are Aggregated lymph follicles of 20 to 30 numbers from a solitary lymphatic vesicle found in the mucosal art of the last part of the ileum. They are circular or elliptical. These bacteria protect the intestine from infection. In typhoid fever, Peyer's patches swell.

Functions of the Small Intestine

The semi-liquid food or chyme from the stomach is digested and absorbed in the small intestine.

Digestion and absorption of food in the small intestine:

After being processed in the stomach, the food is passed through the pyloric contractile muscle to the small intestine. After the milky chyme enters the digestive tract, a major part of the digestion and absorption processes take place here. Here, it is mixed with three different liquids:

- Bile which emulsifies fats for absorption, neutralizes chyme and is used to excrete waste products such as bile and gallstones. Bile is produced by the liver and then stored in the gall bladder. The bile present in the gall bladder is very concentrated.
- Digestive juice prepared by the pancreas.
- Intestinal enzymes of alkaline mucosal membranes. These enzymes include maltase, lactase and sucrase (all three only process sugars) and trypsin and chymotrypsin.

When the pH level in the small intestine changes and gradually becomes coaxial, more enzymes are activated that chemically breakdown various nutrients into smaller molecules so that they can be absorbed into the circulatory or lymphatic systems. These tiny, finger-like structures called **Villi,** each of which are surrounded by even smaller, hair-like structures called **Microvilli,** improve the absorption of nutrients by increasing the surface area of the intestine and speeding up the absorption of nutrients. Blood filled with absorbed nutrients is carried out of the small intestine via the hepatic portal vein and transported to the liver where it is filtered, removing toxins and processing nutrients.

The small intestine and the rest of the digestive system perform peristalsis, which moves food from the stomach to the rectum and absorbs food mixed with digestive juices. Circular and vertical muscles are opposites, when one muscle contracts, the other relaxes. When the circular muscles contract, the antrum becomes more narrow and elongated and the food is pushed forward by squeezing it. When the vertical muscles contract, the circular muscles relax and the alimentary canal becomes wider and shorter, allowing food to enter.

Digestive Movements of the Small Intestine

There are two main types of muscular activity in the small intestine which helps in the digestion of food:

A. Mechanical Activities:

1. **Segmenting Contraction:** Due to the strong contraction in the circular muscle fibers, the intestine is divided into different segments. This allows the chyme to temporarily come into contact with the walls of the intestine for digestion and absorption. Chyme remains in the region of compacted segments and then the

segments become loose. When the chyme enters the small intestine, the duodenum and ileum are simultaneously fragmented.

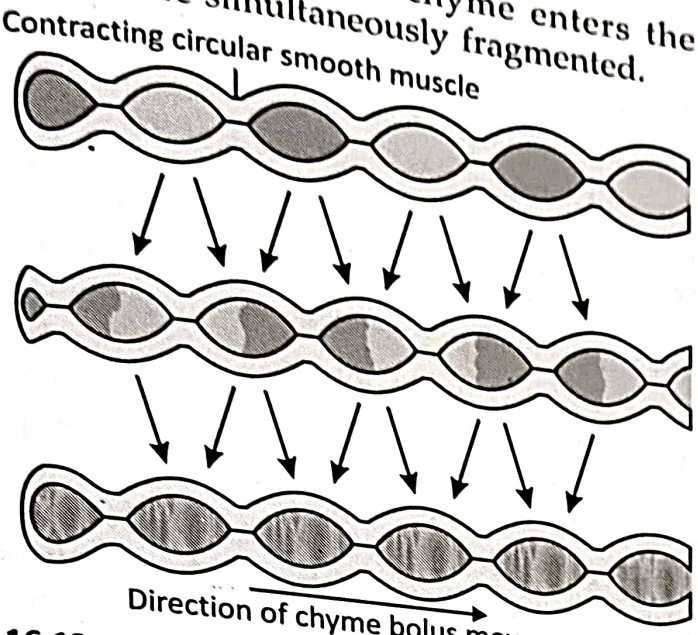


Fig. 16.13: *Segmenting Contractions of the Small Intestine*

2. **Peristaltic Contractions:** These are slowly moving wave-like motions that cause the food to move forward. After peristaltic contractions reach the end of the small intestine, new waves begin at the initial site.
3. **Pendular Movements:** By the oscillations of the intestine or pendulum-like swinging motions, the chyme gets mixed with the digestive juices and due to this the food becomes more dilute and due to this, the chemical action of digestive enzymes on the food is very good.

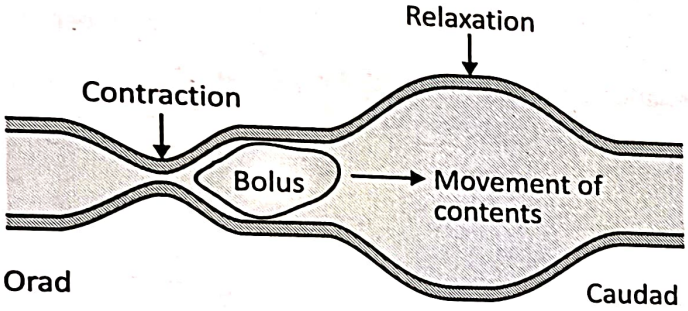


Fig. 16.14: *Peristaltic Contractions of the Small Intestine*

B. **Chemical Activities:** When gastric food or chyme enters the small intestine, this bile mixes with Pancreatic Juice and Intestinal Juice, which chemically act on the chyme.

Pancreatic juice: It is a clear alkaline liquid produced from the vascular cells of the pancreas. It contains water, mineral salts and the following types of enzymes:

- **Enterokinase:** It converts trypsinogen released by the pancreas into functional trypsin.
- **Lipase:** It completes the process of conversion of fats into fatty acids and glycerol.
- **Lactase:** It converts lactose (milk sugar) into simple sugar.
- **Maltase:** It acts on maltose to convert it into a simple sugar like glucose.
- **Sucrase:** It converts sucrose produced from sugarcane into simple sugar.
- **Peptidase:** It acts on peptones and converts them into amino acids.

Importance of pH in Digestion

Digestion is a complex process that is controlled by many factors. pH plays an important role in a normally functioning digestive tract. The mouth, pharynx and esophagus are usually 6-8, which is very weakly acidic. In this area of the digestive tract, saliva controls the tongue. Saliva contains salivary amylase and initiates the breakdown of carbohydrates into monosaccharides. Most digestive enzymes are sensitive to bacteria and will not function in an environment with low levels of pH, such as the abdomen. A pH of less than 7 indicates acidity, whereas a pH greater than 7 indicates a base, although the concentration of the acid or base also plays a role.

The acid in the stomach is highly acidic and blocks the breakdown of carbohydrates while it is there. These highly acidic substances in the stomach have two benefits, denaturing proteins in the small intestine to further digestion, as-well-as providing non-specific immunity, which slows down or kills various pathogens.

Bile leaks into the digestive tract to activate digestive enzymes in the small intestine as the pancreatic duct empties into the digestive tract and neutralizes the acidic chyme by adding bicarbonate, thus, creating a neutral environment. The mucous tissue of the small intestine is alkaline, forming a pH of about 8.5 and thus enables absorption in an alkaline environment.

LARGE INTESTINE

It is the posterior section of the intestine. The large intestine is wider and shorter than the small intestine. Approximately 1.5 meters or 5 feet, in length. It consisting typically of four regions: The cecum, colon, rectum and anus. The term Colon is sometimes used to refer to the entire large intestine.

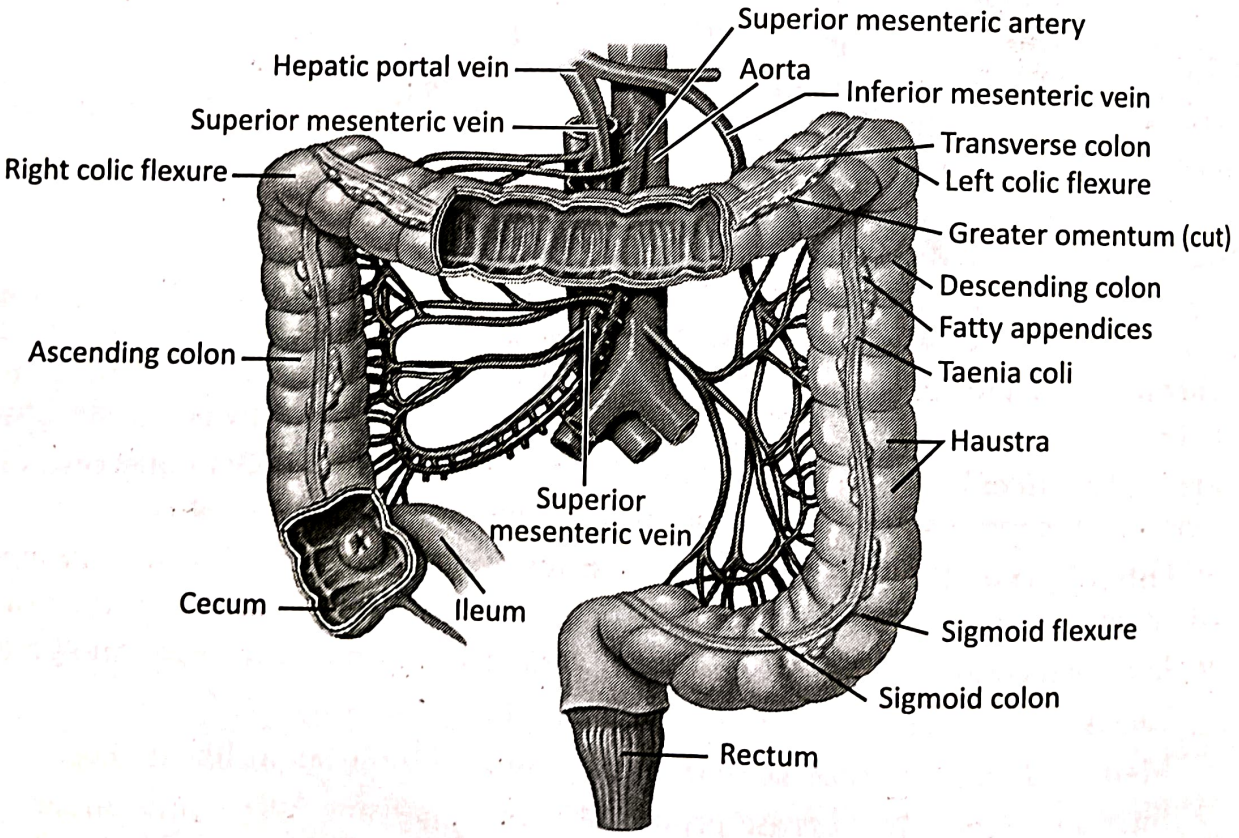


Fig. 16.15: ***Large Intestine***

Caecum

This is the swollen part of the beginning of the large intestine, which is at the end of the small intestine and is located in the right iliac fossa. This intestine is wide and its lower end is dark (closed). Upward it remains attached to the ascending colon. The ilium enters it from one side. Below the ileocecal valve from the cecum is attached a narrow esophagus, which is called the **Caudate** or **Vermiform appendix.** Its composition is similar to that of the walls of the large intestine. But it has more lymphatic tissue. Inflammation of the appendix is called **Appendicitis.**

Colon

Ascending Colon

This is the part of the large intestine that goes above the cecum, which after reaching the liver, suddenly turns to the left and merges into the transverse colon. This bend of the colon is called the **Right Colic or Hepatic Flexure.**

Transverse Colon

It passes the abdominal cavity from right to left and reaches the spleen and merges with the descending colon by turning abruptly below the spleen. This bend of the large intestine is called the **Left Colic** or **Splenic Flexure.**

Descending Colon

The descending colon moves down from the left side of the abdominal cavity to the True pelvis and is called the **Sigmoid Colon.**

Sigmoid Colon

The descending colon of the large intestine, located in the left iliac region of the pelvis, is a long part of the English letter 'S' shaped from the rectum.

Rectum

The rectum remains attached to the sigmoid colon upwards. It is about 12 cm long and passes through the pelvic diaphragm to form the anus. Its structure is similar to that of the colon, but its muscular layer is thicker. In the mucous lining of the rectum, 8-10 erectile and 2-3 absent rings are found. The vertical rings are called the **Columns of Morgagni,** in the middle of them there are Depressions, which are called Rectal sinuses. The lower part of the rectum dilates and is called the rectal ampulla. There is a dense network of veins in the mucosa and submucosa of the rectum, which is called hemorrhoidal plexus. When these veins become swollen and twisted and there is blood supply, then this condition is called Haemorrhoids.

Anal Canal

The rectal duct is a small (about 4 cm long) tube that opens out from the rectum. The perpendicular rings of the rectum go down into the anal canal where the involuntary

circular muscle fibers thicken and form the **internal anal sphincter**, which occupies the upper three-fourth part of the anal canal. The **external anal sphincter** is under nerve control. In normal condition, it keeps the anal canal and anal opening closes and opens only during excretion of stool.

Anus

The anus is the opening where the GIT (Gastrointestinal Tract) ends and exits the body. The anus starts at the bottom of the rectum, the last portion of the colon (large intestine). The anorectal line separates the anus from the rectum. Tough tissue called fascia surrounds the anus and attaches it to nearby structures. Circular muscles called the external sphincter ani form the wal of the anus and hold it closed. Glands release fluid into the anus to keep its surface moist. A plate-like band of muscles, called the Levator ani muscles, surround the anus and form the floor of the pelvis.

Functions of the Large Intestine

After passing through the small intestine, the food enters the large intestine. The process of digestion in the large intestine lasts long enough for bacteria in the alimentary tract to act and ferment, which breaksdown some of the waste material left behind by processing in the small intestine. Some of the products of splitting are absorbed. In humans these substances comprise the most complex saccharides (up to three disaccharides can be digested in humans). In addition, in many vertebrates, the large intestine reabsorbs the fluid. Common bacteria that produce vitamin K and folic acid are found in the large intestine. Deficiency of vitamin K in the absence of these causes intestinal hemorrhage in which blood starts passing with stool and deficiency of folic acid causes anemia.

The cells of the intestinal glands of the large intestine secrete a large amount of alkaline mucus, which helps neutralize the acids produced by intestinal bacteria and also lubricates the lumen for easier passage of stool.

Defaecation

The large intestine absorbs water from the esophagus and stores the stool until it is expelled. Food products that cannot pass through the Villi such as cellulose (dietary fiber), are mixed with other waste products in the body and become hard and concentrated stool. This stool remains in the rectum for a certain period and is then expelled from the body through the anus due to contraction and relaxation. The exit of this waste material is controlled by the contractile muscle of the anus. If there is a delay in bowel movements, the feeling of the rectum being full disappears, the wall of the rectum absorbs more of the water present in the stool, thus causing constipation.

PANCREAS

The pancreas is a soft, pinkish-brown, flat, about 12 to 15 cm (5 to 6 inch) long, clustered gland located transversely behind the stomach. It extends from the duodenum to the spleen. Its external secretion is the pancreatic juice containing digestive enzymes and the

internal secretion produced by the beta cells of the **Islets of Langerhans,** dispersed throughout its substance, plays a major role in the regulation of the metabolism of insulin carbohydrates. Its deficiency causes diabetes. It is divided into three parts, Head, Body, Tail.

1. **Head:** It is attached to the duodenum and is the widest part of the pancreas.
2. **Body:** It is the main part of the pancreas, which is located behind the stomach and in front of the first vertebral column.
3. **Tail:** This is the narrow part of the pancreas leading to the left side, which is located in front of the left kidney and extends to the spleen.

Structure of Pancreas

Pancreas is made up of many lobules which have many small Alveoli whose walls are made of secreting cells from which pancreatic juice is secreted, this juice contains water and salts. A small duct emerges from each lobe and the microducts of all the segments join at the end to form a large **Pancreatic Duct.** The main pancreatic duct does not pour its contents directly into the duodenum, but instead connects to the common bile duct and eventually a duct also called **Ampula of Vater,** just before entering the wall of the duodenum.

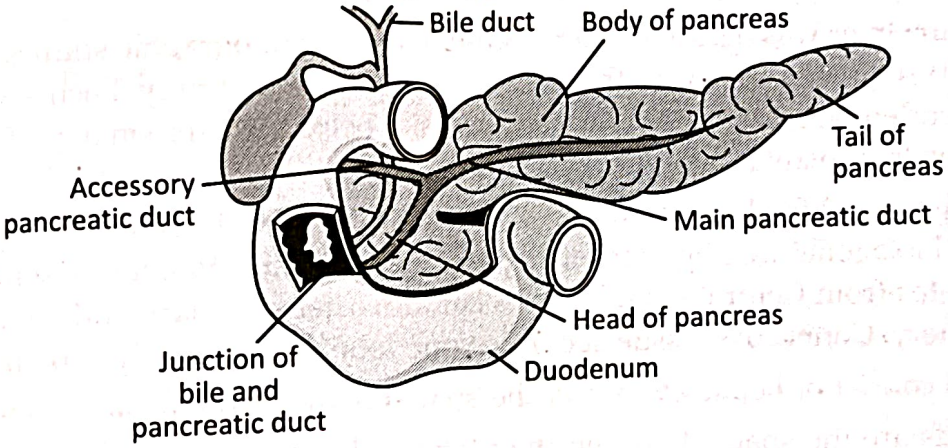


Fig. 16.16: ***Pancreas***

Functions of Pancreas

A healthy pancreas produces the correct chemicals in the proper quantities, at the right times, to digest the foods we eat.

LIVER

The liver is an important organ in the body. It is about 2% of the body weight in the adult. It weighs around 1400 grams in adult female and about 1800 grams in adult male. It performs wide range of functions like detoxification, protein synthesis and production of bile. Liver is also responsible for thousands of biochemical reactions.

The bile is a bitter, brownish yellow or greenish yellow in colour and secreted by the liver, stored in the gallbladder and discharged into the duodenum when it is required for fat digestion.

Liver is the second largest organ in the body and it is located in the right upper quadrant of the abdomen just below the diaphragm. It is almost completely behind the rib cage. The lower edge may be palpated along the right costal margin during inspiration. A connective tissue layer called Glisson's capsule covers the surface of the liver. The capsule extends to invest all but the smallest vessels within the liver. The falciform ligament attaches the liver to the abdominal wall and diaphragm and divides the liver into larger right lobe and smaller left lobe.

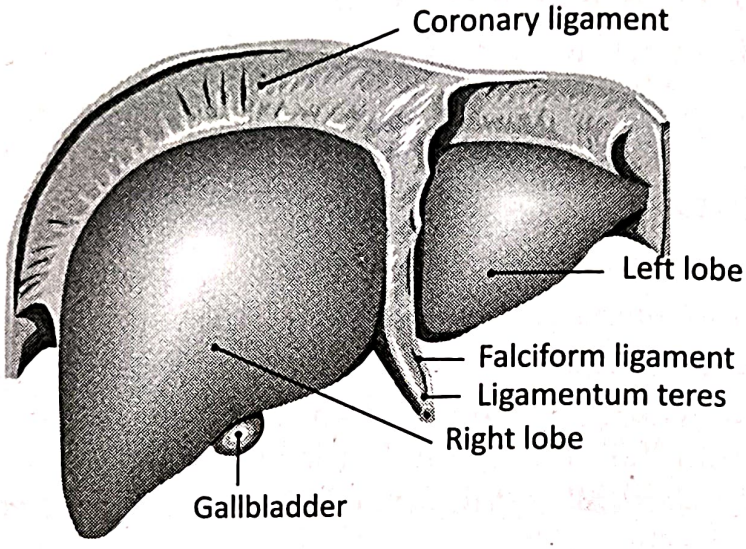


Fig. 16.17: *Liver*

Earlier the liver was divided into 8 segments, later radiographic studies describes the liver into 20 segments based on the distribution of blood supply. Each segment has its own independent vascular and biliary branches. It helps the surgeon to perform resection for tumor or transplantation.

Each segment of the liver is further divided into lobules. Lobules usually represented as discrete hexagonal aggregation of hepatocytes. The hepatocytes assemble as plates which radiates from Central vein. Lobules contain arterial, biliary and venous vessels at their periphery. Connective tissue separates one lobule from another lobule.

Lobules consist of hepatocytes and the spaces between them called sinusoids.

Sinusoids are the spaces between the plates of hepatocytes. These sinusoids receive blood from the portal triads.

Blood supply: The blood supply to the liver is unique among all the organs of the body due to the hepatic portal vein system. The blood traversing through the spleen, stomach, pancreas, gallbladder and intestines passes through capillaries in these organs and is collected in to the hepatic portal vein.

Portal vein divides into branches, the interlobular veins which surrounds the lobules. From these vessels the blood passes between the hepatocytes in sinusoids to reach the center of the lobule as 'Central vein' which drains into the hepatic vein that leads to Vena cava and returns to the heart.

The liver also has its own system of arteries and arterioles which provide oxygenated blood to the tissues. Hepatic artery which supplies blood to the liver divides into branches which accompany those of the portal veins between the lobules and enters into the sinusoids where it mixes with blood from the portal vein.

Each sinusoid passes through the liver tissue which contains two types of cells called as *Kupffer cells* and *Hepatocytes*.

Functions of Liver

- Lymphatic vessels emerge from the liver, which expel some lymph in the abdominal region and some in the thoracic region.
- The right and left Hepatic duct formed by the combination of bile capillaries in the liver come out of the liver, which transport bile from the liver to the gall bladder.
- Bile is also produced in the liver. It is produced by the cells of the liver.
- Bile or bile produced by hepatic cells reaches these microscopic bile ducts.
- The liver stores glycogen (fuel for the body) made from glucose and when needed, glycogen is converted into glucose and flows into the bloodstream.
- Helps the liver process fats and proteins from digested food.
- The liver makes proteins for blood clotting.
- It also performs the function of making blood in the embryonic stage.

GALLBLADDER

The gallbladder is pear shaped hollow organ located under the liver on the right side of the abdomen.

Its primary function is to store and concentrate the bile. The gallbladder serves as a reservoir of the bile when it is not used for by digestion. The gallbladder stores about 50 ml of bile. It is about 7 to 10 cm long and 4 cm in diameter in human and dark green in colour.

The gallbladder has a muscular wall which contracts in response to cholecystokinin, which is a peptide hormone synthesized in the small intestine.

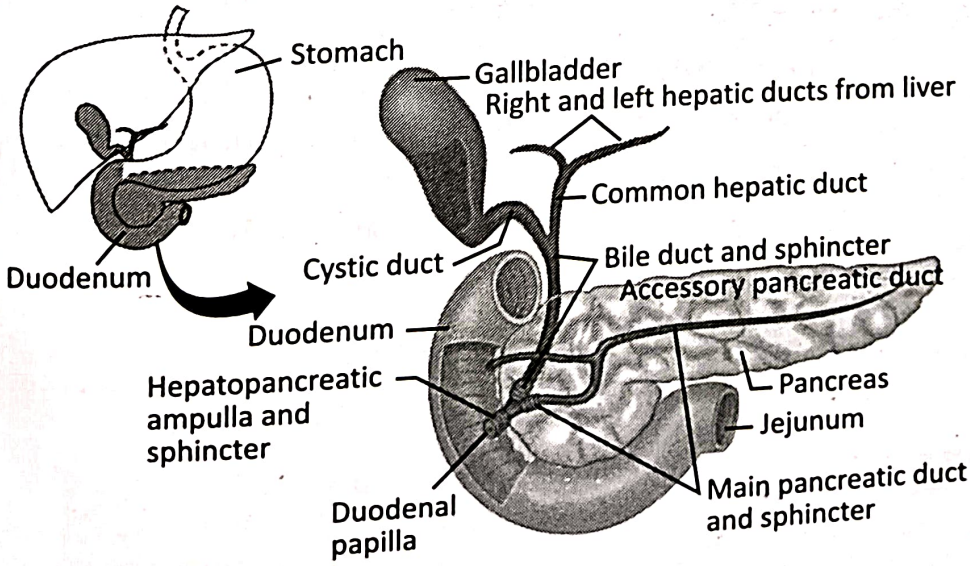


Fig. 16.18: ***Gallbladder and Billary Tract***

The gallbladder is divided into three parts:

(a) **Fundus:** The outer layer is of the peritoneum.

(b) **Body:** Intermediate muscular layer.

(c) **Neck:** This is the layer of mucous membrane which merges with the lining of the bile ducts. This mucous membrane is made up of columnar epithelium cells from which mucin is secreted and water is quickly absorbed but bile salts are not absorbed due to which the bile becomes thick. When the gallbladder is empty small wrinkles form on its mucous membrane. When food is not being digested bile gets stored in the gall bladder, which evaporates when it is full.

BILIARY TRACT

The cystic duct is about 4 cm long. The cervix of the gallbladder narrows forward, it is formed from the same cervix. The common hepatic duct is formed by the fusion of the hepatic vessels on the right side outside the portal fissure. The cystic duct together with the common hepatic duct forms the common bile duct. The common bile duct joins the main pancreatic duct at the site of its entry into the duodenum 10 cm away from the pyloric gate and forms **Ampulla of Vater.** This ampulla passes obliquely through the wall of the duodenum and opens into the duodenum through the duodenal papilla. At the exit of the common bile duct, there is a constriction called the **Sphincter of Boyden** and below it, i.e., the **Sphincter of Oddi,** is located at the opening in the duodenum. The common bile duct is about 7-5 cm long and 6 mm in diameter.

BILE

Bile is a thick, viscous, bitter-tasting fluid secreted by the liver that collects in the gallbladder and, when needed, is poured out through the common bile duct into the duodenum for the digestion of fats.

Bile consists of 88-97% water, with the remaining part being solids. Solids are divided into two parts, inorganic and organic:

Inorganic components of bile: It includes sodium, potassium, chloride of calcium carbonate and phosphate etc.

Organic constituents of bile: These include the following substances:

1. **Mucin:** It is a glycoprotein which is the main constituent of mucus.
2. **Bile pigments:** Two bile pigments called bilirubin and biliverdin in bile which are formed from haemoglobin of blood and due to these the Feces are brown in colour.
3. **Bile salts:** Base salts of bile called sodium glycolate and sodium taurocholate.
4. **Cholesterol:** Cholesterol is also found in bile. Due to the high amount of cholesterol in bile, there is a possibility of formation of Gallstone.

GALLSTONES

Gallstones are hard masses of bile salts, bile pigments and cholesterol that develop in the gallbladder. The term cholelithiasis is used when the stones are present in the gallbladder. These gallstones are formed when the components of bile crystallize. Important bile

components which take part in the formation of gallstones are cholesterol, calcium bicarbonate and calcium carbonate, which can solidify into either one large stone or several small stones.

LIVER FUNCTION TESTS (LFT)

Liver function tests can be done to:

- Find out liver infections like hepatitis etc.
- Monitor the progress of the disease
- Analyze the severity of the disease particularly in cirrhosis
- Understand possible side effects of certain drugs.

Some common liver function tests are:

1. **Alanine Transaminase (ALT):** Alanine transaminase is an enzyme found in the liver that helps the body to metabolize protein. When the liver is damaged, alanine transaminase level increases.
2. **Aspartate Transaminase (AST):** Aspartate transaminase is an enzyme that helps to metabolize Alanine, an amino acid. AST is present in the blood at low levels. In liver damage or muscle damage, the AST level in the blood increases.
3. **Alkaline Phosphatase (ALP):** ALP is an enzyme in the liver, bile ducts and bone. Increase in the level of ALP in the blood indicates liver damage or liver disease. Example: Obstruction of bile duct in some bone diseases.
4. **Albumin and Total Protein:** Albumin is one of the important proteins synthesised in the liver. Proteins are very essential to fight infections and perform other functions. Decreased level of albumin indicates liver disease or liver damage.
5. **Bilirubin:** Bilirubin is a pigment produced during the normal breakdown of red blood cells. Bilirubin passes through the liver and is excreted in the feces. Increased levels (Jaundice) indicate liver disease or liver damage and sometimes anemias.
6. **Gamma Glutamyl Transferase (GGT):** GGT is an enzyme in the blood; increased level may indicate liver damage or liver disease but can also be increased in several other disorders.
7. **L-lactate Dehydrogenase (LD):** LD is an enzyme found in the liver. Increased level may indicate liver disease or damage and also can be increased in other diseases.
8. **Prothrombin Time (PT):** PT is the time taken for clotting of blood. Increased PT indicates liver damage but can also be increased if patient is taking some blood thinning drugs such as warfarin.

15 CHAPTER

Respiratory System

INTRODUCTION

Inhalation is called **Inspiration** and exhalation is called **Expiration.** This 'intra-respiratory-expiratory action' is called the 'Respiratory System'.

There is an exchange of oxygen and carbon dioxide between the atmosphere and the cells of the body, which includes inhalation and exhalation. During inhalation oxygen is taken which reaches the pulmonary alveoli and there by diffusion the oxygen mixes in the blood and is carried to the cells of the body and carbon dioxide from the body cells is carried through the blood to the alveoli from where it comes out during exhalation.

Respiration is mainly of the following types:

- **Aerobic Respiration:** Air or free oxygen is used in this type of respiration.
- **Anaerobic Respiration:** Respiration in which free oxygen does not participate, it is achieved through chemical reactions.
- **Amphoric Respiration:** In this type of respiration, in the case of a large pleural cavity or pneumothorax, on auscultation, a sound similar to that heard when a bottle is blown into the mouth.
- **External Respiration:** In this type of respiration, there is an exchange of oxygen and carbon dioxide between the air located inside the lungs and the blood of the capillaries located in the walls of the alveoli.
- **Internal Respiration:** The exchange of gases between the cells of the body and the blood is called internal respiration.
- **Interrupted Respiration:** This is such a respiration in which inhalation and expiratory sounds do not occur continuously.
- **Kusmoul's Respiration:** This type of respiration involves breathing deeply, gasping, which is characteristic of air hunger or sannyasin or unconsciousness caused by diabetes.
- **Labored Respiration:** Shortness of breath or difficulty in breathing.
- **Thoracic Respiration:** In this, only the movements of the chest take place and the abdominal wall does not participate in it.

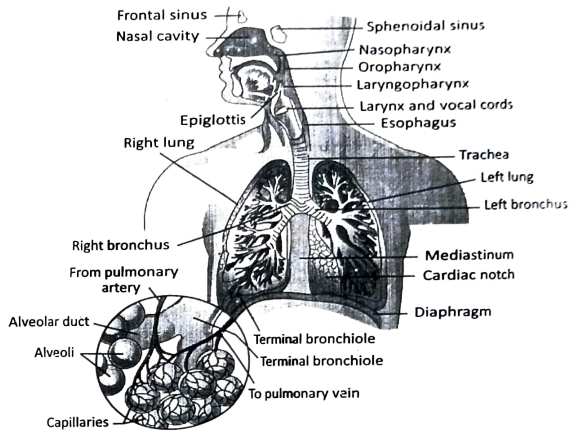


Fig. 15.1: ***The Respiratory System***

- **Slow Breathing:** This is the rate of breathing below 12 in a minute.
- **Forced Respiration:** Voluntarily increasing the speed and intensity of respiration.
- **Abdominal Respiration:** Respiration by the abdominal muscles and diaphragm while there is no movement of the chest as seen in segmental pneumonia.
- **Accelerated Respiration:** This is the rate of respiration that occurs above the normal rate of 25 per minute in a young person. It is seen as a result of physical exertion or mental problems and in diseases like pneumonia and asthma etc.
- **Artificial Respiration:** Respiration given to the patient when he has stopped breathing.

RESPIRATORY TRACT

The respiratory organs, which are continuous from the nostrils to the pulmonary alveoli, through which air moves, form the respiratory tract. They are located in the following order:

1. Nose and Nasal Cavity
2. Pharynx
3. Larynx
4. Trachea
5. Bronchioles
6. Alveoli
7. Lungs
8. Bronchus or Bronchi in the pleura

NOSE AND NASAL CAVITY

There are two ways of breathing – one right and the other wrong way. Breathing through the nose is the right way but breathing through the mouth is wrong. One should always breathe through the nose because there are small hairs inside the nose. These hairs trap the dust in the air outside and do not let it in. One should never breathe through the mouth, because by doing so, along with the air (breath), dust and harmful germs also go inside the body.

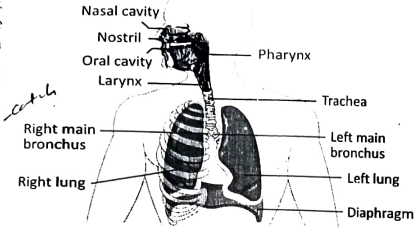


Fig. 15.2: *Respiratory Organs*

The nose is the first breathing organ, in which there is a large cavity called nasal cavity which is divided into two equal parts by a septum. When the nasal cavity is divided, there are two holes or stoma in front (outward) and behind it. The front or external openings are called nostrils or anterior nares, which carry air from outside to the inside and the holes which remain on the back side are called posterior nares which pass from the nasal cavity to the back of the pharynx and open in. The structure of the nasal cavity is made up of bones and cartilages.

The roof of the nasal cavity is composed of the Cribriform plate of the ethmoid bone, the hyoid or sphenoid bone, the frontal or frontal bone and the nasal bones. The floor of the nasal cavity is formed by the hard and soft palate located on the roof of the mouth. The hard palate is made up of the maxilla bone and the palatine bone and the soft palate is made up of involuntary muscle. Each lateral wall of the nasal cavity is made up of maxilla bone, vertical plate of palatine bone, ethmoid bone and Turbinate bone. The posterior part of the nasopharynx dividing the cavity is formed by the Perpendicular plate of the ethmoid bone and the vomer bone and the front part is made up of the Hyaline cartilage. The nasal septum forms the intermediate wall of the nasal cavity.

In the nasal cavity, there are three curved bony plates protruding in the lateral walls on either side, which are called superior, middle and inferior nasal concha. The superior and middle nostrils are Projections of the ethmoid bone and the inferior nostrils are themselves a bone also called conical or turbinate bone. From these three nostrils, each half of the nasal cavity is divided into the upper, middle and lower three nasal passages. These Projections increase the area of the inner surface of the nostrils and these bulges disturb the air drawn with the breath and reach the nostrils, due to which the air spreads properly over the entire nasal surface. In the middle of the nasal cavity, there is a partition made of bone and cartilage, extending from the Palate to the frontal bone, by which the nasal cavity is divided into two equal parts, right and left and this forms the intermediate wall of the nasal cavity. Its front part is made up of Hyaline cartilage and back bone is made up of Perpendicular plate of ethmoid bone and vomer bone.

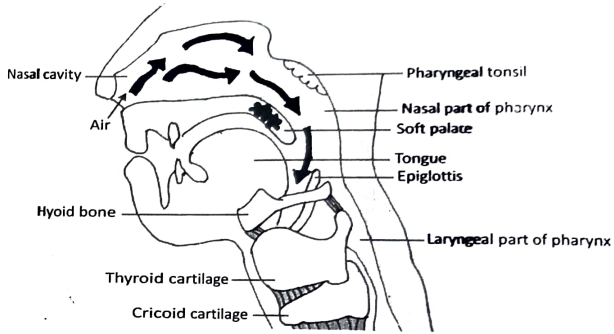


Fig. 15.3: *Arrows showing the Pathway of Air from the Nose to the Larynx*

The nasal septum is covered with a mucous membrane on both sides which is quite thick. The organs of the sense of smell are located in the mucous membrane above the superior nasal concha or nasal concha. The mucosal layer above the middle and inferior nasal concha is highly vascular with blood cells.

Anterior nostrils are the external openings of the nostrils, whose lateral broad walls are made of cartilage and which open inside Vestibule of the nose. The wall of the nasopharynx is covered with a skin covered with short, coarse hard hairs that merge into the epidermis. There are openings in the nasopharynx of the posterior nasal cavity, through which the connection of the nasal cavity with the nasopharynx is established.

The walls of the remaining part of the nasal cavity are lined with ciliated columnar epithelium. The mucous membrane is relatively thick and swells under the influence of many stimuli like chemical substances and infection etc. There are many blood vessels in the mucous membrane which are very well developed especially in the anterior part of the nasal septum. This is where nasal discharge often occurs. In the ciliated columnar epithelium of the mucous membrane, mucinous secretory cells are found in which Mucous is secreted, due to which the mucous membrane of the nostrils remains moist, smooth and sticky. The hairs present in the nostrils prevent dust mites and microorganisms etc., from entering and act as a filter of the air. These fine particles and bacteria get stuck in the mucous. The follicles of the mucous membrane pass the mucus to the pharynx for swallowing or for expelling it in the form of Mucous.

In addition to the anterior nostril and posterior nasal cavity, there are some other Openings in the nasal cavity in which air is filled. These are called Air sinuses. The connection between the two nostrils and the air sinuses is established through microscopic holes. The air sinuses are covered by a mucous membrane which merges with the mucous membrane of the nasal cavity. The main air sinuses are the

lateral walls, the frontal and sphenoidal in the spire (roof) and the ethmoidal air sinuses in the upper part of the lateral walls.

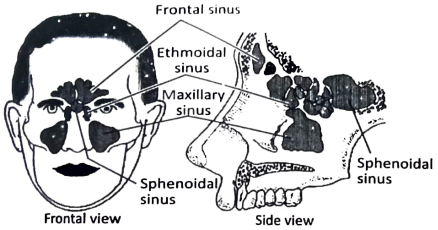


Fig. 15.4: *Air Sinuses*

The major air sinuses are as follows:

- **Frontal Sinus:** These are located above the eye cavity towards the midline of the frontal bone. They have the same average height, width and depth.
- **Maxillary Sinus:** These are located in the maxilla below the eye cavity. Their shape is like a pyramid. These open into the middle duct of the nose. Their height, width and depth are not the same.
- **Sphenoid Sinus:** These are located in the main part of the sphenoid bone. Their length, width and depth are not the same.
- **Ethmoid Sinus:** These are numerous and are located in the parts of the ethmoid bone separating the eye cavity from the nose.

Respiratory Functions of the Nose

The main functions of the nose are as follows:

- The hairs in the nose filter the air (breath). Due to which the air reaching the respiratory system is purified.
- The air entering the nostrils passes through the vestibule. The vestibule has a lining of skin. Hair is present on this skin. These hairs are large particles of dust that stick to the mucous. The mucus also protects the nasal epithelium from dryness.
- Gases are exchanged through the nose, i.e., the carbon dioxide produced by the cells of the body is exhaled through the breath.

PHARYNX

The muscular passageway for air to the larynx behind the nostrils and from the mouth to the esophagus for food is called the **Pharynx.** The upper part of the duodenum is formed by the main part of the sphenoid bone and the lower part remains mixed with the esophagus. It is a muscular tube 12 to 14 cm long, located near the base of the cranium

and behind the nasal cavity, oral cavity and larynx, whose upper end is wide. The pharynx has the following three parts.

1. **Nasopharynx:** This is the part of the pharynx that is located behind the nostrils above the line of the soft palate. On its back wall are bulges of lymphoid tissue called pharyngeal tonsils or adenoids. Sometimes these tissues enlarge and cause obstruction in the pharynx, which allows the child to breathe through the mouth. The auditory tubes open into the lateral walls of the nasopharynx and from these the air reaches the middle ear. The nasopharynx is covered with a ciliated mucous membrane that mixes with the lining of the nose.
2. **Oropharynx:** This is the mouth part of the pharynx, which starts from below the level of the soft palate and reaches the level of the upper part of the body of the third cervical vertebra. The walls of the pharynx merge into the soft palate to form two layers on each side.

   The lateral walls of the pharynx are joined with the soft palate. Between the folds of these walls, there are bulges of lymphoid tissue called **Palato-Glossal Arches.** These are called **Palatine Tonsils.**

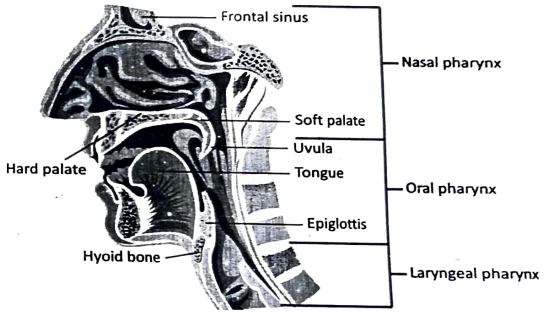


Fig. 15.5: *Pharynx*

3. **Laryngiopharynx:** This is the posterior part of the pharynx, which runs from the level of the hyoid bone to the back of the larynx. The respiratory and digestive systems are separated from this part of the pharynx. Air enters the larynx from the front and food from the back into the esophagus.

Structure of the Pharynx

The wall of the pharynx, from the inside out, is made up of the following three layers:

1. Mucous membrane
2. Fibrous tissue
3. Muscle tissue

1. **Mucous Membrane:** This is the innermost lining. Its thickness is different in different parts. Nose-pharynx consists of Ciliated columnar epitheliai tissue. Whereas the mouth-pharynx and larynx are made of scaly layered epithelium in the pharynx. Therefore, this mouth-pharynx and larynx are thick till the pharynx, which remains like this till the lining of the mouth and the esophagus.
2. **Fibrous Tissue:** This is the middle layer which is made up of collagen fibers. It thickens in the nasopharynx and becomes thinner by coming down.
3. **Muscular Tissue:** This is the outermost layer. There are many involuntary or linear muscles in it. This means that these muscles are not under conscious control. These muscles help in swallowing which is not under control.

LARYNX

The larynx is a Musculocartilaginous airway between the lower part of the pharynx and the trachea, which contains the vocal cord. This larynx connects the pharynx to the Trachea. It extends from the bottom of the tongue to the respiratory tract. In adult males it is located in front of the third, fourth, fifth and sixth cervical vertebrae and in children and adult females it is located higher than this.

Below the hyoid bone and in front of the pharynx is the larynx. The air (breath) taken from the nose comes into this larynx through the throat. There is a lid on its end, which is called 'vocal cord'. This lid is kept open all the time, but while eating food, this lid is closed so that the food does not fall into the larynx, but falls back into the esophagus. Sometimes due to diseases or due to carelessness, when some part of food or water falls into the larynx, then there is a very loud cough. The coming of this cough means that the part of water or food which has fallen in it (in the larynx) should come out. When swallowing food, at that time the larynx appears to rise and then fall. When air enters it, the sound is produced. Thus, it also helps us a lot in speaking.

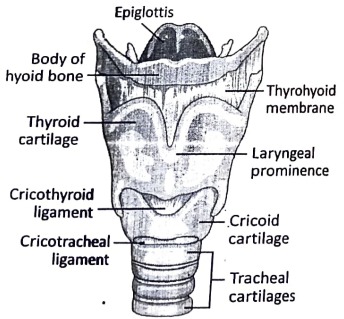


Fig. 15.6: *Anterior aspect of Larynx*

The entire larynx is made up of many amorphous cartilages, which are held, together by ligaments and membranes.

Thyroid Cartilage

Thyroid cartilage is made up of two flat pieces of cartilage that join together at the front to form the Addam's apple. In common language it is called **Throttle**. There is a Notch on top of that bulge which is called **Thyroid Notch**. The thyroid cartilage is larger in men than in women. The upper part is covered by Stratified epithelium and the lower part by ciliated epithelium.

Cricoid Cartilage: It is located below the thyroid cartilage and its shape is like a ring or signet-rig with the widest part facing back. It forms the side and back walls of the larynx and is covered by a Ciliated epithelium.

Epiglottis: It is a leaf shaped cartilage attached to the inner side of the anterior wall of thyroid cartilage just below the thyroid notch. It forms the lateral and posterior walls of the larynx. During the act of swallowing, the throat moves up and forward so that its opening is blocked by the epiglottis.

Erytenoid Cartilage: These are small pyramidal joints made up of hyaline cartilage. They are located above the broad part of the cricoid cartilage and are attached to the ligaments of the cords. They form the back wall of the throat.

Vocal Cords

From the inner wall of the protrusion of the thyroid cartilage inside the larynx, there is a string-like structure made of fibers of elastic connective tissue on both sides extending from the back to the arytenoid cartilages, which is called Vocal Cord. They produce sound while speaking. When the muscles of the arytenoid cartilage contract, the cartilages come in the middle and bring the vocal cords closer together, causing the space between them to narrow and a Rima glottidis is formed. When air forcefully passes through this crack, the vocal cords vibrate and sound is produced. When the laryngeal muscles relax, the cartilages move outwards, causing the vocal cords to move away from each other and the cleavage dilates so that no sound is produced. The intensity of sound depends on the force with which the vocal cords vibrate.

TRACHEA

Trachea is a cartilaginous tube that runs from the larynx down at the level of the sixth Cervical vertebra, which is covered with a mucous membrane and divides into two main branches, the right and left bronchi, at the level of the fifth dorsal vertebra. It is about 12 cm long tube whose diameter is about 2-5 cm. In front of the upper part of the windpipe passes through the narrow Isthmus of the thyroid gland and the arch of the aorta lies in front of the lower part, with the manubrium of the sternum also in front.

The alimentary canal is located behind the windpipe, which separates it from the main parts of the thoracic vestibule. On either side of the

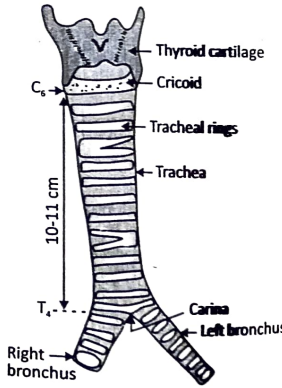


Fig. 15.7: *Trachea*

trachea are the pleura, over which the sections of the thyroid gland are located, the trachea wall is made of involuntary muscle and fibrous tissue and is supported by incomplete rings of hyaline cartilage. This imperfection of the hyaline cartilage rings occurs at the back where the windpipe makes contact with the alimentary canal. These rings are interconnected by fibrous tissue. When a mouthful of food is swallowed, the alimentary canal is able to expand without obstruction, but the cartilage keeps the airway open.

The trachea is covered with a ciliated epithelium that contains goblet cells that secrete mucus. The ciliates of the epithelium carry the mucous and foreign particles up to the throat. The respiratory system has two parts, the Cervical trachea and the Thoracic trachea. The cervical respiratory tract is the part of the respiratory tract that passes through the cervix. In front of which the narrow Isthums of the thyroid gland passes through and in the side of the grave respiratory tract the segments of the thyroid gland are adjacent. The thoracic respiratory tract passes through the Superior mediastinum and lies behind the sternum and in front of the esophagus and in contact with the brachiocephalic artery and the aortic arch. It is separated from the vertebral column by the esophagus.

The air drawn with the breath comes from the larynx into the respiratory tract or trachea, from where it passes through both the trachea to the lungs.

BRONCHI

The Bronchus divides into two right and left branches at the level of the fifth thoracic vertebra or thoracic vertebrae, which are called **Trachea or Bronchi.** Each trachea enters the lung of its side and as soon as it enters the lungs, it divides into many smaller branches. The right bronchus is wider but shorter than the left and is often in line with the windpipe. It is about 2-5 cm long and after entering the lung it divides into three branches on the hilum, one branch each goes to each segment of the lung (the right lung has three segments - the vertical, middle and lower). Cartilage and mucosal glands are present in the walls of the bronchi and are covered with ciliated columnar epithelium. The columnar cells gradually transform first into cuboidal cells and then into simple scaly cells of the walls of the alveoli. The bronchioles progressively divide into smaller trachea. The cartilages at the distal end of the bronchi become disorganized in shape and disappear at the level of the bronchus.

BRONCHIOLES

Each trachea or bronchus entering the segment of the lung, divides into subtle branches, which are called Bronchioles. They do not have cartilage but are made up of muscular, fibrous and flexible tissue.

ALVEOLAR DUCTS AND ALVEOLI

The bronchioles divide into fine and very fine branches and then into alveolar ducts. The alveolar vessels finally open into very fine alveoli. The alveoli are covered with a network of blood capillaries. During respiration, there is an exchange of gases between the alveoli and the walls of the capillaries.

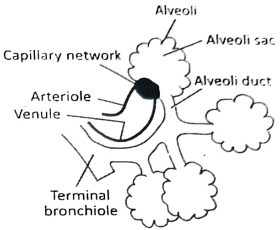


Fig. 15.8: *Alveoli*

LUNGS

Lungs are the main spongy organs of the respiratory system. The lungs are located on both sides of the mid-line of the body and are separated from each other by the mediastinum. The mediastinum is the space between the two lungs, in which the Trachea along with the large blood vessels, esophagus, right and left bronchi, lymph glands and thymus gland etc., are located.

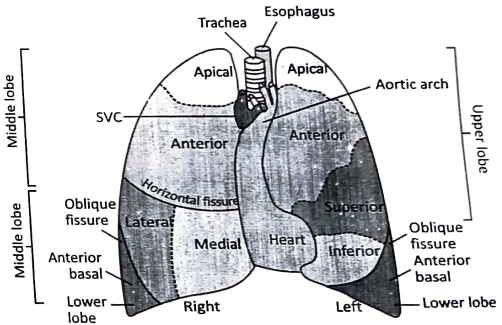


Fig. 15.9: *Lungs*

The lungs extend from the lower part of the neck to the diaphragm and are conical in shape. Each lung has an Apex, base downwards and Costal, medial and Diaphragmatic and medullary surfaces and anterior and posterior margins. The surface of the base of the lungs on the diaphragm is called the diaphragmatic surface. The upper constricted part of each Apex is the spire, which rises about 1 inch above the middle third of the globular and clavicular bone, to the root of the cervix.

The structures related to this are the first rib in the root of the cervix and the blood vessels and nerves located in the cervical root. Each lung is divided into Lobes by a deep fissure.

The left lung consists of two segments, separated by an oblique fissure. The upper segment lies above and in front of the lower segment. The lower segment is cone-shaped. There are three segments in the right lung. The lower segment is divided by an oblique fissure and the remaining part by a Transverse fissure and in the middle section. Each segment is then divided into smaller segments, which are called broncho-pulmonary segments and which have different names.

These segments are separated from each other by a wall of connective tissue and each segment is also divided into many smaller units called lobules. The bronchi and alveoli are filled in these segments. The numerous existing alveoli are the respiratory parts of the lungs. The air inhaled through the respiratory tract reaches the alveoli, where there is an exchange of gases between them and the walls of the capillaries.

The outer surface of the lungs is convex and is in contact with the costal cartilages, the muscles between the ribs and the intercostal ribs.

Pleura

Pleurisy is the Double serous membrane that surrounds the lungs. One layer which is completely adjacent to the lungs, it is called **Visceral pleura.** It penetrates into the fissures of the lungs, which separate the Fissures and is attached to each segment. Reaching near the plane of the lungs, it is reflected to form the second layer, the **Partial pleura,** which covers the inner surface of the thoracic cavity. The part lining its ribs is called **Periosteal pleura** or **costal pleura,** the part adjacent to the cervical pleura and the part covering the mediastinum is called **Mediastinal pleura.** Between the two layers of the pleura there is a nominal space called the **Pleural cavity.** It is filled with a thin serous fluid which lubricates the pleura (keeps it moist and lubricated) and prevents friction (rubbing) during respiration. Pleurisy-cavity does not contain air and the pressure inside it is negative. There is no relation between the right and left pleural cavities. In a disease called pleurisy, there is inflammation (swelling) of the pleura.

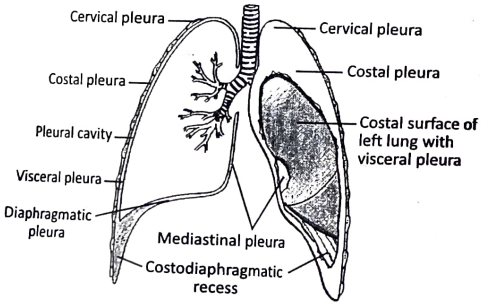


Fig. 15.10: *Pleura*

Blood Supply of the Lungs

The pulmonary artery carries impure (deoxygenated) blood from the right ventricle of the heart to the lungs and divides into two branches and moves side-by-side. Within the

lungs, each pulmonary artery divides into many branches and eventually they form a dense network of capillaries around the walls of the alveoli. The exchange of gases takes place through two very thin membranes made of only one layer of flattened epithelium cells, both the walls of the alveoli and of the capillaries. This exchange of gases is based on the physical laws of diffusion. Pulmonary capillaries go on joining together; Large vessels are formed from them and finally two pulmonary veins are formed in each lung. These pulmonary veins exit through the hilum of the lungs and carry pure (Oxygenated) blood to the left atrium of the heart, from where it is spread throughout the body through the left ventricle or ventricle, through the aorta and its branches.

MUSCLES OF RESPIRATION

During Inspiration, the chest expands. This is due to muscular activity. It is partly voluntary, i.e., under our control and partly involuntary, i.e., not under our control. The muscles of the neck, shoulders and abdomen help while breathing forcefully. In normal quiet respiration, the Intercostal muscles and the Diaphragm are the main respiratory muscles.

Intercostal Muscles

There are 11 pairs of interstitial muscles which surround the spaces between 12 pairs of ribs. They are arranged in two layers, as external and internal intercostal muscles. The external intercostal muscle fibers run forward from the lower edge of a rib to the upper edge of the lower rib. The internal intercostal muscle fibers extend backward from the lower edge of a rib to the upper edge of the lower rib.

Diaphragm

Its shape is like a dome. It separates the thoracic and abdominal cavity. It forms the Roof of the thoracic cavity and the roof of the abdominal cavity. The diaphragm moves up and down during breathing. It helps in increasing the size of the thoracic cavity. It has a central tendon to which muscle fibers radiate. They are attached to the lower ribs and sternum and vertebral column or vertebral column by two crura (long bodies resembling crura legs. When the diaphragm muscles are at rest, they are parallel to the eighth vertebra of the central tendon. When the muscles contract, the central tendon is parallel to the ninth vertebra of the thorax. When the diaphragm rises, it gives space to the organs of the abdominal cavity. The diaphragm is supplied by the phrenic nerves.

The intercostal muscles and diaphragm contract in such a way that when the diaphragm is raised it expands the thoracic cavity and when it is lowered the abdominal cavity is reduced in size.

CYCLE OF RESPIRATION

During respiration, oxygen gas is drawn inside the body and carbon dioxide is released out. This process is repeated 10-15/min. The stages of the respiratory cycle are as follows:

1. **Inspiration:** When air and oxygen are drawn in, it is called Inspiration. During inhalation, the thorax expands due to the movement of the diaphragm and intercostal muscles. When the diaphragm contracts during inhalation, it flattens.

and slides down and the volume of the thoracic cavity increases and expands to fill this enlarged space. Due to their expansion, the pressure in the air passages and the alveoli present in the lungs becomes less than the pressure of the external atmospheric air, due to which the external atmospheric air is drawn and enters the alveoli of the lungs through the air passages. This process is called inhalation because through this the external air is drawn into the lungs.

2. **Expiration:** The release of carbon dioxide along with air from the lungs in the process of respiration is called exhalation. During Expiration both the diaphragm and the intercostal muscles relax. Their relaxation causes the thoracic cavity to constrict, which puts pressure on the lungs and the carbon dioxide-rich air from within the lungs is forced out through the respiratory tract. This action is called inhalation.

GASEOUS EXCHANGE

Oxygen and carbon dioxide gases are exchanged (exchange) between the air in the alveoli in the lungs and the blood in the plexus of cells of the pulmonary arteries that surround the alveoli. The oxygen in the air drawn into the alveoli inhaled is much higher than the oxygen present in the impure blood of the capillaries of the pulmonary arteries that surround the alveoli. The walls of both alveoli and capillaries are made up of only one layer each of flattened epithelial cells. The exchange of gases takes place through these two very thin membranes between the air inside the alveoli and the blood in the capillaries.

Due to more oxygen in the alveoli, its pressure in the alveoli is also high, due to which oxygen diffuses from the walls of the alveoli and blood capillaries and enters the capillaries and gets mixed in their blood. The opposite is true for carbon dioxide. The capillaries of the pulmonary arteries contain impure blood that contains an excess of carbon dioxide and a lack of oxygen. There is a lack of carbon dioxide in the pure air of the alveoli, so the carbon dioxide of the blood crosses the walls of the blood capillaries and alveoli, reaches inside the alveoli and mixes into the air present in them. Thus, at the end of respiration, there is an exchange of oxygen and carbon dioxide gases in the lungs followed by Expiration.

RATE OF RESPIRATION

Normally a healthy person breathes 16 to 20 times in a minute. At different ages, respiration takes place as follows:

Age	Number per minute
2 months to 2 years	35 times per minute
2 to 6 years	23 times per minute
6 to 12 years	20 times per minute
12 to 15 years	18 times per minute
15 to 21 years	16 to 18 times per minute

The above breathing rate is increased by exercise and anger etc., but this breathing rate decreases while sleeping or resting. In many diseases such as pneumonia, asthma, tuberculosis, malaria, jaundice, heart (heart) and kidney diseases, the breathing rate increases. Similarly, by consuming opium, after injury to the brain and in some diseases of the brain, this breathing rate is reduced.

CONTROL OF RESPIRATION

Respiration is controlled by the respiratory center located in the medulla oblongata of the brain. The accumulation of carbon dioxide in the blood stimulates the specialized cells of the large arteries. Impulses are carried to the respiratory center by the vagus and glossopharyngeal nerves. The impulses required by the phrenic nerves come from the respiratory center to the diaphragm and through the intercostal nerves to the intercostal muscles. These muscles constrict and thus breathing occurs.

VOLUMES AND CAPACITIES OF AIR IN THE LUNGS

The exchange of air between the lungs and the surrounding air and the amount of air in the lungs is described by dividing it into the following volumes and capacities. These are measured with a special device **Spirometer.**

- **Tidal Volume:** This is the amount of air that is inhaled and exhaled during normal quiet breathing. It is about 500 ml and is similar in men and women.
- **Inspiratory Reserve Volume-IRV:** The amount of air inhaled during rapid inhalation after normal exhalation is called IRV. Its volume is 3300 ml in males and 1900 ml in females.
- **Expiratory Reserve Volume:** Approximately 1000 ml from the lungs after quiet exhalation. The air that is likely to be released at full velocity is called the expiratory reserve volume.
- **Residual Volume:** The residual volume of air left in the respiratory passages even after deepest exhalation is called residual volume. Its volume is 1100 ml.
- **Vital Capacity:** This is the volume of air ejected from deepest to deepest exhalation followed by deepest inhalation. It is about 4000 ml.

Unit - IV

13 CHAPTER

Cardiovascular System

THE HEART

The human heart is an organ that pumps blood throughout the body via the circulatory system, supplying oxygen and nutrients to the tissues and removing carbon dioxide and other wastes.

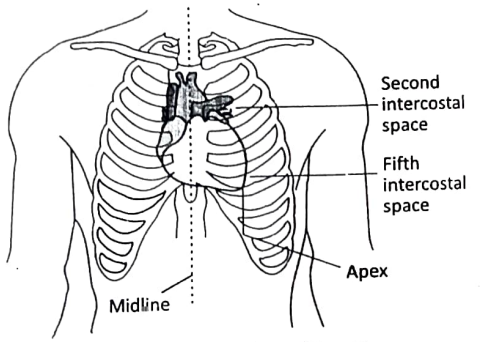


Fig. 13.1: *Position of Heart*

The upper part of the heart is somewhat broad which is called the base and some remain inclined towards the right. The lower pointed part is called the Apex, which tilts slightly to the left and slightly forward and is situated on the diaphragm. The range of the Apex reaches the intercostal of the fifth and sixth left ribs and on placing the hand at this place one gets the impression of pulsation (heart beat).

The heart is roughly the size of a large fist. The length of the heart of an average adult person is 12 cm, width is 8.5 cm and thickness is 6 cm respectively. Its weight is about 280-340 grams in males and 230-280 grams in females.

STRUCTURE OF THE HEART

The heart wall is made up of the following three layers:

1. Pericardium
2. Myocardium
3. Endocardium

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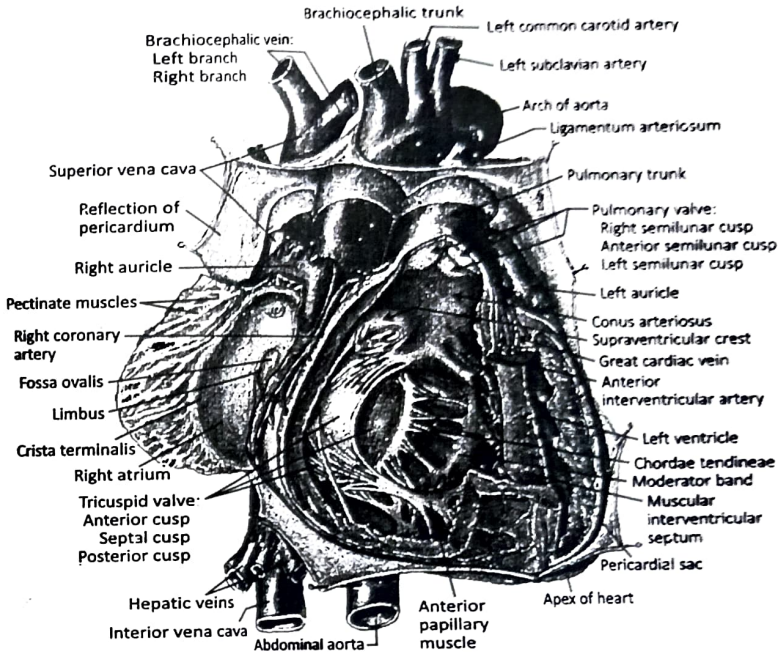


Fig. 13.2: *Heart–Anterior View*

1. **Pericardium:** It is the outer covering membrane of heart. It consists of two sacs. Outer sac is made up of fibrous tissues. Inner sac consists of two layers of serous membrane. Outer sac is continuous with blood vessels.

There are two layers of serous membrane:

(a) Parietal Pericardium

(b) Visceral Pericardium.

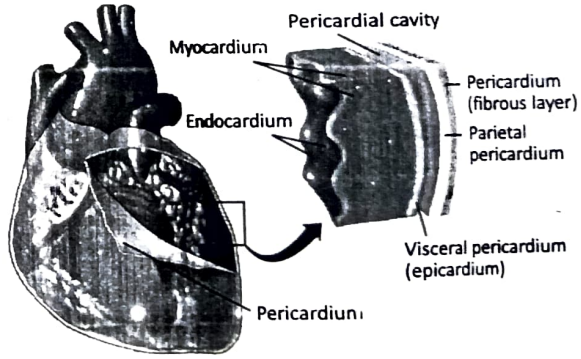


Fig. 13.3: *Layers of the Heart*

2. **Myocardium:** This is the middle layer of heart covering. It consists of special cardiac muscles. The layer of myocardium is thick at the tip of the heart and thin at the base. The myocardium is essential for the contraction of the heart.
3. **Endocardium:** This is innermost layer of heart. This is a lining membrane of heart. It allows blood flow in the heart. This layer is made up of flattened epithelial cells.

CHAMBERS OF THE HEART

The heart consists of the following five special types of conducting tissues in which impulses arise which spread throughout the heart, causing contraction of the heart:

1. **Sinoatrial (S.A.) Node:** A collection of Perkinson fibers near the entrance of the superior vena cava in the wall of the right atrium, which normally generates impulses that generate the heartbeat.
2. **Internodeal Pathways:** These transmit the impulse arising from the S.A. node to the atrioventricular node. These are three bundles of small fibers which end in A.V. Node. These three bundles of small fibers are called the anterior middle and posterior internal pathways respectively.
3. **Atrioventricular (A.V.) Node:** It is a collection of Perkinson fibers located in the lower part of the interatrial septum, from which the Bundle of His arise.
4. **Bundle of His with Right and Left Branches:** This Starts from A.V. node, which after going some distance in the interventricular septum, divides into two branches, which supply fiber to both the ventricles. It conducts the impulse from the atria to the ventricles.
5. **Purkinje Fibres:** These are very large Fibres arising from Bundle of His in the heart and enter the ventricles. They conduct heart-impulse from the auricles to the ventricles.

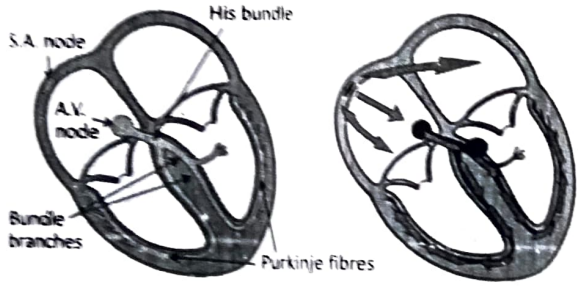


Fig. 13.4: *Purkinje Fibres*

VALVES OF THE HEART

The heart has valves to prevent blood flow from going in the wrong direction. The heart has the following four main valves:

1. *Tricuspid Valve:* Located between the right atrium and the right ventricle.
2. *Pulmonary Valve:* Located between the right ventricle and the pulmonary artery.
3. *Mitral Valve:* Located between the left atrium and the left ventricle.
4. *Aortic Valve:* Located between the left ventricle and the aorta.

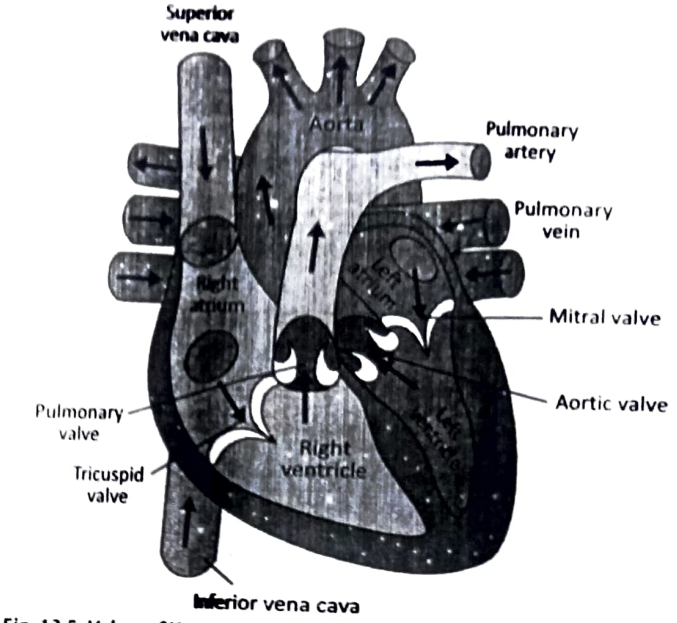


Fig. 13.5: *Valves of Heart, Anterior View (Arrow showing blood circulation)*

CONDUCTION SYSTEM OF THE HEART

The circulatory system of the heart consists of four structures (which have been studie earlier). There is muscle in this system and normal cardiac muscle can also be sensitize Nervous impulses produced in the brain can also stimulate or reduce the functioning the heart.

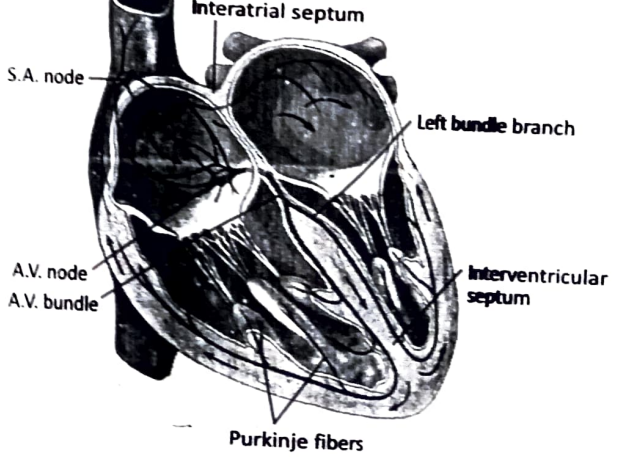


Fig. 13.6: *Conduction System of the Heart*

BLOOD SUPPLY OF THE HEART

The blood vessels that carry blood from the heart to different parts of the body are called **Arteries** and the blood vessels that carry blood from different parts of the body to the heart are called **Veins.** The blood returning to the heart from the myocardium empties directly into the right atrium through the coronary sinus. The opening of the coronary sinus is protected by a thin and hemispherical valve called the valve of the coronary sinus. This prevents blood from returning to the sinus during contraction of the right atrium. Apart from this, there is also an incomplete valve which is located at the place of joining of the lower ventricle in the right atrium. This is called the **Inferior vena cava.** The heart is supplied with blood from the right and left coronary arteries, which are branches of the aorta. They meet at several places in the heart muscle, but most of their blood flows from the myocardium into veins, which empty into the coronary sinus.

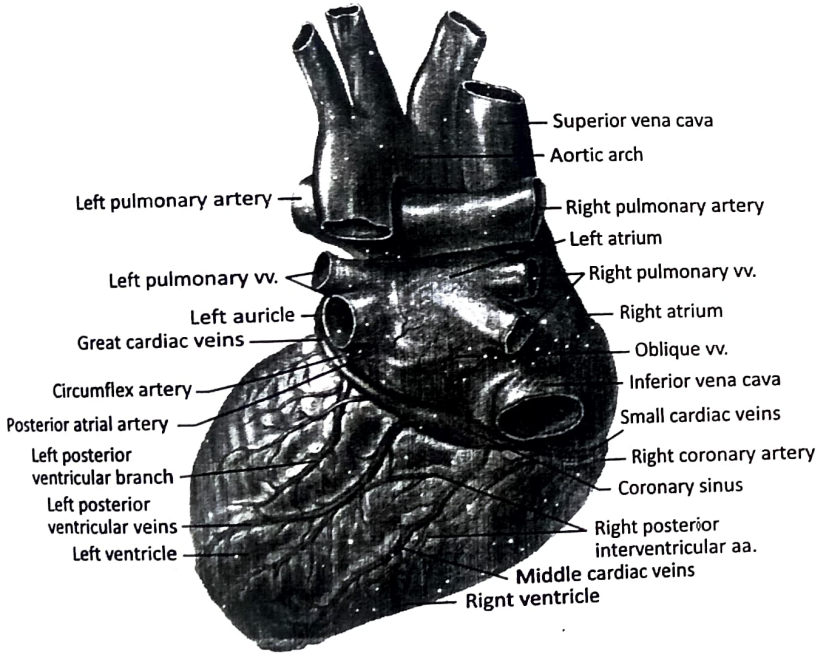


Fig. 13.7: ***Coronary Arteries and Veins***

INNERVATIONS OF THE HEART

Muscle fibers are supplied to the heart by an independent nervous system. The Cardiac plexus is formed by sympathetic muscle fibers and parasympathetic muscle fibers which are located near the arch of the aorta. From these cardiac plexuses, the fibrous fibers enter the heart along with the right and left large ducts. Here, many fibers expire in S.A. Node, but many A.V. Node and atrial reach into the myocardium. The sympathetic nerves of the heart are also called accelerator nerves. The vagus muscle fibers act as inhibitory nerves.

FUNCTIONS OF THE HEART

Four main functions of the heart are as following:

1. Pumping oxygenated blood to the other body parts.
2. Pumping hormones and other vital substances to different parts of the body.
3. Receiving deoxygenated blood and carrying metabolic waste products from the body and pumping it to the lungs for oxygenation.
4. Maintaining blood pressure.

HEARTBEAT

In systole, the sound of the heart is produced when the apex of the left ventricle hits the chest wall. It is felt in the left fifth intercostal space about 3½ inches from the center of the sternum and within about an inch of a line drawn parallel to the sternum down the middle of the clavicle bone. This is called the **Heartbeat** of the heart.

HEART SOUNDS

The heart beats at a lifetime value of 70 to 80 times per minute, although its speed is affected by age, emotion and exercise. Each beat is a cycle of movements that takes 0.8 seconds. The blood collects in the chambers through the venules. When both are filled, there is a simultaneous contraction and blood reaches the ventricles. The contraction of cells takes 0.1 second.

The pressure produced by the entry of blood into the ventricles causes the atrioventricular valves to close and the first sound in the heart, which can be heard by placing a stethoscope on the tip of the heart, is like the word **'Lubb'.** It takes 0.3 seconds for the ventricles to contract. Its pressure opens the pulmonary and aortic valves. Blood is pumped into the aorta and pulmonary vasculature and when the ventricles relax, the pressure of the large blood vessels closes the aortic and pulmonary valves. At this time there is a second heart sound which can be heard near the second right rib. This sound is of **'dupp'** and is louder.

During contraction of the ventricles, the chambers relax. After contraction of the ventricles, the whole heart relaxes for about 0.4 seconds, the contraction is called Systole and relaxation is called **Diastolic.**

CARDIAC CYCLE

The period from the start of the heartbeat to the start of the second heartbeat in which there is a systolic phase – in which the atria and ventricles contract and push the blood forward and the diastolic phase – in which the atria and ventricles dilate and then they are filled with the blood that is returned.

Stages of Cardiac Cycle

The normal rate of the heart cycle is 60 to 80 per minute and the average is 74. Each cycle is of 0-8 seconds. This includes the following situations:

1. **Atrial systole:** Narrowing of the aorta. It is about 0.1 second.
2. **Ventricular systole:** Contraction of the ventricles. It is about 0.3 seconds.
3. **Complete cardiac diastole:** Relaxation of the aorta and ventricles, this is about 0.4 seconds.

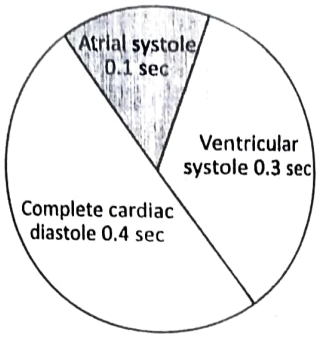


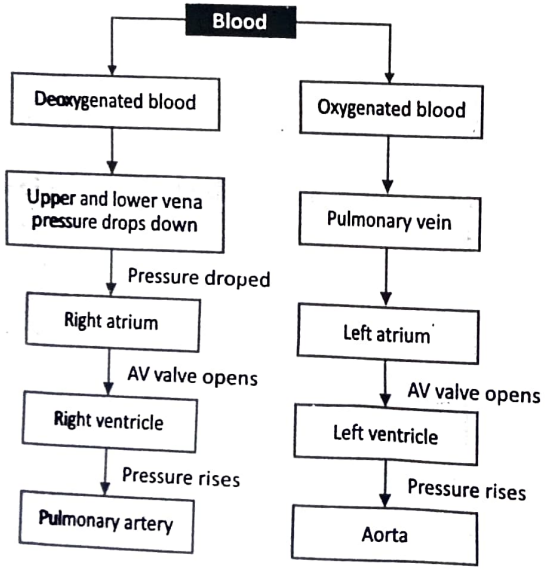
Fig. 13.8: *The Stages of One Cardiac Cycle*

The heart beats continuously day and night. It beats like this throughout life and rests only during ventricular diastole.

Contraction of the aorta is short-lived whereas contraction of the ventricles is relatively longer and stronger. The contraction of the left ventricle is the strongest. S.A. Node a wave of contraction is released which spreads to the myocardium of both at the Atria. This causes the contraction of the cells to reach the ventricles. Then these waves reach A.V. Node and A.V. Bundle Node are spread to the ventricle muscle by bundle branches and Perkinson fibers. The waves of contraction start from the tip of the heart and travel towards the ventricles and reach the pulmonary artery and aorta. The increased pressure during ventricular contraction and causes the atrioventricular valves to close, preventing the reverse flow of blood.

Both the atria and ventricles relax during complete cardiac dilatation. Its duration is 0-4 seconds. During this time the myocardial muscles prepare for the next contraction.

Heart valves open or close according to pressure. The valves close when the pressure increases, while the valves open when the pressure decreases.



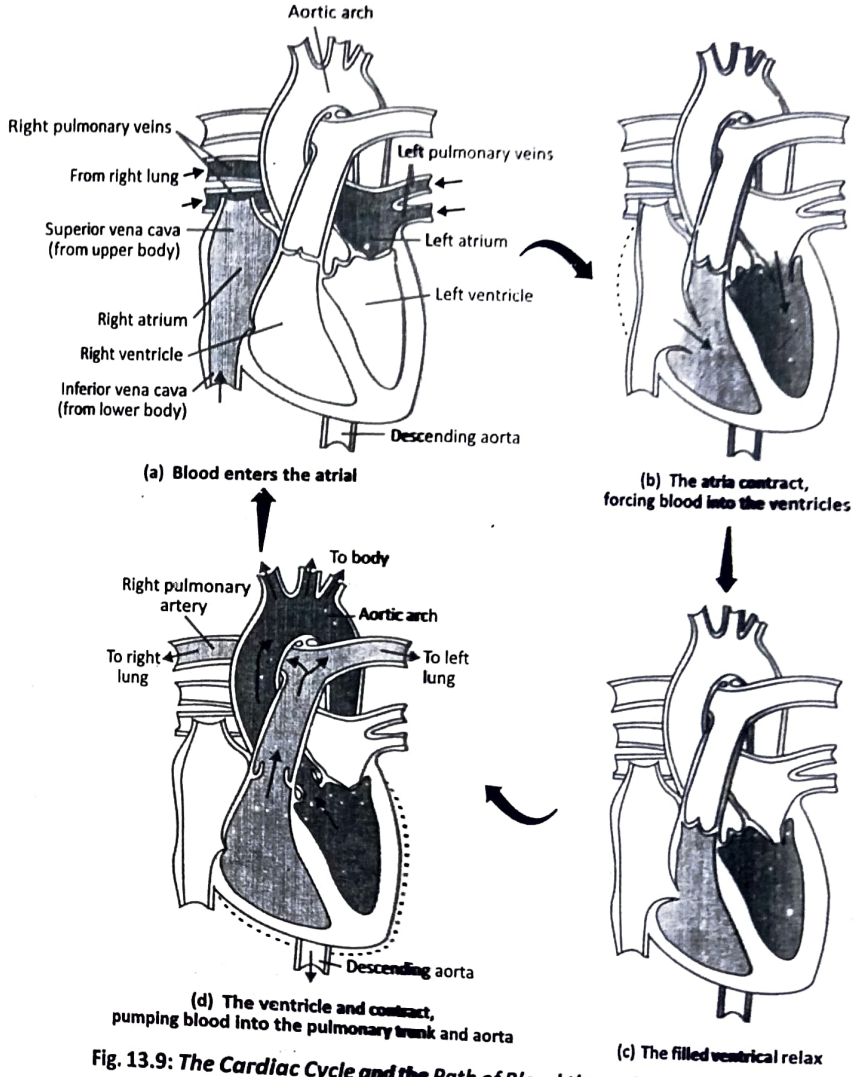


Fig. 13.9: *The Cardiac Cycle and the Path of Blood through the Heart*

THE BLOOD VESSELS

The circulation of blood throughout the body is through blood vessels. The blood vessels are of the following types:

- Aorta, Arteries
- Arterioles
- Capillaries
- Venules
- Veins and Vena Cava

STRUCTURE OF ARTERIES

An artery is an elastic blood vessel that transports blood away from the heart. This is the opposite function of veins, which transport blood to the heart. Arteries are components of the cardiovascular system. This system circulates nutrients to and removes waste material from the cells of the body.

There are two main types of arteries:

1. Pulmonary arteries
2. Systemic arteries

1. **Pulmonary Arteries:** Carry deoxygenated blood. It begins from the upper part of the right ventricle of the heart. It passes upwards and divides into left and right pulmonary arteries at the level of the 5th thoracic vertebrae.
2. **Systemic Arteries:** They deliver blood to the rest of the body. The aorta is the main systemic artery and the largest artery of the body. It originates from the heart and branches out into smaller arteries which supply blood to the head region (Brachiocephalic artery) the heart itself (Coronary arteries) and the lower regions of the body.

The smallest arteries are called arterioles and they play a vital role in microcirculation. Microcirculation deals with blood circulation from arterioles to capillaries to the smallest veins called venules.

The arteries have the following three layers:

1. **Tunica Externa (Adventitia):** Outer layer made up of fibrous tissue.
2. **Tunica Media:** Middle layer made up of elastic tissue and smooth muscles.
3. **Tunica Interna:** Inner layer made up of squamous epithelium.

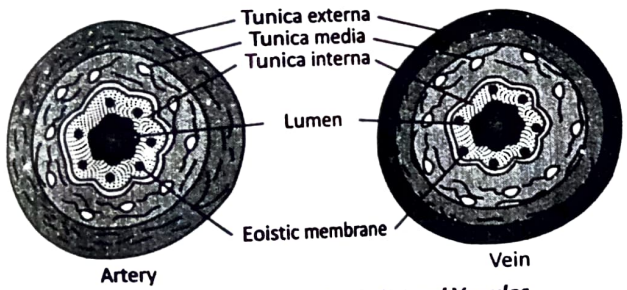


Fig. 13.10: ***Structure of Arteries and Venules***

CAPILLARIES

Arteries end in very tiny blood vessels called capillaries. It is finer than hair. Capillaries are very small blood vessels through which pure blood reaches the tissues and cells of different parts of the body for their nourishment and oxygen supply. They are laid like a net in all the fibers of the body. These are made up of a single layer, i.e., the inner endothelium lining of the arteries, they can only be seen under a microscope. Wall cells are interconnected by a porous structure, allowing the exchange of substances between

the blood and tissue cells within them. Many nutrients, oxygen and some part of blood plasma permeate through the walls of the blood capillaries to the tissue cells and in the form of excretory substances, carbon dioxide and other substances cross the capillary walls from the cells of the tissues and get into the blood. And then the arterial or pure blood gets converted into venous or impure blood. Therefore, impure blood reaches the ventricles, from where it passes through the big veins and reaches the heart.

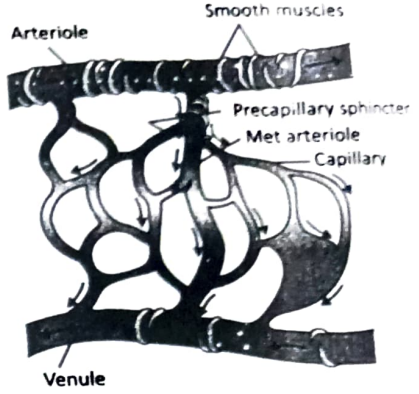


Fig. 13.11: ***Capillary Bed***

VEINS

It is a duct in which, in addition to the pulmonary vein, which carries pure (oxygenated) blood from the lungs and dark red blood (blood that has given up most of its oxygen to the tissues) flows to the heart. Veins are made up of three layers like arteries. Veins have lower average blood pressure than arteries. Many veins, especially the ones in the upper limbs, have valves. These valves prevent the reverse flow of blood.

Venules

This is the last smallest vein that merges into a single cell. It is also called Capillary vein. Fibroids collect blood from capillaries and carry it to the veins.

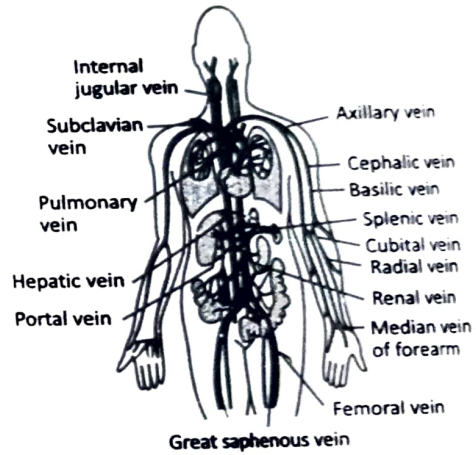


Fig. 13.12: ***Veins***

BLOOD CIRCULATION

In the living state, blood is always circulating in the body. The process of circulating blood in this way is called blood circulation.

The process of blood circulation is divided into the following three parts:

1. Systemic or General Circulation
2. Pulmonary Circulation
3. Portal Circulation

1. **Systemic or General Circulation:** Blood is pushed from the left ventricle of the heart into the aorta from where it travels through the branches (arteries) of the aorta and then through the arterioles to the blood cells. Oxygen and nutrients filter through the walls of the capillaries and reach the tissues and CO_2 and waste products from the tissues mix with the capillaries into the blood. In this way, the pure blood reached through the arteries in the tissues becomes impure, which passes through the venules and then through the venules to the large venules, superior vena cava and inferior vena cava from where it reaches the right atrium. Superior vena cava collects blood from the head and upper arms and inferior vena cava collects blood from the trunk and lower arms to the right atrium.

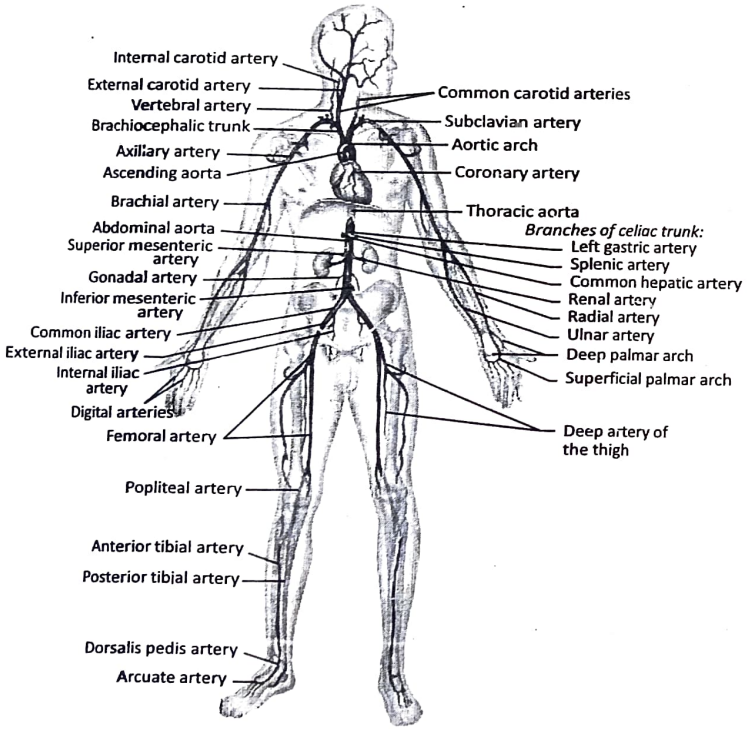


Fig. 13.13: ***Major Arteries of the Systemic Circulation***

2. **Pulmonary Circulation:** The vessels carry impure blood from the heart to the lungs and pure blood back to the heart. The pulmonary trunk carries venous blood from the left ventricle. At the level of the fifth thoracic vertebra, it divides into the right and left pulmonary artery, which then divides to supply blood to other parts of the lungs. The vessels are the only arteries carrying impure blood.

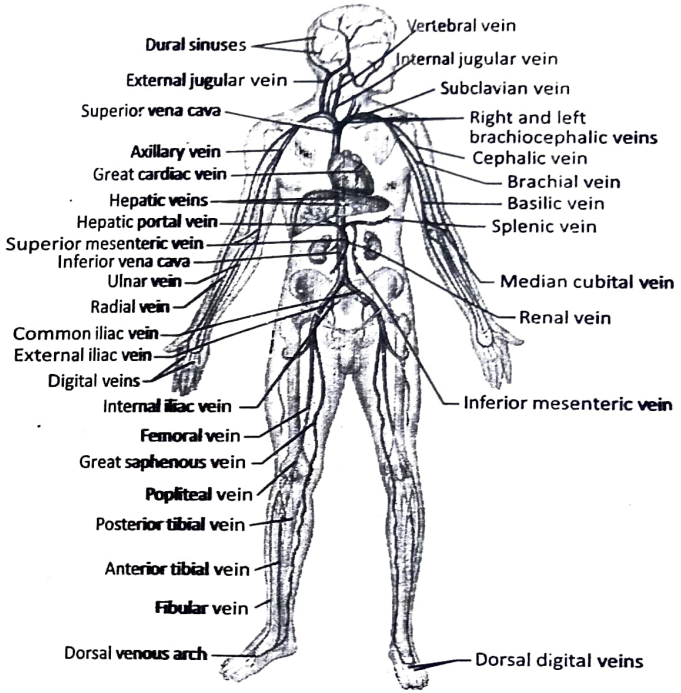


Fig. 13.14: ***Major Veins of the Systemic Circulation***

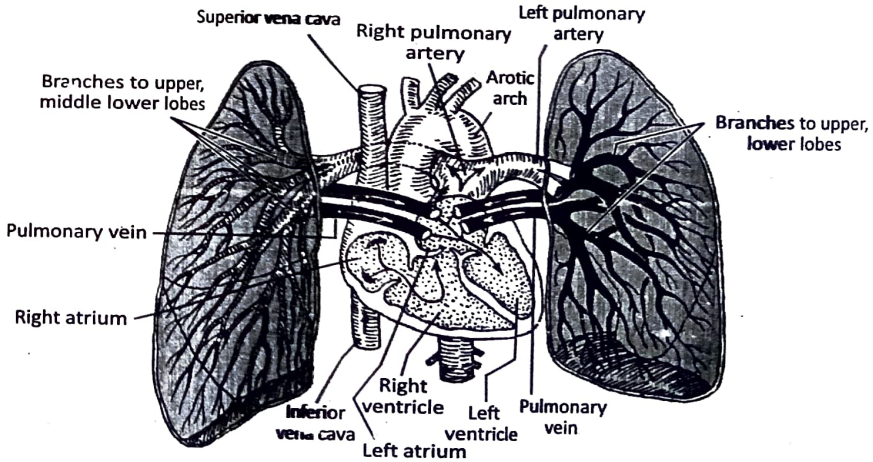


Fig. 13.15: ***Pulmonary Circulation***

Four pulmonary veins carry impure blood from the pleura to the left chamber. Two such vessels emerge from each pleura. These are the only veins that carry impure blood.

3. **Portal Circulation:** All those veins are included in the portal blood circulation that bring blood from the abdominal part of the digestive system and from the pancreas, spleen and gall bladder. Blood from these organs passes through the liver and portal vein, which ends in capillary-like vessels called venules or sinusoids. The blood then collects from the hepatic veins into the lower aorta. The liver must also receive impure blood and it is received by the hepatic artery.

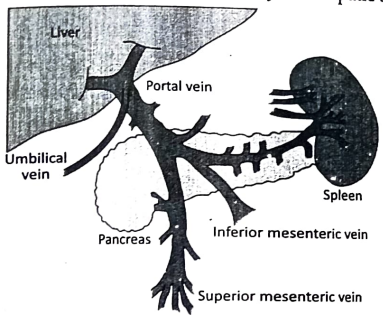


Fig. 13.16: *Portal Circulation*

MAJOR ARTERIES

AORTA

The aorta is the largest artery in the body. The aorta begins at the top of the left ventricle, the heart's muscular pumping chamber. The heart pumps blood from the left ventricle into the aorta through the aortic valve.

The aorta is a tube about a foot long and just over an inch in diameter. The aorta is divided into four sections:

1. Ascending Aorta
2. Aortic Arch
3. Descending Thoracic Aorta
4. Abdominal Aorta

1. **Ascending Aorta:** Right and left coronary arteries arise from the ascending aorta. It is located above the cusp (section of the heart valve) of the aortic valve, which supplies blood to the heart wall. It is about 5 cm long.

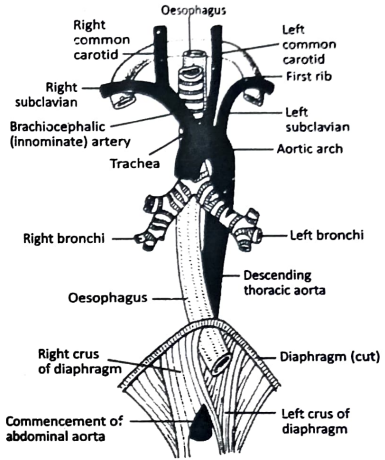


Fig. 13.17: *Aorta and its main branches*

2. **Aortic Arch:** It starts behind the sternum of manubrium and extends above, behind and to the left of the Trachea. After that it comes to the left and down of the aorta. It comes along with the descending aorta. The following three arteries emerge from the aortic arch.
   (a) **Innominate or brachiocephalic artery:** This is the right branch of the aortic arch. It is about 5 cm long. They go up, backward and to the right by turning diagonally. At the stronoclavicular joint it splits into the right common carotid artery and the right subclavian artery.
   (b) **Left common carotid artery:** It is an artery directly emerging from the aortic arch to the left of the innominate artery.
   (c) **Left subclavian artery:** It is an artery directly emerging from the aortic arch on the left side of the left carotid artery.
3. **Descending Thoracic Aorta:** The descending thoracic aorta travels down through the chest. Its small branches supply blood to the ribs and some chest structures.
4. **Abdominal Aorta:** The abdominal aorta begins at the diaphragm, splitting to become the paired iliac arteries in the lower abdomen. Most of the major organs receive blood from branches of the abdominal aorta.

ARTERIES OF THE HEAD AND NECK

The common carotid arteries and the vertebral arteries are the arteries supplying blood from both sides of the head and neck. The normal carotid arteries are enclosed in a fascia

called the carotid sheath. At the level of the upper end of the thyroid cartilage, it divides into the external carotid artery and the internal carotid artery. At the bifurcation of the common carotid artery there is a flattened structure called the carotid body.

External Carotid Artery

This artery supplies blood to the face and the outer parts of the skull.

Internal Carotid Artery

It ascends up to the base of the skull and enters the cranial cavity through the carotid foramen in the temporal bone where it splits into the anterior and middle cerebral arteries which supply blood to the brain and thereby the ophthalmic artery. It also emerges, whose branches supply blood to the eyeball, lacrimal gland and forehead.

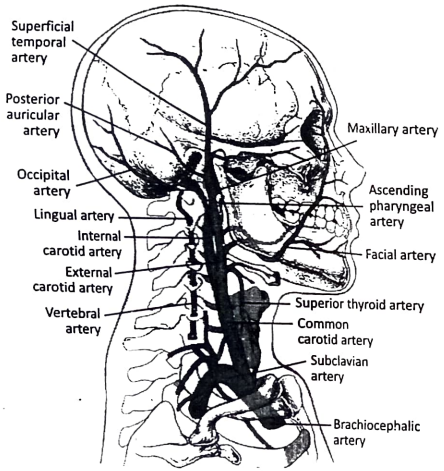


Fig. 13.18: ***Arteries of the Head and Neck***

Circle of Willis

It begins to form when the right and left Internal Carotid Artery (ICA) enters the cranial cavity and each one divides into two main branches:

1. **Anterior Cerebral Arteries (ACAs):** It supplies most midline portions of the frontal lobes and superior medial parietal lobes.
2. **Middle Cerebral Arteries (MCAs):** It supplies most of the lateral surface of the hemisphere, except the superior portion of the parietal lobe and the inferior portion of the temporal lobe and occipital lobe.

The structure of the circle of willis includes:

- Left and right internal carotid arteries
- Left and right anterior cerebral arteries
- Left and right posterior cerebral arteries
- Left and right posterior communicating arteries
- Basilar artery
- Anterior communicating artery

Ulnar Artery

The ulnar artery runs down the inner side of the forearm and passes through the front of the wrist to form the superficial palmar arch. Small arteries emerge from these palmar arches to supply blood to the fingers. Each arch is connected to each other, so that if one artery is cut, the portion supplied by the injured vessel can be supplied by another artery.

Working of Miscellaneous Artery

- Phrenic arteries supply blood to the diaphragm.
- The celiac main artery originates below the arterial orifice of the diaphragm and divides into three branches.
  (a) Left gastric artery which supplies blood to the abdomen and gives out two or three branches which go up through the opening of the esophagus in the diaphragm and merge with the esophageal artery.
  (b) The hepatic artery supplies blood to the liver and sends branches to the right gastric artery apart from the duodenum and bile duct.
  (c) The splenic artery divides into several branches and supplies blood to the spleen and pancreas.
- The superior mesenteric artery supplies blood to the small intestine and the early part of the large intestine.
- Middle suprarenal arteries: It arises from the opposite side of the upper mesenteric artery on either side of the aorta and supply blood to the suprarenal gland.
- The renal arteries provide blood to the kidneys. The left artery is slightly higher than the right, because that is the position of the kidneys.
- The arteries around the ankle joint branch freely and form a network of vessels.
- Ovarian arteries in women and testicular arteries in men supply blood to those organs on the basis of which they are named.
- The lower mesenteric artery supplies blood to the sigmoid colon and rectum, the rest of the large intestine.
- The blood supply to the legs is through the distal iliac artery, which passes through the middle of the upper part of the thigh and extends into the thigh and becomes the femoral artery. This femoral artery goes down inside the thigh where it is called the popliteal artery.

It goes into the leg and gets divided into the following two parts:

- The anterior tibial artery runs down the front of the leg to the anterior surface of the interosseous membrane and passes in front of the ankle to form the dorsalis pedis artery, which supplies blood to the upper surface of the foot.
- The posterior tibial artery runs down the back of the leg and runs down the inside of the ankle to the sole of the foot and turns into the plantar arch.

❖ The abdominal aorta divides into two common iliac arteries. They again divide at the height of the last lumbar vertebral disc into the internal iliac artery which supplies blood to the pelvic organs, perineum and buttocks and the external iliac artery which supplies blood to the legs.

VENOUS SYSTEM

VEIN

A vessel in which, in addition to the pulmonary vein, which brings pure (oxygenated) blood from the lungs, dark red blood (blood that has given up most of the oxygen to the tissues) flows towards the heart, is called a **Vein.** The veins of the whole body carry blood to the two major veins, the superior vena cava and the inferior vena cava. The blood of

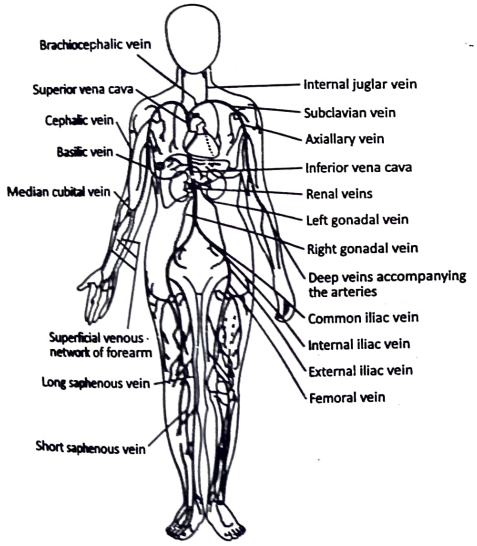


Fig. 13.19: ***Venous System***

the whole body reaches the right atrium of the heart through these two large veins. The number of veins is more than that of arteries. Veins are of two types: superficial and deep.

Superficial Veins: These veins are located just below the skin and are related to deep veins located below at some points.

Deep Veins: These veins run along the arteries and their position also remains in the inner part of the body parts like arteries. Deep veins are usually found along with arteries, hence they have the same name. Some deep veins have a different name because they are different from arteries.

VEINS OF THE HEAD AND NECK

The blood of the head and neck veins is returned by the deep and superficial nerves. Epithelial veins are named after branches of the external carotid artery, such as the auricular vein, etc. They return the venous blood to the epidermal structure of the face and cranium and assemble to form the external jugular vein. This vein starts at the angle of the jaw in the neck and goes into the subclavian vein. Venous blood from deeper areas of the brain collects in the sinuses.

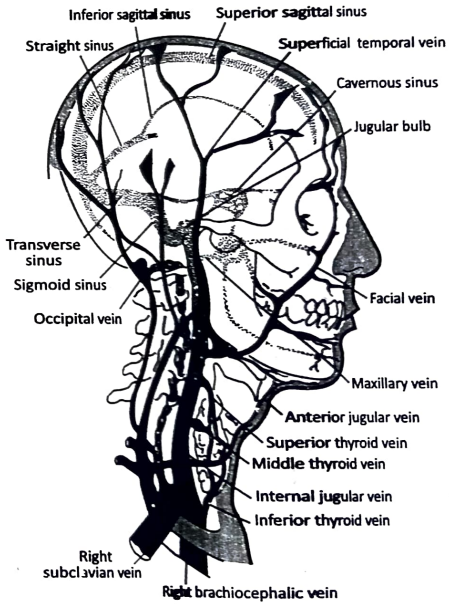


Fig. 13.20: ***Veins of the Head and Neck***

The main sinuses are as follows:

- **Superior sagittal sinus:** It carries venous blood from the upper part of the brain to the oblique sinus.
- **Inferior sagittal sinus:** This is the sinus located in the brain, which goes back to form the straight sinus.
- **Straight sinus:** This goes back and down to become the left transverse sinus.
- **Transverse sinus:** This curve runs along the sinus. The curved sinus changes into the internal jugular vein.
- **Internal jugular vein:** This vein comes down in the neck behind the clavicle and joins with the subclavian vein carrying blood from the upper parts to form the veins related to the arm and head.

VEINS OF THE UPPER LIMB

The veins of the upper arm are divided into two classes, the superficial and deep veins.

The following are the four superficial veins that start at the hand:

1. Head or Cephalic Vein
2. Basilic Vein
3. Median Vein
4. Median Cubital Vein

1. **Head or Cephalic Vein:** It begins at the back of the hand where it collects blood from the plexus of superficial veins. It then ascends to the side of the forearm and at the bend of the elbow, a large branch median cubital vein emerges from it. After this, it goes up and ends in the axillary vein below the clavicle bone and carries blood to it.

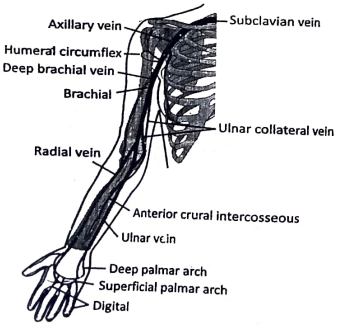


Fig. 13.21: *Major Veins of Upper Limb—Right Anterior View*

2. **Basilic Vein:** It starts from the ulna bone at the back of the hand and moves upwards through the middle edge of the forearm and upper arm and opens into the axillary vein. The cephalic and basilic veins reach the upper arm near the shoulder to form the axillary vein.
3. **Median Vein:** This is a small vein that starts from the palm and runs upwards in front of the forearm and ends in basilic or median cubital vein. This vein is not present in any person.
4. **Median Cubital Vein:** It is a prominent superficial upper limb vessel. Its located in the cubital fossa, on the anterior/flexor aspect of the elbow joint.

The following are deep veins:

- Palmar Metacarpal Veins
- Ulnar Veins
- Brachial Vein
- Subclavian Vein
- Deep Palmar Venous Veins
- Radial Veins
- Axillary Vein

VEINS OF THE THORAX

Most of the venous blood from the organs located in the thoracic cavity comes in the azygos vein and the hemizygos vein. The azygos vein opens into the upper aorta and the hemizygos vein into the left brachiocephalic vein, which collects impure blood and drains it into the right atrium of the heart. The left brachiocephalic vein is larger than the right. The brachiocephalic veins carry blood from the head and upper arms and additionally from the veins of the upper part of the thorax including the mammary veins. The combination of both the brachiocephalic veins forms the superior vena cava which carries blood to the right atrium of the heart.

VEINS OF THE ABDOMEN AND PELVIS

The femoral vein ends near the inguinal ligament and becomes the external iliac vein. Near the sacroiliac joint, it joins the **internal iliac vein**, which brings blood from the pelvic organs. The **common iliac vein** is formed by the union of the external and internal iliac veins. The inferior vena cava is formed by the joining of the right and left common iliac veins to the right of the fifth sciatica. When the lower venous rises upwards through the abdomen, many veins come together in it, which bring blood from the organs below the diaphragm to the lower ventricle to reach the heart. In the lower ventricle, the thoracic veins come and open, which bring blood from the posterior abdominal wall. In addition to these, the testicular or ovarian veins, renal and suprarenal descending inferior frenic and hepatic veins come and open in the lower venous, which carry the venous blood of the related organs to the lower venous.

Blood from the rest of the abdominal cavity passes through the liver through portal circulation before entering the lower venous.

VEINS OF THE LOWER LIMB

Superficial and deep veins are found in the lower arms or legs.

Superficial veins are the following:

1. **Short Saphenous Vein:** It starts from the outer part of the foot's surface and is formed by the joining of many small veins there, which bring blood from the foot's surface and deliver it. It reaches the knee through the middle of the calves and joins a deep vein located in the popliteal space called the popliteal vein, which later on is called the femoral vein. Small veins come and open in it, through which blood reaches it from the back of the leg and foot.

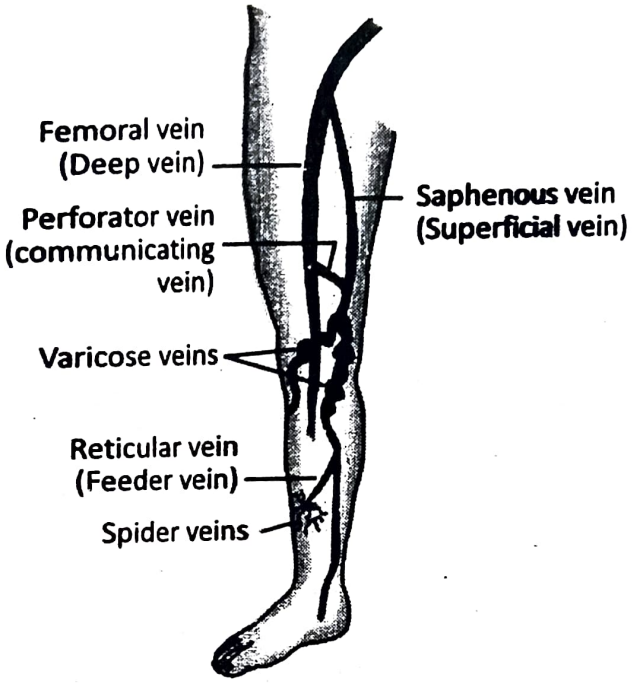


Fig. 13.22: ***Major Veins of the Lower Limb***

2. **Great Saphenous Vein:** It is the longest vein in the body. It starts from the medial part of the dorsal part of the foot and moves upward and joins the femoral vein just below the inguinal ligament. Many small branches open along the entire length of this vein.

The deep veins of the legs are the following:

- ❖ Femoral Vein
- ❖ Anterior Tibial Vein
- ❖ Peroneal Vein
- ❖ Medial Planter Vein
- ❖ Popliteal Vein
- ❖ Posterior Tibial Vein
- ❖ Dorsal Pedal Vein
- ❖ Lateral Planter Vein

In the lower arms, the superficial veins are connected with each other by many communicating veins and the subarachnoid veins are connected with the deep veins, through which blood flows from one subarachnoid to the other and from the subacute veins to the deep veins. Due to the presence of many valves in the veins, the flow of blood cannot be done backwards.