First year medical students (2026)

Contents:

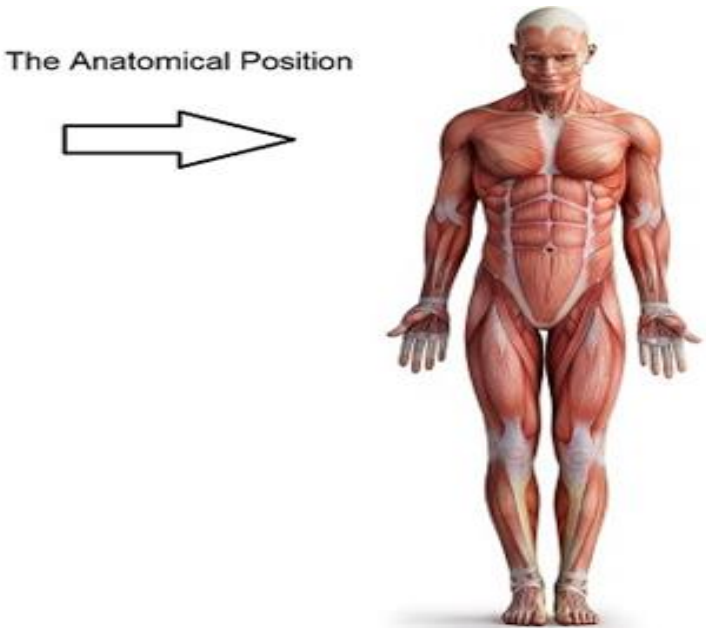
Introduction to Anatomy

- **Anatomy:** means cutting up for studying the normal structure of organs in living. It is concerned with the consideration of Various structures which make up the human body.

Types of study:

- **Macroscopic anatomy:** studying normal structure of organs by naked eye.
- **Microscopic anatomy (Histology):** studying of normal structure of cells under microscope.
- **Developmental anatomy:** studying the intrauterine life.
- **Applied anatomy:** application of anatomical facts in medicine & surgery.
- **Surface anatomy:** identification of borders of organs on the skin surface.
- **Radiographic anatomy:** studying anatomy by using imaging techniques: CT, MRI, X-ray.
- **Anatomical position & anatomical planes:**

  - **Anatomical position:**
    The anatomical position is a standing erect position, with the head facing forward with the arms hanging by the side. The palms are facing forward with the fingers extended, and the thumbs are pointing away from the body. The feet are spaced slightly apart with the toes pointing forward.

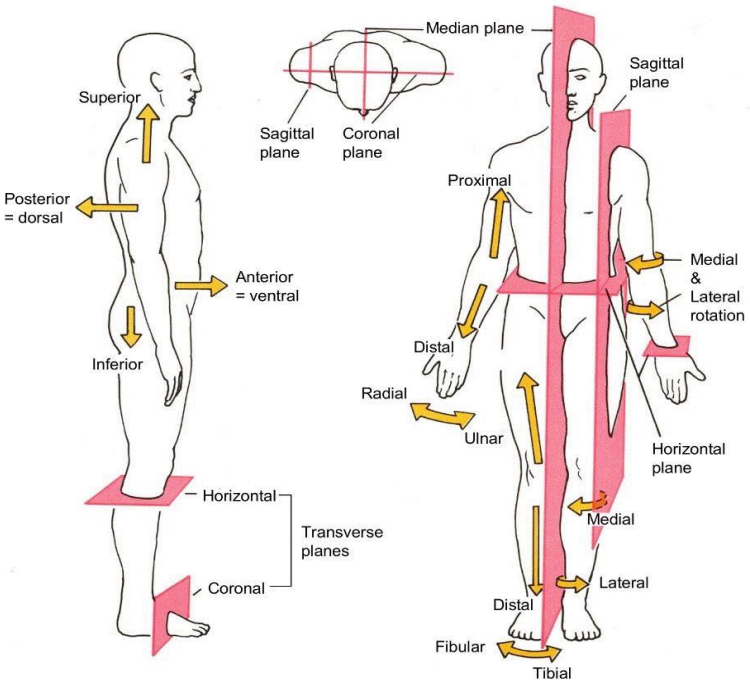


- **Anatomical planes:**

1- **Sagittal plane:** a vertical plane which divides the body into right & left parts. If it is divided into two equal halves, it's called **mid-sagittal or median plane.**

2- **Coronal (frontal) plane:** a vertical plane which separates the "anterior" portion of the body from the "posterior" portion. front & back parts.

3- **Transverse plane:** a horizontal plane (cross-section) which divides the body into upper & lower parts. Is a plane at right angle to the sagittal plane.



<u>Terms of relationship</u>:

Express the relationship (refer to a structure's location) of one structure to another.

- **Anterior** (or ventral) means "front of" or "in the front." Your abdominal muscles are on the anterior side.

Posterior (or dorsal) means the opposite of anterior: "back of" or "behind/on the back." Nearer to the backbone.

- **Superior** (or cranial) means "toward the head end of the body" or "higher/above."

Inferior (or caudal) means just the opposite: "away from the head, nearer to the tail" or "lower/under/below.

- **Medial** means toward the midline of the body.

Lateral means away from the body's midline.

Intermediate means "between" two structures.

o **Terms of comparison**:

- **Proximal:** Closest to point of attachment of the limb to the trunk.

Distal: Furthest from point of attachment of the limb to the trunk.

- **Superficial (or external)** means nearer to the surface, skin (or outside) of the body.

Deep (or internal) means the opposite: away from the outside of the body. Far below the surface of the skin. The muscles are deep to the skin, and the skin is superficial to the liver.

Terms of movements:

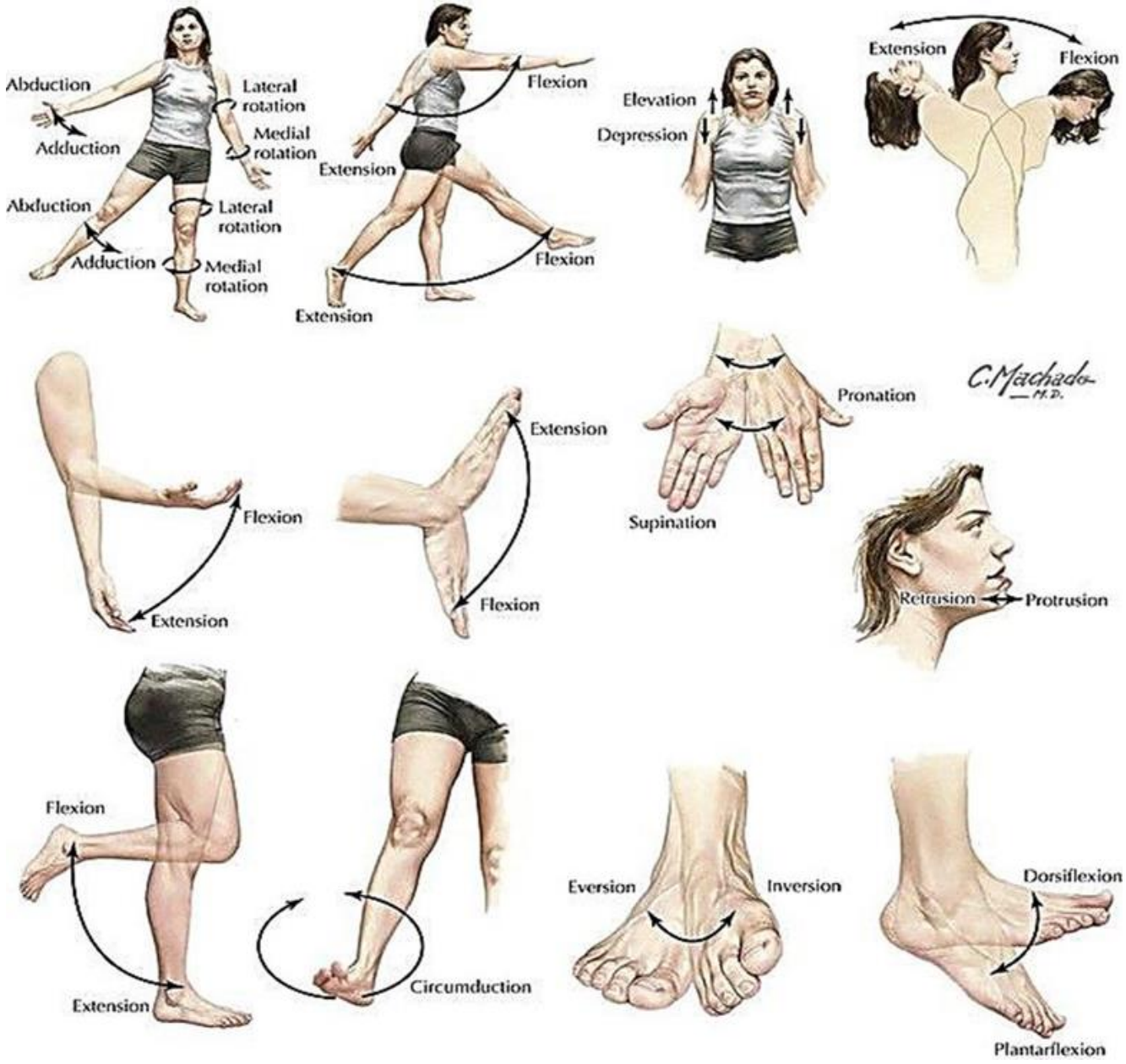
When describing joint movements, two factors are included:

1- **Axis** around which the specific part moves.

2- **Plane** of the movement

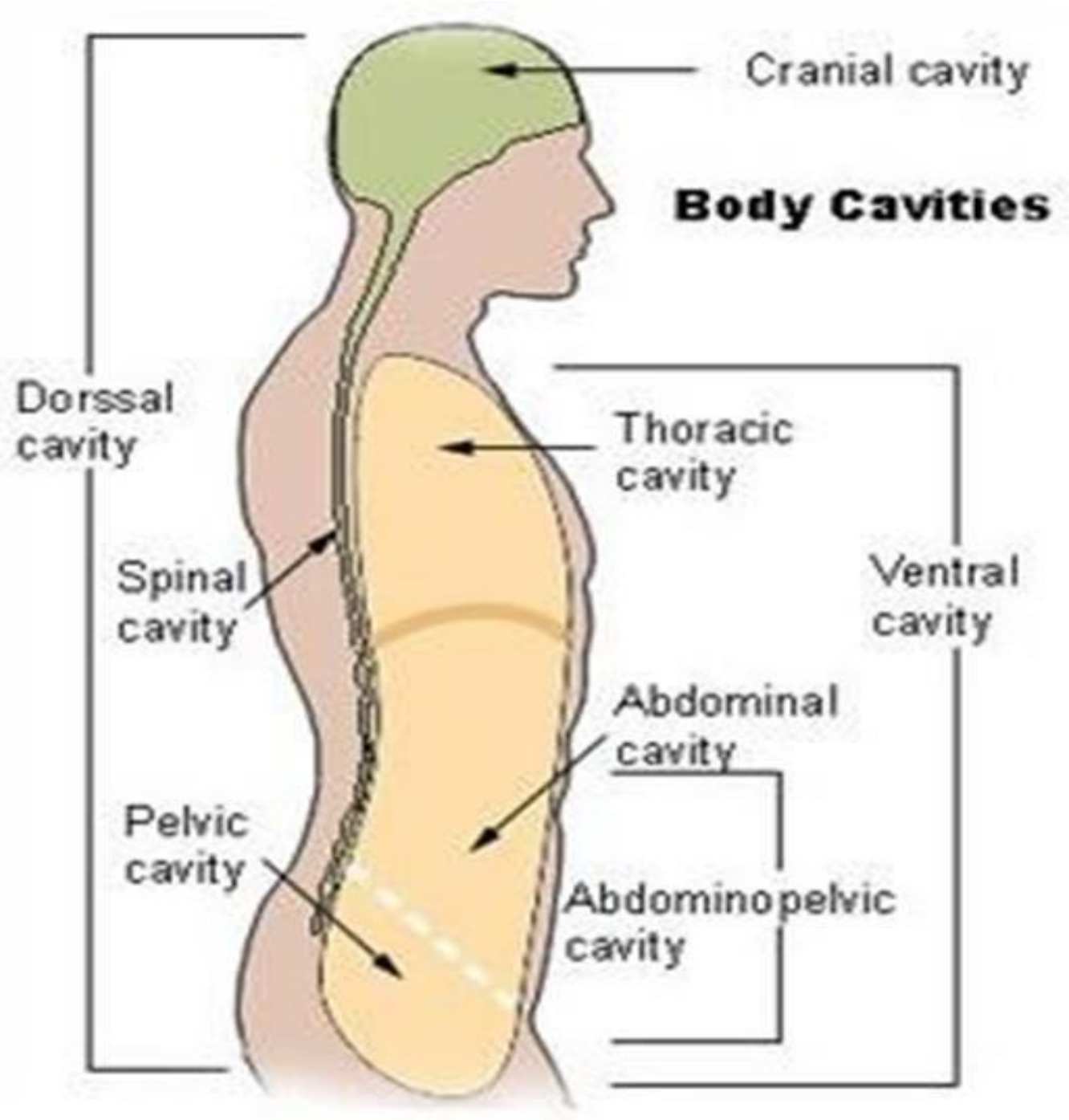
- **Flexion:** To bend, decrease the angle between two structures.
- **Extension:** To straighten, increase the angle between two structures.
- **Abduction:** Movement away from the median plane.
- **Adduction:** Movement towards the median plane.
- **Circumduction:** Multi-axial movement in a sequence of flexion, abduction, extension & adduction or vice versa.
- **Rotation:** Turning of a bone (Spiral or Twisting movement) around its longitudinal axis towards or away from the midline.
  - **Lateral rotation of forearm** is called **supination** → palm of the hand is facing forward, and thumb is directed laterally.
  - **Medial rotation of forearm** is called **pronation** → palm of the hand is facing backward, and thumb is directed medially.
- **Inversion:** Sole of the foot is facing inward (medially).
- **Eversion:** Sole of the foot is facing outward (laterally).
- **Dorsiflexion**: Lifting the foot so toes close the front of leg. Flexion of the dorsum (top) part of the foot.

- **Plantarflexion**: Depressing the foot (pointing the toes). Flexion of the plantar (underside) part of the foot.
- **Depression:** Moving downwards.
- **Elevation**: Moving upwards.
- **Protraction**: Movement forward.
- **Retraction:** Movement backward.



Body cavities:

- **Ventral body cavities:** Lined by serous membranes.
  - **The thoracic cavity** contains the **lungs** & the **heart**.
  - **The abdominal & pelvic cavities** contain the **abdominal** & **pelvic viscera.**
- **Dorsal body cavities:** Lined by meninges.
  - The **cranial cavity** houses the **brain**.
  - The **vertebral (spinal) canal** houses the **spinal cord.**



Skin and Fascia

Skin:

- It is the largest organ that forms the external coat of the human body.
- The skin acts as a **protective barrier** that limits the migration of microbes and chemicals into the body.
- It plays an integral role in thermoregulation.
- Neurons in the skin detect sensory input that helps with interacting with the environment.
- The main factor determining the color of skin is the degree of pigmentation produced by **melanocytes** in the basal layer of the epidermis.

- **Structure of skin:** it is composed of two components:

1) **Epidermis**: It is the outermost epithelial layer of skin, provides a waterproof barrier and creates our skin tone. It is composed of keratinized stratified squamous variety. It is thin with eyelids but thick in palms and soles. It is devoid of blood vessels.
2) **Dermis:** which is the deeper connective tissue layer which is arranged into:

Two layers:

I. The **outer papillary layer**, characterized by ridges or papillae protruding into the epidermis, and by greater cellularity and vascularization.

II. The **inner reticular layer**, consisting chiefly of dense irregular collagen fibers.

- The patterns of arrangements of collagen fibers in papillary ridges, especially those of the fingers, are stable throughout life and specific to everyone thus form the **fingerprints** (**dermato-glyphic**). 3 patterns of fingerprints; **arches**, **whorls** and **loops**.
- **Types of skin:**
  - **Thick skin:** found on palms and soles, where epidermis is extremely thick.
  - **Thin skin:** found all over the rest of the body.

- **Flexure lines of skin (skin creases):**

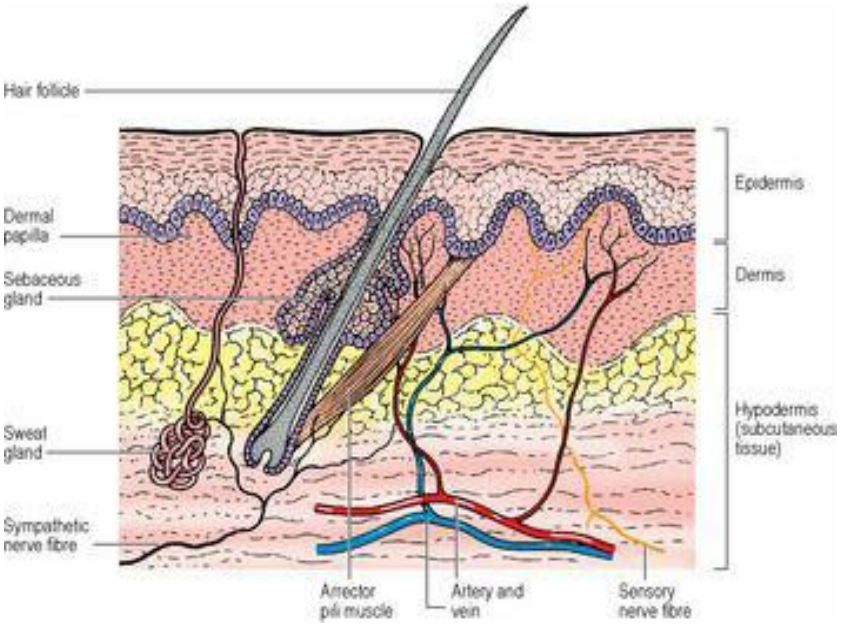
• Linear skin furrows lie opposite joints.

• Site: found in the palm & digits of the hand, and the front of the wrist joint.

• It is produced by firm attachment of the skin to the underlying deep fascia.

- **Skin appendages:**

Sweat glands, sebaceous glands, hair and nails are specialized derivatives of epidermis.



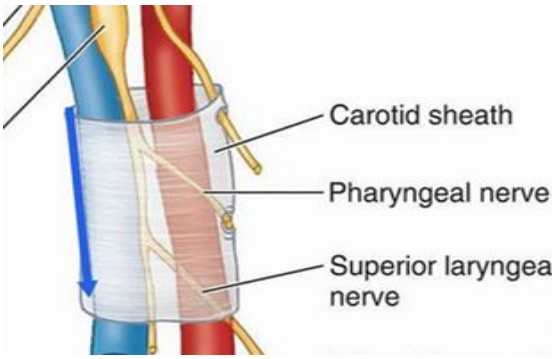
- **Sweat glands** are distributed all over the skin except on the tympanic membranes, lip margins, nipples, glans penis and labia minora. The greatest concentration is in the thick skin of the palms and soles, and on the face. Sweat glands are coiled tubular structures that extend into the dermis and subcutaneous tissue. **Apocrine glands** are large, modified sweat glands confined to the axillae, areolae of breasts, genital and perianal regions.
- **Sebaceous glands** are small saccular structures in the dermis, where they open into the side of hair follicles. They are absent in the palms and soles. They are particularly large on the face.
- **Hair** is formed from the hair matrix, a region of epidermal cells at the base of the hair follicle, which extends deeply into dermis.
- **Nails** are keratinized plates on the posterior surfaces of the digits.

Fascia:

Fascia is a collection of connective tissue that lies immediately beneath the skin. It is divided into:

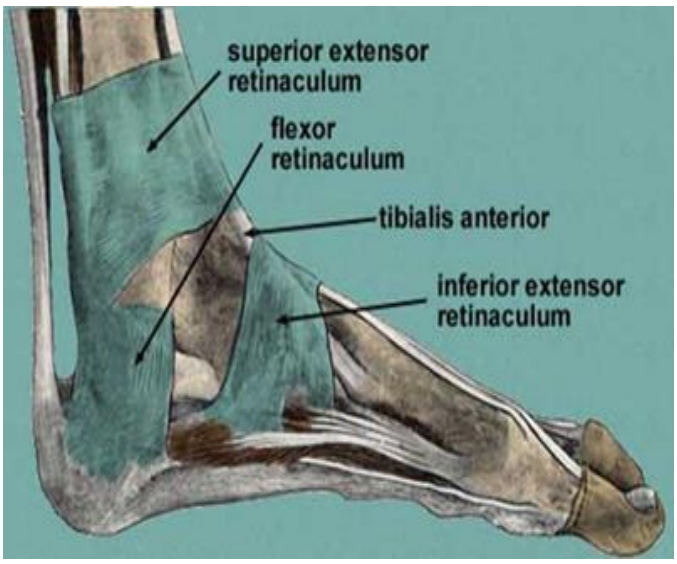
⊡ Superficial fascia:

- It is a mixture of loose areolar and adipose connective tissue of variable thickness and fat content.
- It is more distinct on the anterior abdominal wall and buttocks.
- Functions of superficial fascia: It facilitates movements of the skin.
  It contains nerves & vessels of skin and acts as insulator protecting the body against heat loss.



⊡ Deep fascia:

- It is a non-elastic dense membrane of fibrous tissue, rich in collagenous fibers of variable thickness.
- It lies underneath the superficial fascia. It is dense in certain places like the palm of hand and sole of foot.
- It is entirely absent in the face.
- Examples of deep fascia:
  - **Intermuscular septa** lie between muscles.
  - **Investing fascia** covers the surface of the muscles.
  - **Retinacula** are localized thickenings around wrist and ankle joints.
  - **Sheaths** enclosing big neurovascular structures.

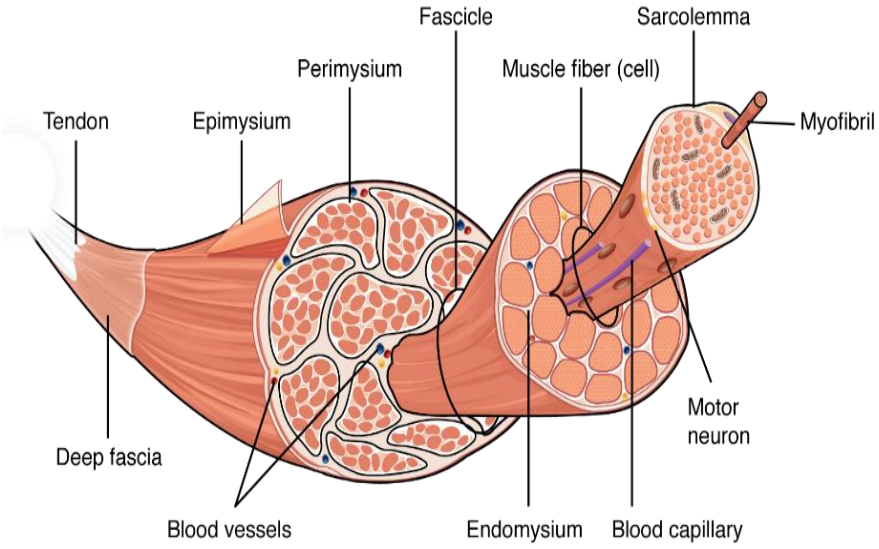


Muscles (Myology: Study of Muscles)

- **A muscle** is defined as a tissue primarily composed of specialized fibers which have **four** main properties: excitability, contractibility, extensibility and elasticity.
- The muscular system performs several important functions. These include the production of **force** and **movement**, **support** of body stature and position, stability of joints, production of body heat (to maintain normal body temperature).
- **Types of muscles:**
- **Skeletal muscles**:
  - They are attached to a skeleton. They have voluntary action.
  - There are about 650 muscles in the human body.
  - Controlled by somatic nerves. Skeletal muscle tissue is composed of
  - long, unbranched cells called muscle fibers that have a transverse striated appearance.
- **Cardiac muscles**:
  - They are present in the myocardium of the heart.
  - They have involuntary action. Supplied by autonomic nerves.
  - Have a branched, striated appearance, with a single central nucleus.
- **Smooth muscles**:
  - They are present in the viscera (intestine & blood vessels).
  - They have involuntary action. Innervation is by autonomic nerves.
  - It consists of narrow spindle-shaped cells.

➢ **Parts of skeletal muscle:**

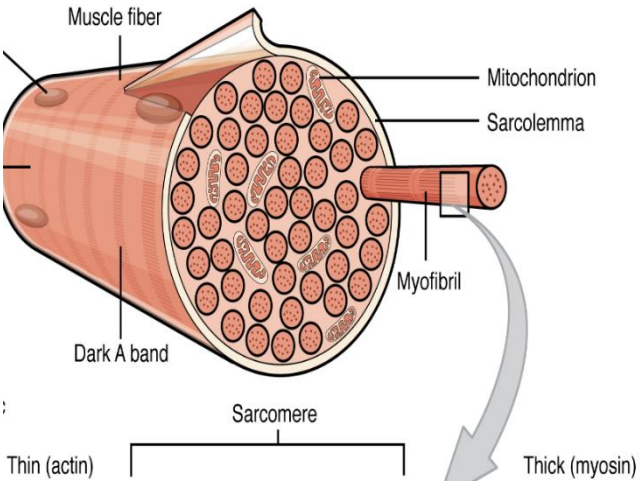
- **Origin**: the proximal fixed end of the muscle.
- **Insertion**: the distal mobile end of the muscle.
- **Fleshy belly:** the central main bulk of the muscle.



Skeletal muscle:

- **It** consists of long muscle fibers which are surrounded by connective tissue, **the endomysium**. Parallel groups of fibers are surrounded by connective tissue, **the perimysium**, to form muscle bundles (fascicles). Thicker connective tissue, **the epimysium**, envelops the entire muscle.

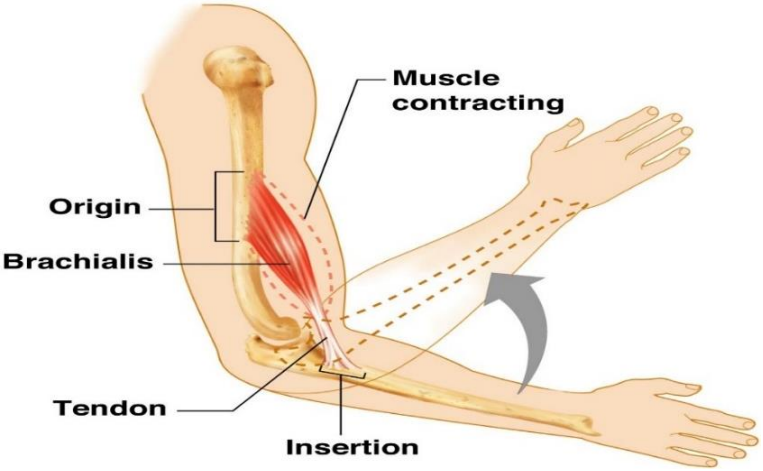
- The plasma membrane of muscle fibers is called the **sarcolemma**, and the cytoplasm is referred to as **sarcoplasm**.
- Within muscle fiber, proteins are organized into organelles called **myofibrils** that run the length of the cell and contain sarcomeres.
- The **sarcomere** is the smallest functional unit of a skeletal muscle fiber.



➢ **Muscle attachment to bone**:

- **Fleshy attachment:** the muscle is attached to the bone by its fleshy belly.

- **Muscle tendon:** it is cord-like structure, formed of longitudinally arranged collagenous fibers.
- **Aponeurosis:** is an expanded sheet of fibrous tissue, formed for wide muscle attachment as in anterior abdominal wall muscles.



⊡ Skeletal muscle forms (architectures):

Muscle form is a description of the relationship between the line of pull of the muscle, direction & arrangement of muscle fibers.

I. **Parallel form**: muscle fibers are parallel to each other. There are three types of parallel muscles:

1- **Quadrilateral muscles**, which have a short, flat form e.g. pronator quadratus muscle

2- **Strap muscles**, that have a narrow belt- or strap-like belly e.g. sartorius muscle

3- **Fusiform muscles**, with a spindle-shaped and extended belly, e.g. biceps muscle.

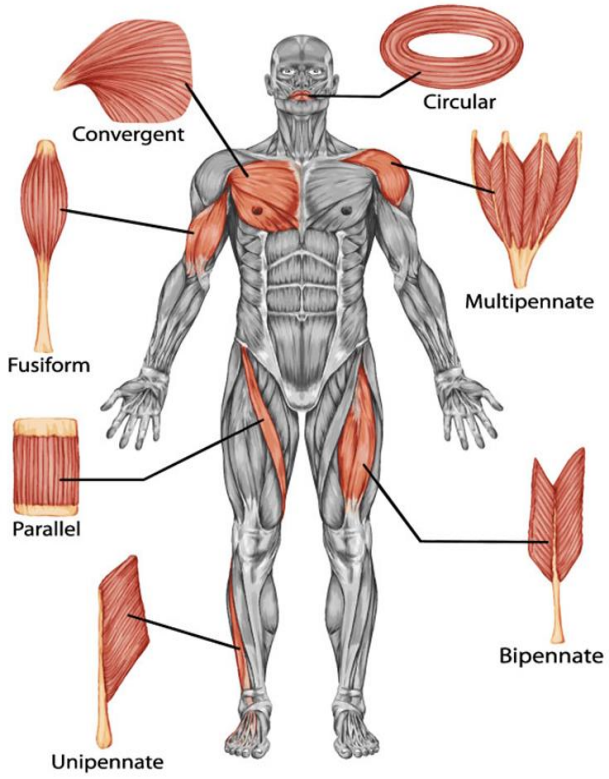
II. **Oblique form (pennate):** In a pennate pattern, the fascicles are short, and they attach obliquely to a central tendon that runs the length of the muscle. Types of Pennate muscles are:

1- **Unipennate**: in which the fascicles insert into only one side of the tendon, has a shape of **half of a feather** like flexor pollicis muscle.

2- **Bipennate**: in which the fascicles insert into the tendon from opposite sides. The tendon is central, giving the muscle a resemblance to a **feather**, like rectus femoris muscle.

3- **Multipennate**: which looks like **many feathers** side by side, like deltoid.

4- **Circum-pennate**: muscle fibers are arranged obliquely towards a central buried tendon like tibialis anterior muscle.



III. **Convergent form**: fan-shaped, triangular, wide origin, narrow insertion like temporalis**.**

IV. **Circular form**: sphincter-like. arranged in concentric rings like Orbicularis oris.

V. **Segmented form**: fused parts. Example: Rectus abdominis.

VI. **Spiral (twisted) form:** like supinator.

- **Muscle actions:**

The Movements are the result of the coordinated activity of many muscles.

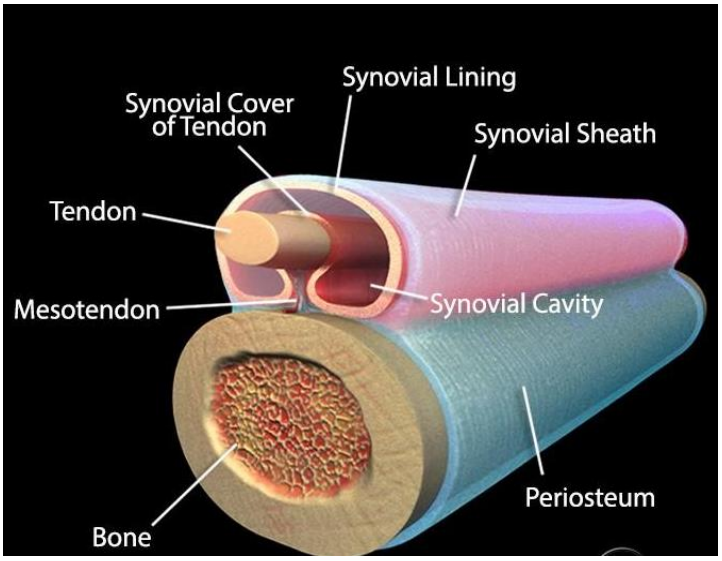
- **Prime mover:** is the muscle which performs the desired movement.
- **Antagonist:** A muscle producing the opposite of the desired movement.
- **Synergists**: prevent unwanted movement.
- **Fixators:** stabilize one attachment of a prime mover muscle so that the other end may move.

Synovial bursa:

- A closed fibrous sac which is lined by a synovial membrane to lubricate and prevent rubbing the muscle or tendon against a bony prominence during movements.
- **Types:**
  a. **Subcutaneous bursa:** is located between the skin and the underlying bone.
  b. **Subtendinous (submuscular) bursa**: beneath the muscle tendon and bone or between adjacent muscles.
  c. **Articular bursa:** inside synovial joints

Synovial sheath:

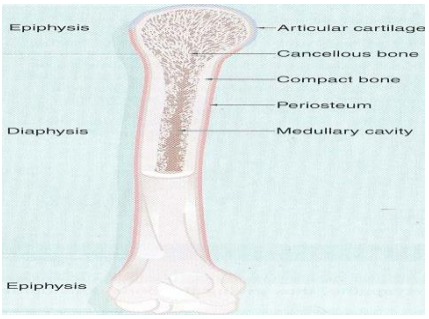
- A tubular fibrous sheath which is lined by a synovial sheath for lubrication.
- It consists of **visceral** and **parietal layers,** separated by **synovial fluid.**
- It wraps around the tendon of the muscle and prevents rubbing against many bony prominences.



Bones & Cartilages

Osteology: study of bones

- **Bone structure:**
  - Bone is a type of vascularized dense connective tissue with bone cells embedded in a matrix composed of organic materials and inorganic salts.
  - The **adult human skeleton** typically consists of **206 bones.**
  - The **outer surfaces of bones** are covered with a thick layer of vascular fibrous tissue, the **periosteum**, which is strongly attached to muscles, tendons and ligaments. Periosteum does not cover the articulating surfaces of the bones in synovial joints.
  - The **inner surfaces of bones** are lined with a single-layered **endosteum,** that is also osteogenic like the periosteum (contributes to new bone formation).
- The **inner core** of bones (**medullary cavity**) contains either red bone marrow (primary site of hematopoiesis) or is filled with yellow bone marrow filled with adipose tissue.



- **Types of bone cells:**
  - **Osteocytes:** mature bone cells.
  - **Osteoblasts:** immature bone cells.
  - **Osteoclasts:** phagocytic cells for bone remodeling.
- **Bone functions:**

1. Gives body framework.
2. Forms joints for locomotion.
3. Protection of vital organs like brain & heart.
4. Containing bone marrow for blood cells formation.
5. Storage for calcium & phosphorus.

- **Types of bones**

▣ ***Structural classification***: two types

1) **Compact bones** are hard, dense and resemble ivory. They occur on the **surface cortex of the shaft of long bones.**
2) **Spongy bones** consist of a sponge-work of delicate trabeculae; bony matrix contains large spaces. Example: **ends of long bones.**

⊡ ***Developmental classification***: two types

1) **Intra-membranous ossification** → osteoblasts are simply laid down in a fibrous membrane; there is no cartilage precursor, example **skull vault.**
2) **Intra-cartilaginous ossification** → formation of bone is proceeded by cartilaginous model of the bone, which is gradually destroyed and replaced by bone. Example **Most of the skeleton bones.**

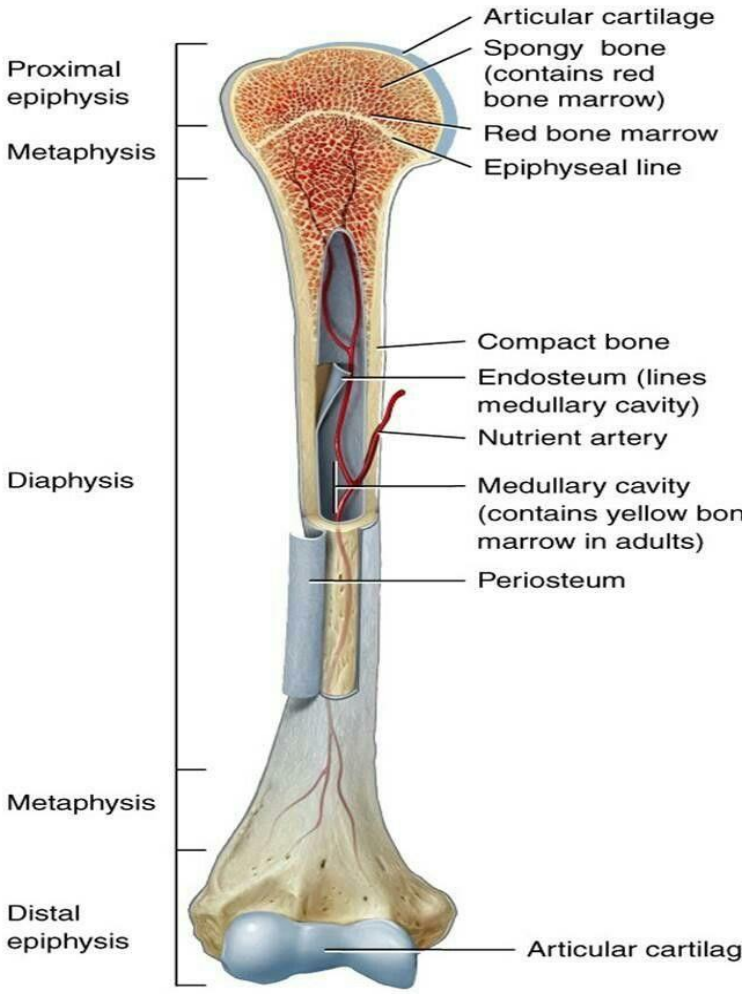
⊡ ***Morphological classification*:**

1- Long bones: Present in limbs like femur, humerus.

The long bone has a shaft (**diaphysis**) & two ends **(epiphyses).**

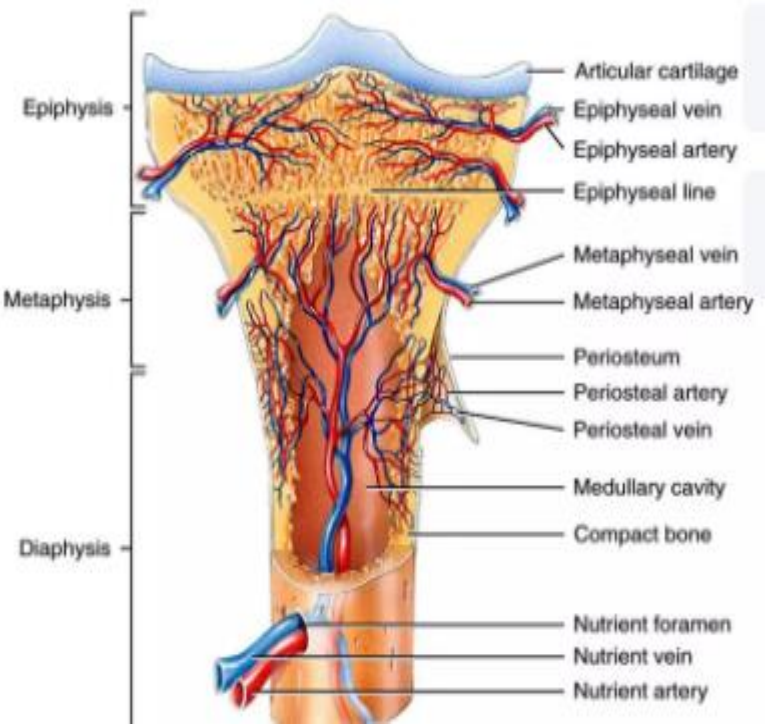
Growth of long bones:

- They are developed by **intra-cartilaginous ossification.**
- **Primary centers** of ossification appear in the middle of the shaft by **the 8th week of intra-uterine life.**
- The ends of the bone (***epiphyses***) remain cartilaginous and only acquire **secondary ossification centers**, usually **after birth.**
- The growing end of the diaphysis is **metaphysis.**
- The **epiphysial plate** is temporary and persists at junction between epiphysis & diaphysis for bone growth till ossification completed.



<u>blood supply of long bones</u>:

i. **Nutrient vessels** enter the cortex through the **nutrient foramen** supplying **medullary canal & inner 2/3 of the cortex**
ii. **Periosteal vessels** supply the **outer 1/3 of the cortex**.
iii. **Metaphyseal vessels** directly supply the metaphases.
iv. **Epiphyseal vessels** directly supply the epiphyses.



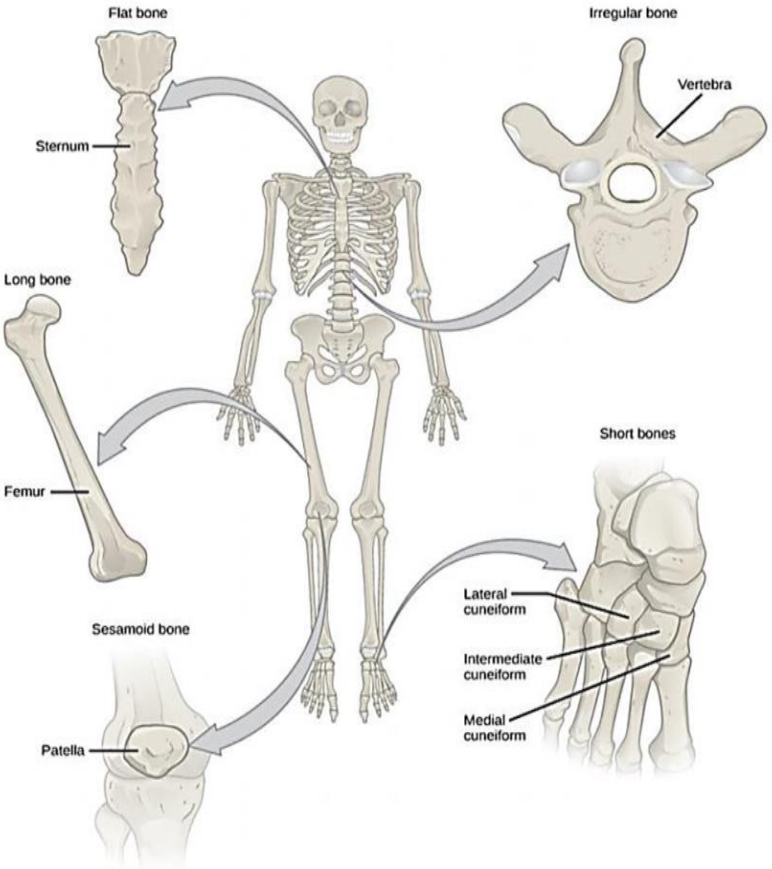
2- Short bones: They are small cubical bones, like **carpal & tarsal bones.**

3- Flat bones: They have flat wide surfaces for protection & muscle attachment, such as **skull vault, scapula & sternum.**

4- Irregular bones: irregular configuration, as **vertebrae.**

5- Sesamoid bones: Small nodular bones inside certain tendons to prevent friction of tendons, like **patella.**

6- Pneumatic bones: Only in facial bones. Air-filled spaces replace the bone marrow & communicate with nasal cavities, like **Para-nasal sinuses.**



Cartilages

- **Cartilage** is a type of dense connective tissue in which chondrocytes are embedded in a firm matrix.
- It is devoid of nerves, blood vessels and lymphatics.
- There are three types of cartilage:

⊡ Hyaline cartilage:

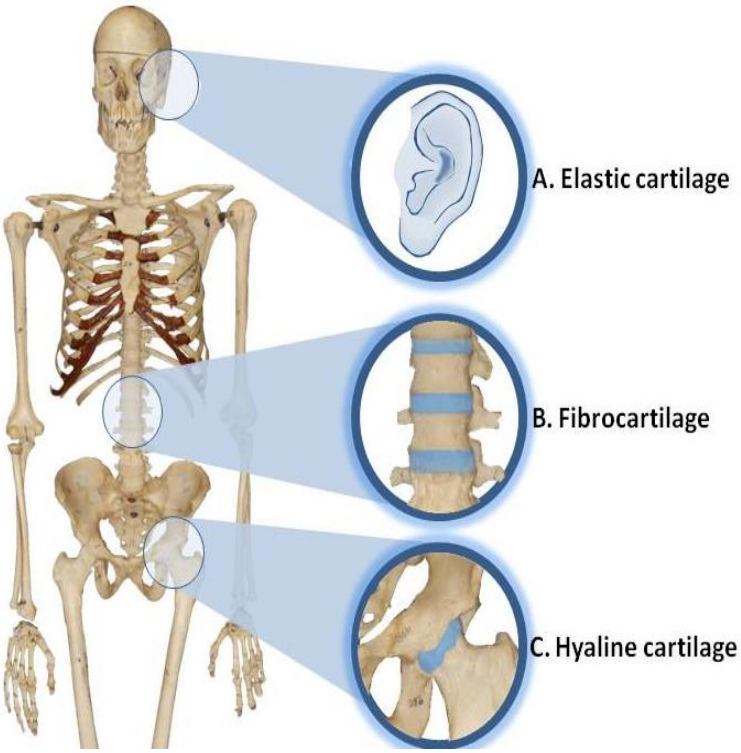
- It is the most common, which has a glossy translucent appearance.
- It is found in the ribs, nose, larynx, trachea, articular cartilage of typical synovial joints and epiphyseal plates of bones.

⊡ Fibrocartilage:

- This is the strongest type.
- Fibrocartilage is made up of alternating layers of hyaline matrix and layers of dense collagen fibers but contains small islands of cartilage cells.
- It is found in **intervertebral discs**, the **labrum** of the shoulder and hip joints, the **menisci** of the knee joints.

⊡ Elastic cartilage:

- Elastic cartilage contains collagen and an abundance of yellow elastic fibers that are arranged into a threadlike network in which chondrocytes can be found.
- It is resilient, flexible and found in structures like the **outer ear & epiglottis**



Joints

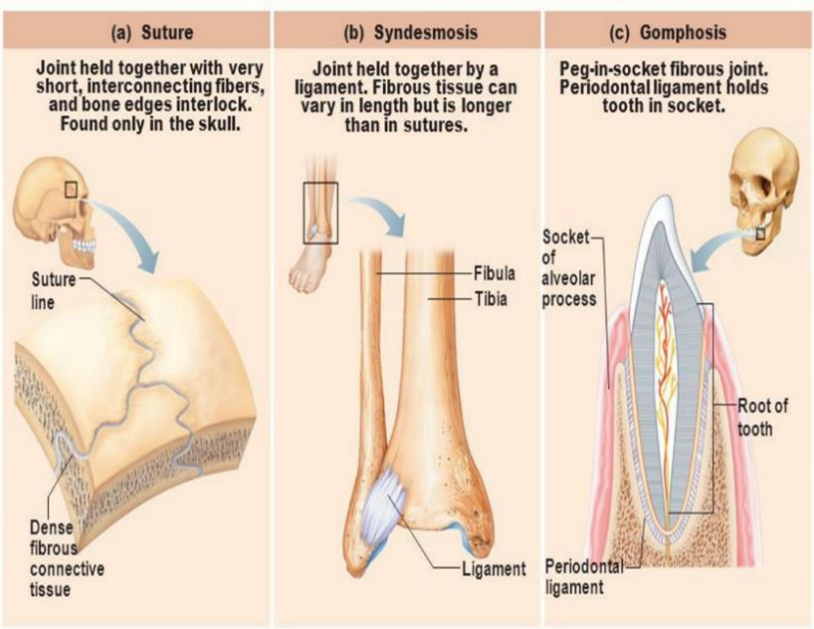
(Arthrology: Study of Joints)

- The point at which two bones or more lay adjacent to each other (with or without the ability to move) is called a **joint.**

⊡ **Types**:

I. **Fibrous joints**: bones are connected by an intervening connective tissue. They are immobile joints. Fibrous joints are found only in **3 areas** throughout the body:

- **Sutures of skull**.
- **Syndesmosis** between the lower ends of tibia & fibula.
- **Gomphosis** joint between the root of the tooth and its socket.



II. **Cartilaginous joints**: bones are connected by cartilaginous tissue.

- **Primary cartilaginous (Synchondrosis) joint:**

- It is formed of hyaline cartilage.
- As the **epiphyseal plates of long bones**.
- It is immobile and temporary.

- **Secondary cartilaginous (Symphysis) joint:**

- It is formed of fibrocartilage.
- As the **intervertebral disc and symphysis pubis.**
- It allows limited movement.
- It is a permanent cartilage.

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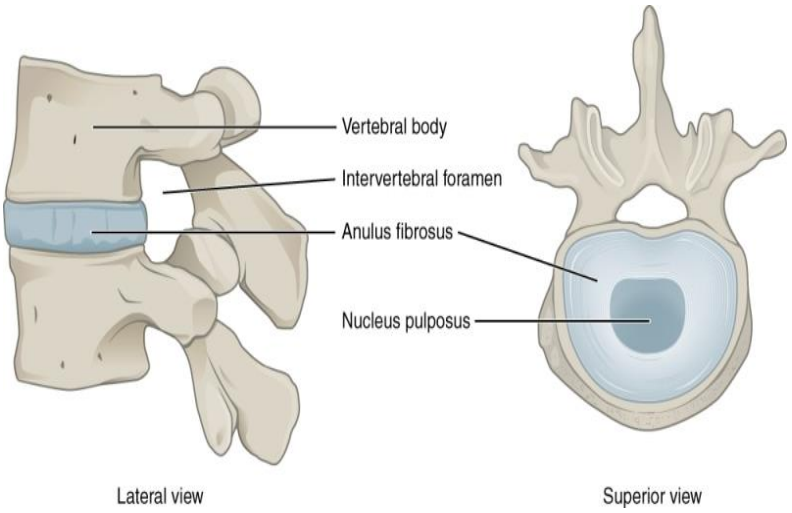
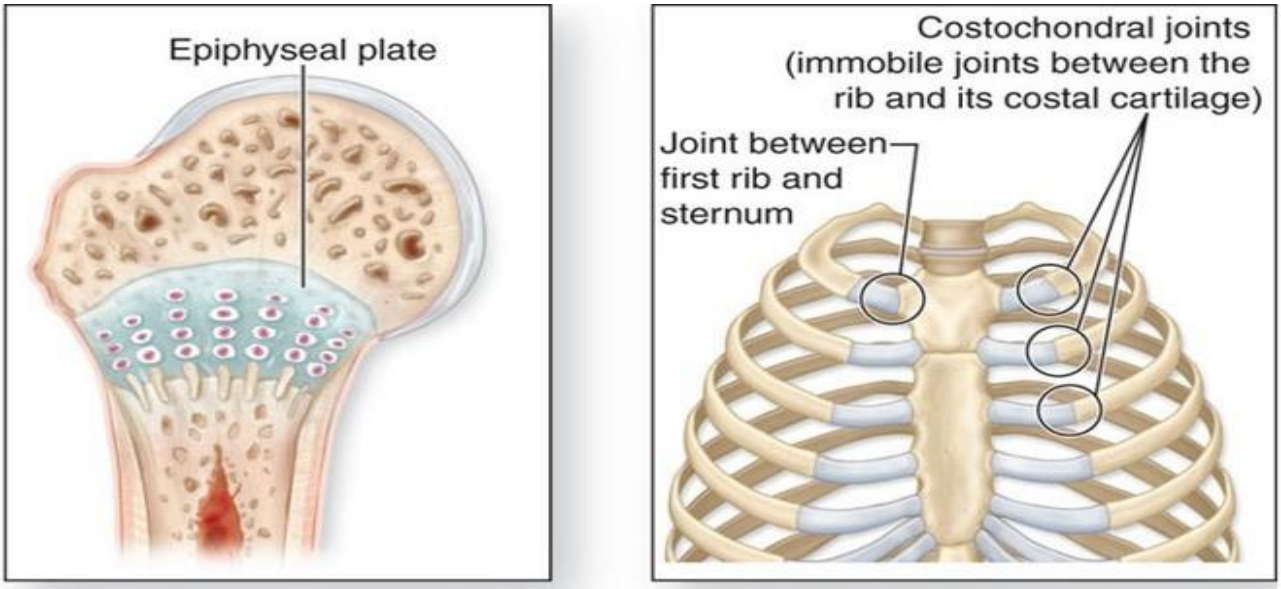
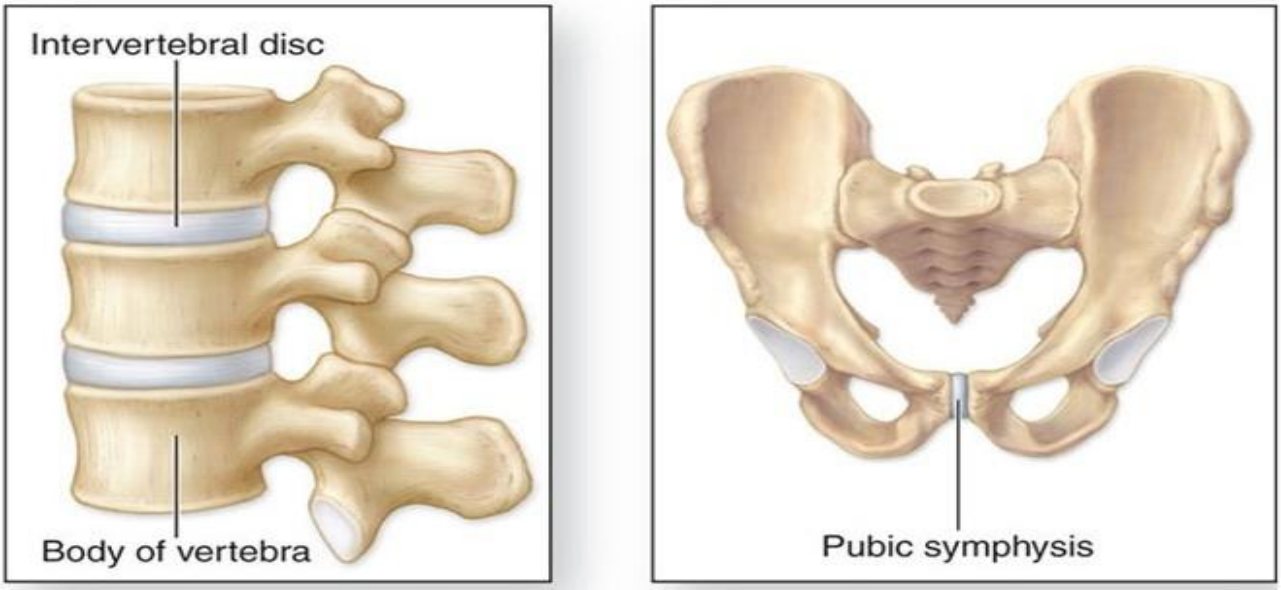
- The **intervertebral disc** consists of a thick outer ring of fibrocartilage called the **annulus fibrosus,** which surrounds an inner gel-like center known as the **nucleus pulposus.**





(a) Synchondroses (contain hyaline cartilage)



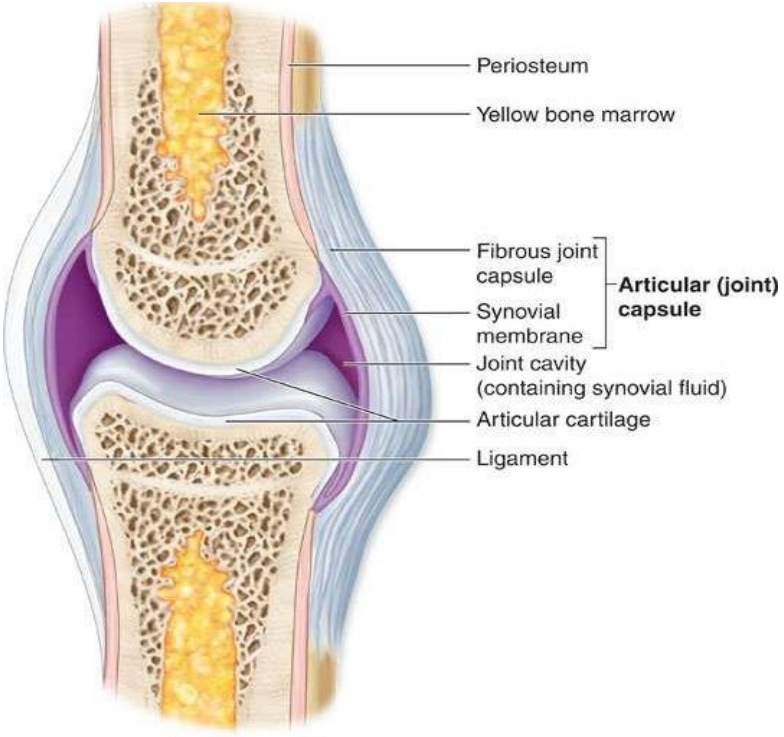
(b) Symphyses (contain fibrocartilage)

III-- Synovial joints:

- **Joints** are defined by the presence of a joint cavity filled with synovial fluid, including all limb joints, varying degrees of movement.
- Features:
  a) Bone ends are covered by **hyaline cartilage**, very smooth surface with no vessels or nerves.
  b) **Fibrous capsule**: fibrous sac enclosing the joint cavity.
  c) **Synovial membrane**: fine delicate membrane secreting synovial fluid.
  d) **Synovial fluid**: lubricates & minimizes friction between articular surfaces.
  e) **Ligaments**: strong fibrous bands connecting bones together.

Structures could be found inside the synovial joint:

- **Articular disc**: formed of fibrocartilage, compressible for shock absorbance & minimize friction. Examples: temporomandibular joint, knee joint & sterno-clavicular joint.
- **Intra-articular ligaments**: ligaments inside the joint cavity. Example: cruciate ligaments inside the knee joint.
- **Muscle tendon**: as in shoulder joint, the tendon of long head of biceps.



Typical synovial joint

Classification of synovial joints:

1. **Plane joints:** Flat articular surfaces allow minimal gliding movement. Example: inter-carpal joint.
2. **Uni-axial joints**: Allow two movements around single axis.

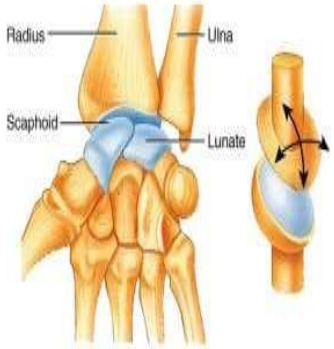
- **Hinge** joints: with transverse axis. Example: elbow joint.
- **Pivot** joints: with longitudinal axis. Example: radioulnar joints.

3. **Bi-axial joints:** Allow four movements around two axes.

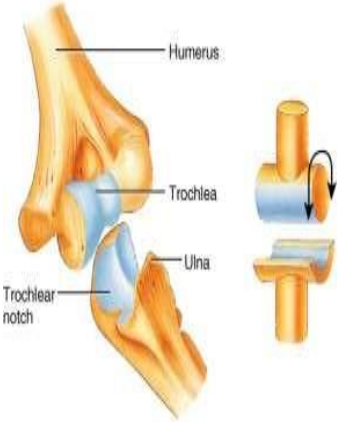
- **Ellipsoid** joint: an oval convexity is introduced into elliptical concavity. Example: wrist joint.
- **Saddle** joint: concavo-convex opposing surfaces. Example: carpo-metacarpal joint of thumb.

4. **Multi-axial joints:** Allow free movement. **Ball & socket** joints. Examples: hip & shoulder joints.

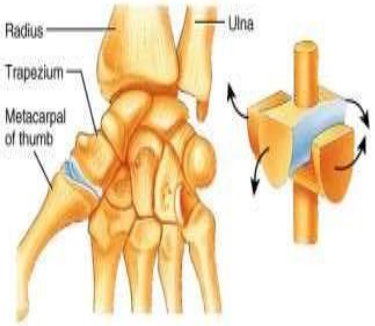
(a) Planar joint between the navicular and second and third cuneiforms of the tarsus in the foot



(d) Condyloid joint between radius and scaphoid and lunate bones of the carpus (wrist)

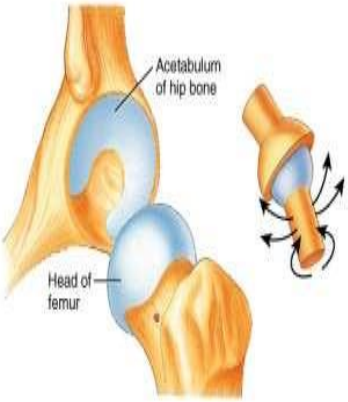


(b) Hinge joint between trochlea of humerus and trochlear notch of ulna at the elbow



(e) Saddle joint between trapezium of carpus (wrist) and metacarpal of thumb

(c) Pivot joint between head of radius and radial notch of ulna

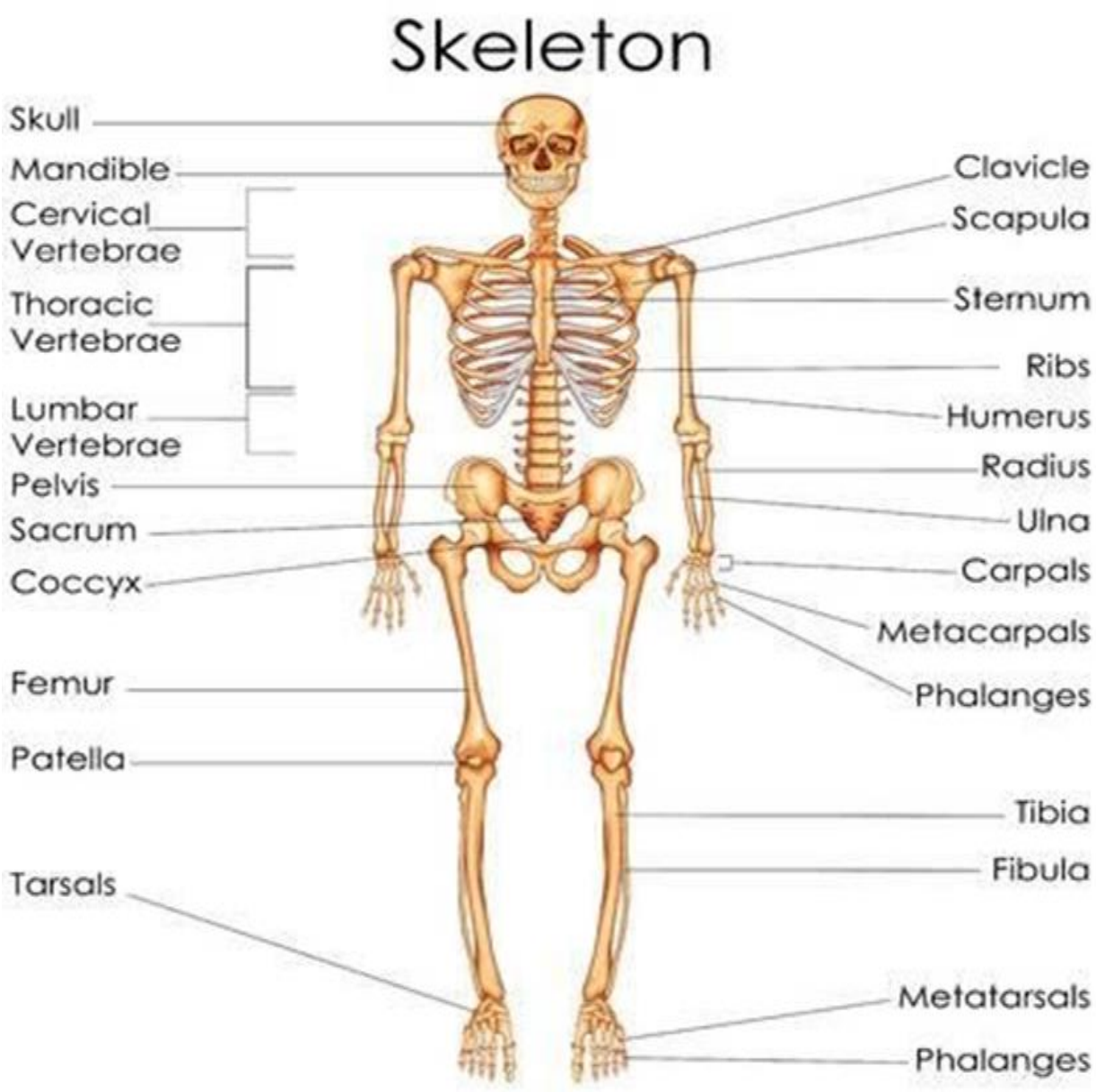


(f) Ball-and-socket joint between head of the femur and acetabulum of the hip bone

09.04

Skeletal system

- The **skeletal system** consists of bones and cartilage that are articulated (connected) by joints
- The **skeleton** is a **bony** and **cartilaginous** framework of the body.
- It consists of **34 single and 86 paired bones.** It is classified as:
  - **Axial skeleton:** consist of **Skull**, **Hyoid bone, Vertebrae, Ribs and Sternum.**
  - **Appendicular skeleton**: consist of bones of the **upper limbs** and the **lower limbs**.

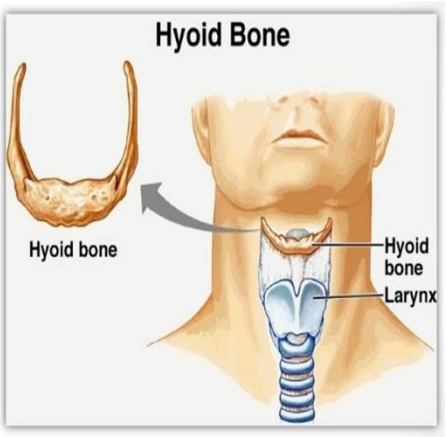


Axial skeleton:

Skull:

- The skull is a bony structure that supports the face and forms a **protective cavity** for the brain.
- It is comprised of **22 bones**, formed by intramembranous and intracartilaginous ossification, which are joined together by **sutures** (fibrous joints). These joints fuse together in adulthood.
- The bones of the skull can be divided into two groups: those of the **cranium** (skull cap and skull base) and those of the **face**.

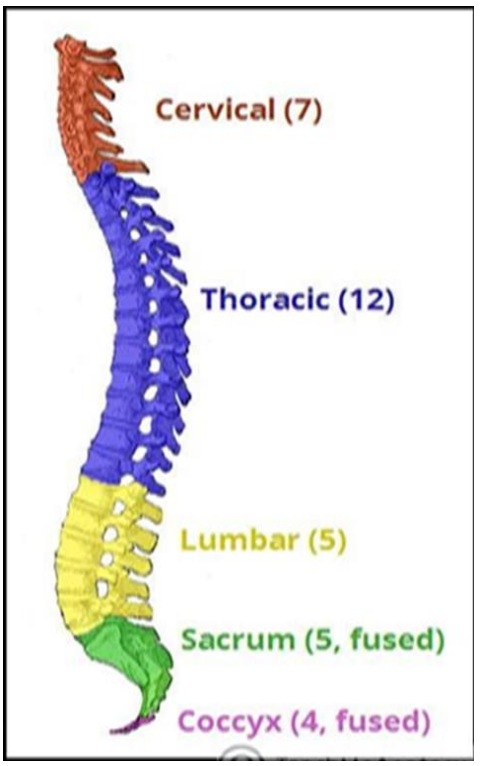
Hyoid bone:



- The **hyoid bone** is the only bone located above the larynx in the anterior neck. It does not directly articulate with other bones.
- It is a **U-shaped bone**.
- It has a **central body, 2 lesser horns and 2 greater horns.**

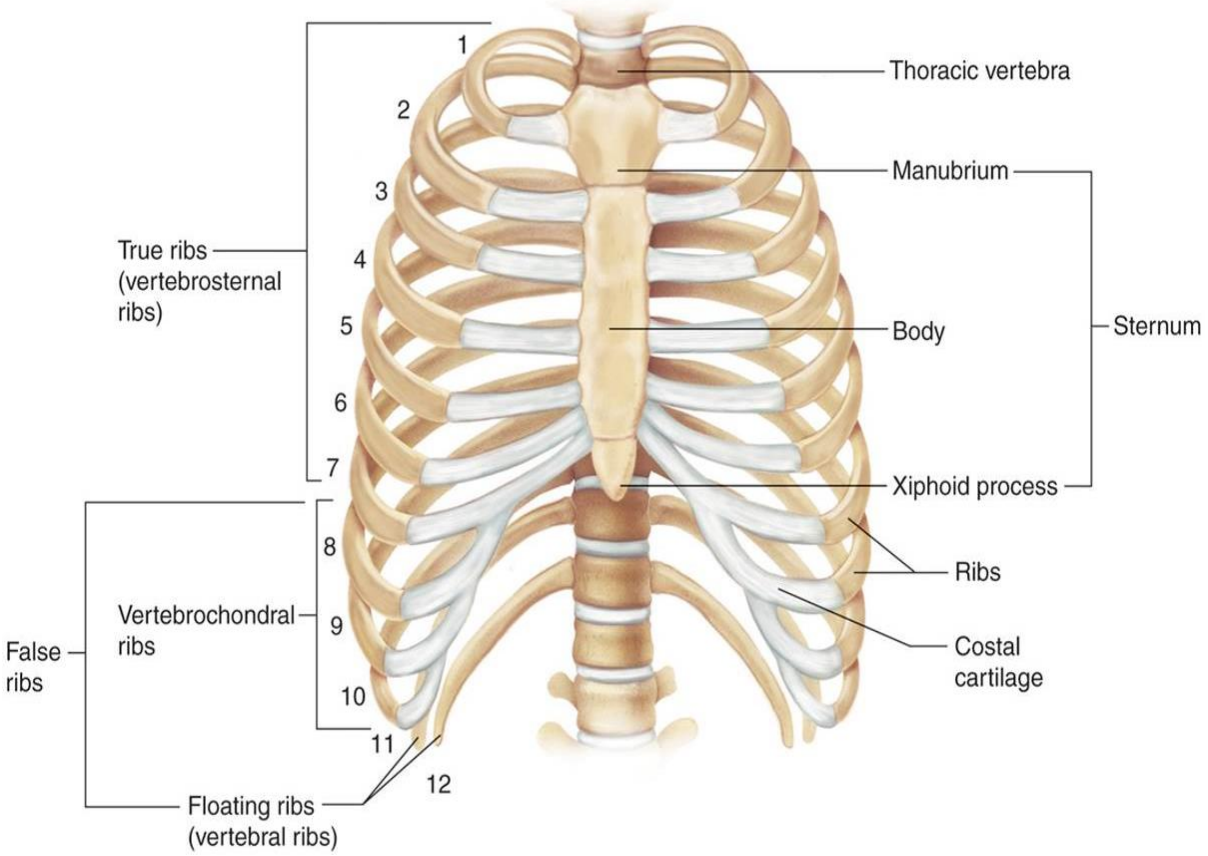
Vertebrae:

- The **vertebral column** consists of a sequence of **33 vertebrae**, which are separated by **intervertebral discs.**
- Each vertebra is an **irregular bone.**
- The vertebral column is subdivided into **five regions**:
  1) **7 cervical vertebrae**.
  2) **12 thoracic vertebrae**.
  3) **5 Lumbar vertebrae**.
  4) Fusion of **5 sacral vertebrae** to form **the sacrum**.
  5) Fusion of **4 small coccygeal vertebrae** to form the **coccyx or tailbone.**
- **Function:**
  - It is a flexible central axis of the body that supports the head, neck, and body and allows for their free movements.
  - Protection of the spinal cord.
  - Transmission of body weight.



Thoracic cage (rib cage):

- It is the osteo-cartilaginous structure that encloses the thorax.
- It is formed by:
  - The **12 unpaired thoracic vertebrae** which are a group of **irregular bones** with their **intervertebral discs**. They articulate with their corresponding ribs.
  - The **12 pairs of ribs:**
    - These are long, curved, **flat bones** enclose the sides and the front of the rib cage.
    - The gap between the two ribs is called **intercosta**l **space**.
    - The **1st seven ribs** (**true ribs**) articulate with the **sternum** through their costal cartilages.
    - The **8th**, **9th** and **10th ribs** (**false ribs**) articulate with the costal cartilage of **7th rib** to form the **costal margin** of the rib cage.
    - The **11th and 12th ribs** are **floating (free) ribs.**
  - **Sternum**: it is a **flat** (unpaired) bone which consists of **3 parts:**
    1- The **manubrium** (broader uppermost part).
    2- The **body of sternum** (longer middle part).
    3- The **xiphoid process** (the smallest and most inferior part).
- The main function of the thoracic cage is to **support** thorax, **protect** the **vital structures** within it (e.g. heart, lungs) and **facilitate** breathing.

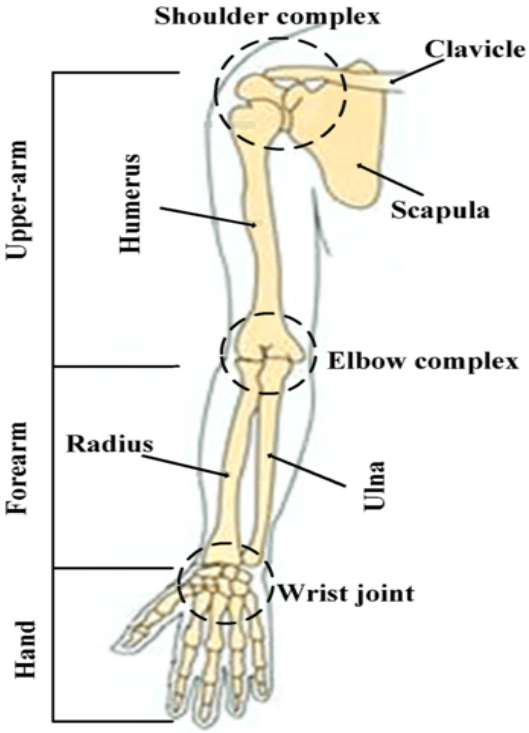


Appendicular skeleton:

- The **appendicular skeleton** is composed of **126 bones**, including those in the upper limb, lower limb, shoulder and pelvic girdle bones, which attach the limbs to the axial skeleton.

Upper limb:

- **Bones of the Shoulder Girdle:** consist of two bones; **clavicle and scapula.**
- **The arm** is formed by a single long bone, the **humerus**.
- **The forearm** is composed of **two bones**; the lateral bone is the **radius**, and the medial bone is the **ulna**.
- **Hand** consists of **carpals**, **metacarpals,** and **phalanges**.



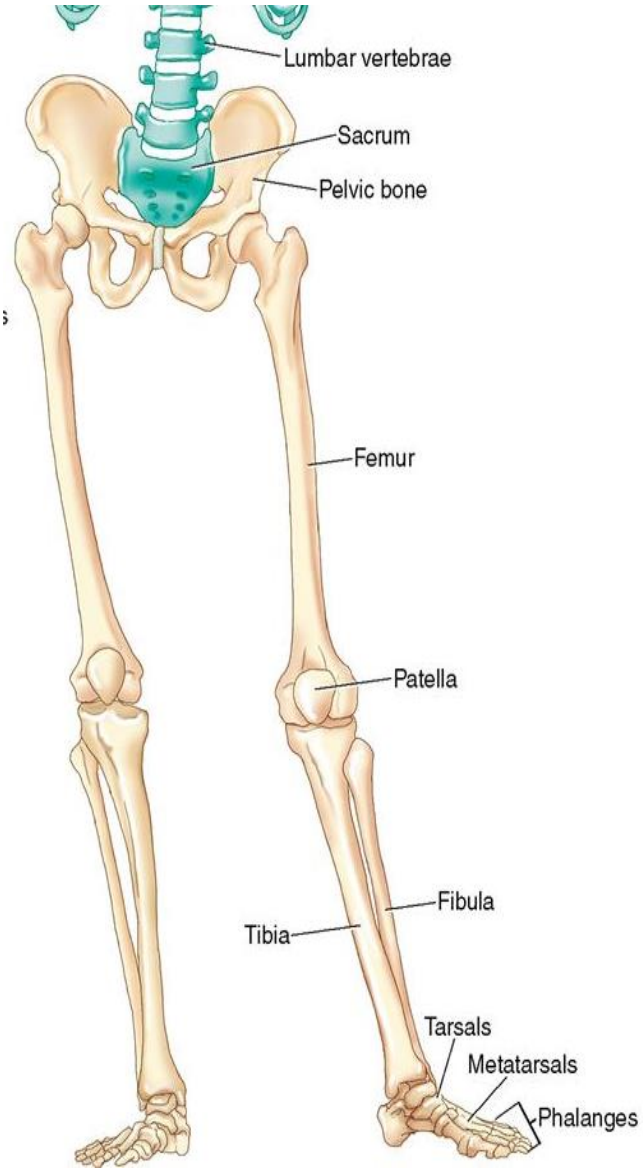
1) **Carpal bones (carpus) or wrist:**
   - The **eight carpal bones**, arranged in **two irregular rows**: **4 bones** each row.
   - They are **short bones.**
2) **Metacarpals**
   - Each is a small, long bone and has **3 parts**; **base** (proximal end), **head** (distal end) and **shaft** (in between).
   - They are numbered **1 to 5,** from the thumb side.
   - The 1st metacarpal bone is the most lateral, shortest and thickest one.
   - When the fist is clenched, the heads of the metacarpals become obvious as the **knuckles**.
3) **Phalanges:** The phalanges are the bones of the fingers.

Each is a small, long bone and has **3 parts**; base (proximal end), head (distal end) and shaft (in between). There are three in each finger (proximal, middle, and distal), except in the thumb, which has only two.

Lower limb:

- **The pelvic girdle is** formed by **two hip bones, sacrum & coccyx.** The Pelvic girdle supports the weight of the upper body, stabilizes it and transmits this weight to the lower limbs, allowing a range of actions to occur (e.g. sitting, standing, bipedal gait). It also protects the abdominopelvic viscera and provides muscular attachments.

- The **thigh bone** is a **femur.**
  - It is the heaviest, strongest and longest bone in the body.
- **Patella** which is a **sesamoid bone** in front of the knee joint.
- **Leg bones** are two bones; the medial bone is the **tibia,** and the lateral one is the **fibula.** Connected along their length by an **interosseous membrane**. two bones, the tibia andfibula, form the skeleton of the leg.
- **The foot skeleton is** composed of **7 tarsals**, **8 metatarsals**, and **14 phalanges**.
- The bones in the foot are arranged to form **three strong arches**: **two longitudinal (medial and lateral) and one transverse.**

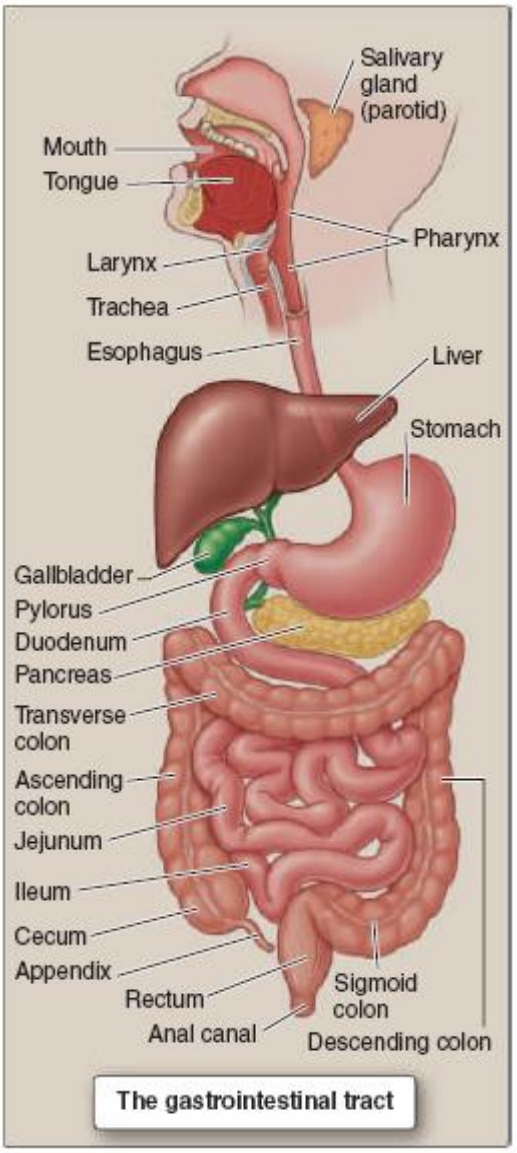


Digestive System

- The **digestive system** consists of two main parts: the **alimentary canal** or gastrointestinal tract and the **accessory digestive organs.**

1. Alimentary canal:

- **Alimentary canal** is a long tube (about 9 meters) starting from the mouth down to the anus.
- It is formed of **6 parts: Mouth, pharynx, oesophagus, stomach, small intestine and large intestine.**



The gastrointestinal tract

2. Accessory digestive organs:

- The organs that facilitate the processes of digestion and absorption. These include **Salivary glands, liver, gall bladder and pancreas.**

Mouth (Oral cavity):

- The mouth cavity is the first part of the alimentary canal. It has the following boundaries:

- **Anteriorly**: Lips.
- **Posteriorly**: continuous with the oropharynx.
- **Laterally**: muscles of the cheeks.
- **Inferiorly**: floor of mouth or oral diaphragm.
- **Superiorly**: hard and soft palate.

- **The mouth cavity** is divided into two parts:

1- The **vestibule of the mouth**; is the space between the lips and cheeks externally and the teeth and gums of the upper and lower jaws internally.

2- The **mouth cavity proper**; is the space inside the teeth and is occupied by the tongue.

Palate:

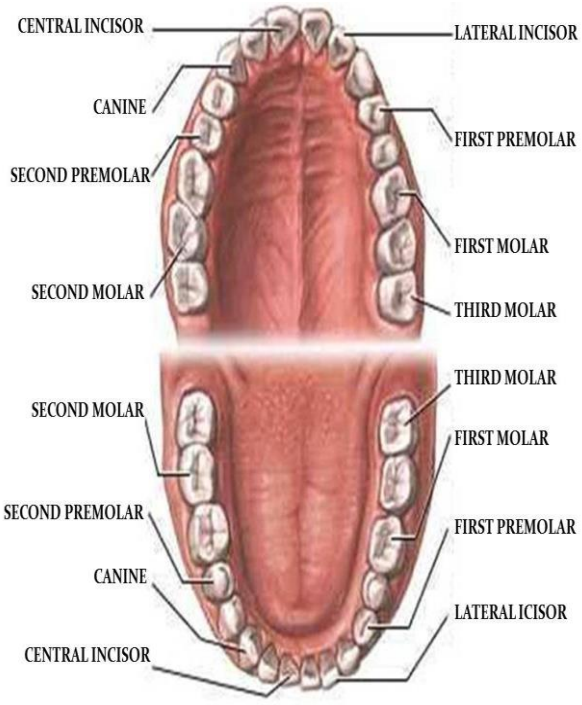
- The palate is formed of two parts: Hard or bony palate (anteriorly) & Soft palate (posteriorly).
- The posterior end of the soft palate is called **Uvula**.
- From the soft palate, 4 arches arise (2 on each side). Between these arches collections of lymphoid tissues exist (called **palatine tonsils**).

***Tongue*:**

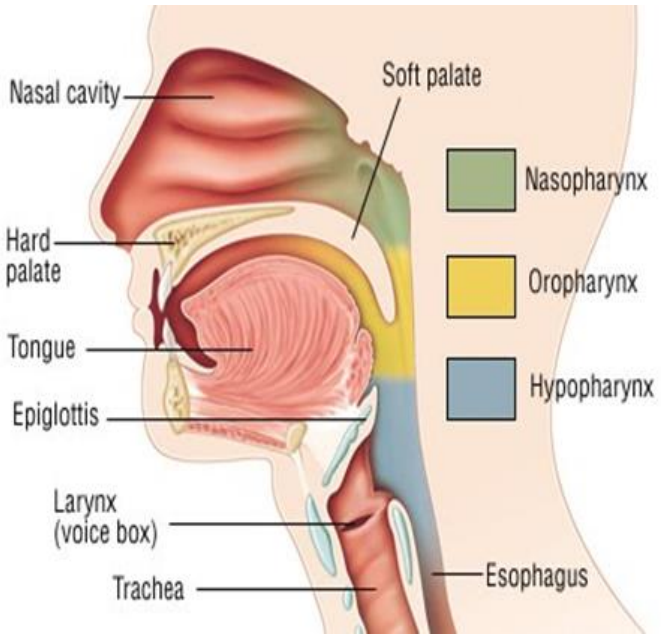
- It is a muscular organ attached to the floor of the mouth by the frenulum on its ventral surface.
- Its dorsal surface is divided into anterior 2/3 and posterior 1/3 by a V- shaped sulcus called sulcus terminalis. It carries numerous papillae called taste buds.

Types of teeth:

- **Temporary (deciduous) teeth: 20 in number**, 10 in each jaw, begins to erupt at 6th month and completed by the end of 24th month.
- **Permanent teeth: 32 in number**, 16 in each jaw, begins to appear in the 6th year and usually completed by the **23 years old by appearance of 3rd molar tooth.**
  - **Structure of the teeth:**
    1) **Crown**: the part that protrudes from the gum.
    2) **Root:** the part embedded in the bone.
    3) **Neck:** between the crown and the root. The pulp cavity of tooth contains blood vessels, nerves and lymph vessels.



PHARYNX:



- The pharynx is a fibromuscular tube, attached above to the base of the skull and continuous below with the esophagus at the level of cricoid cartilage.
- It is about 12 cm in length, it is a funnel-shaped, common passage in respiratory and digestive systems.
- It lies in front of the vertebral column down to 6th cervical vertebra.
- Its anterior wall is deficient, it thereby communicates with the nose, mouth and larynx.
- It is divided into 3 parts: Nasopharynx, Oropharynx & Laryngopharynx.
- During swallowing, the soft palate is raised to close the pharyngeal isthmus, epiglottis descends to close larynx and constrictor muscles of the pharynx contract to move food down to esophagus.

OESOPHAGUS:

- It is a muscular tube, 25 cm in length and 2 cm in diameter.
- It is continuous above with the pharynx and below with the cardia of the stomach.
- The oesophagus makes **a reverse S- shaped** in front of the vertebral column.
- It is divided into **3 parts**:

1) **Cervical part:** in the neck, behind the trachea.
2) **Thoracic part:** is the main part, it descends in the posteriorly in front of bodies of thoracic vertebrae, behind the heart, and between both lungs.
3) **Abdominal part:** shortest part, passes through esophageal hiatus of diaphragm.

at the level of the **10th thoracic vertebra** to end into the cardiac orifice of the stomach.

- Its lower sphincter (cardiac sphincter) prevents reflux of gastric acid into the oesophagus.
- There are **4 normal Constrictions.**

STOMACH:

- **Position:** It occupies the upper part of the left side of the abdominal cavity; it is interposed between the esophagus and duodenum.
- **Shape:** Stomach is the most dilated part of alimentary tract. It is variable in shape, it may be like the letter **J**.
- **Parts of the stomach:**

  1- **Fundus:** upper convex part (dome-shaped) above the level of cardiac orifice, below the left copula of diaphragm.

  2- **Body:** the large main middle part of the stomach.

  3- **Pylorus:** the funnel-shaped terminal part, ends by the pyloric sphincter.
- **Openings (orifices):**

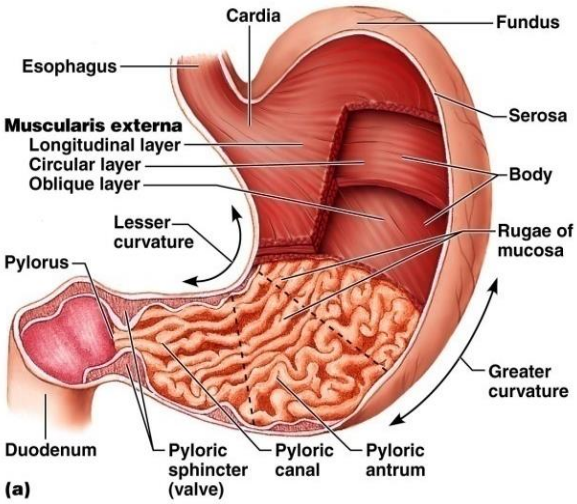
  1- cardiac orifice (cardia): by which stomach communicates with esophagus

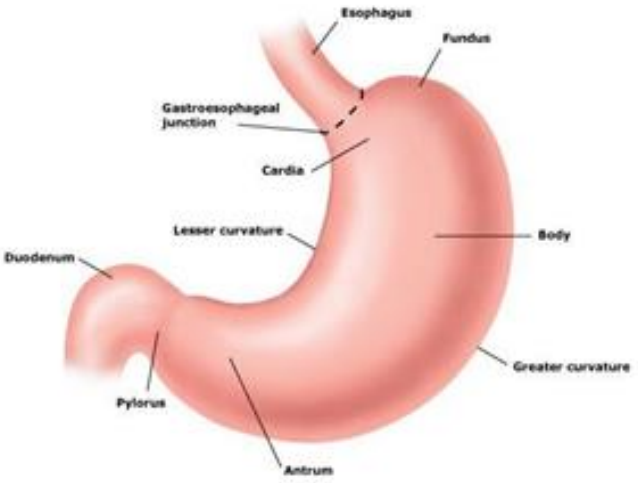
  2- pyloric orifice: by which stomach communicates with duodenum.
- **Curvatures:**

  -Lesser curvature: forms the right border.

  -Greater curvature: forms the left border.
- **Surfaces:**

- Anterior surface: Related to; Lt lobe of liver, diaphragm, ribs & anterior abdominal wall.
- **Posterior surface (*stomach bed*):** Related to; Diaphragm, spleen, pancreas, splenic artery, transverse colon, Lt suprarenal gland, and Lt kidney.



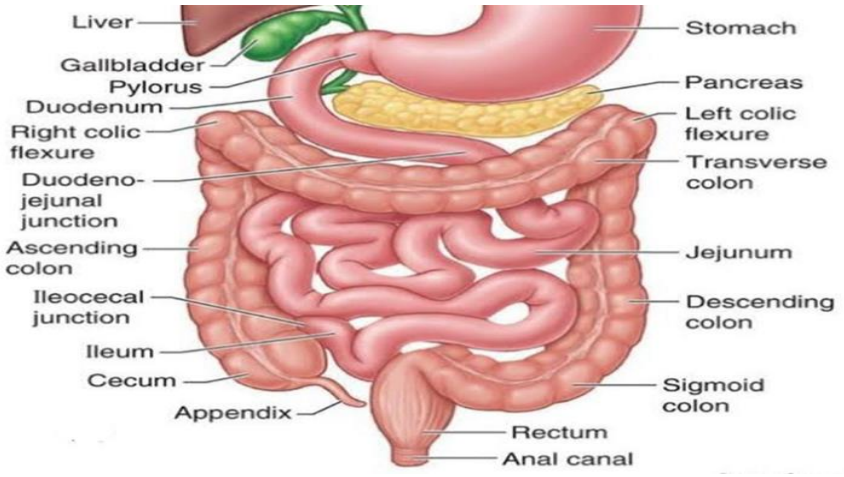


SMALL INTESTINE:

- It is the **longest part of the alimentary tract** (about 6 meters). It extends from **pyloroduodenal** junction to **ileocecal junction.**
- The small intestine consists of the **duodenum, jejunum and ileum.**

1) Duodenum:

- It is a **C-shaped tube** about **10 inches** around the **head of the pancreas**.
- It is formed of **4 parts**: superior, descending, horizontal and ascending parts.
- The **common bile duct** & the **main pancreatic duct** open into the middle of the 2nd part of duodenum at the major duodenal papilla above it the **accessory pancreatic duct** which empties into the minor duodenal papilla.



2) Jejunum:

- The Jejunum lies coiled in the upper part of the infracolic compartment of peritoneal cavity.
- It forms the **proximal 2/5** of small intestine.
- It has a thick muscular wall, very vascular and wider lumen.

- The mucosa is highly folded (plicae circularis), longer villi and more numerous.

3) Ileum:

- It lies coiled in the lower part of the infracolic compartment of the peritoneal cavity and in the pelvis.
- It forms the **distal 3/5** of small intestine.
- It has a thin muscular wall, less vascular and narrower lumen.
- Submucosa is rich in lymphoid aggregation, called Peyer's patches.

LARGE INTESTINE:

- It has a length of about 180 cm; it forms a frame around the small intestine. It is divided into **caecum, appendix, colon, rectum and anal canal.**

1- **Cecum:** This blind pouch of the large intestine projects downwards from the commencement of the ascending colon, below the ileocaecal junction in the right iliac fossa.

2- **Vermiform appendix:**

- The vermiform (worm-shaped) appendix is a blind-ending tube varying in length (commonly about 6–9 cm).
- It opens into the posteromedial aspect of the caecum.
- It has a variety of Positions; The most common is the **retrocecal** position. Next in order of frequencies are pelvic, subcaecal, pre-ileal & post-ileal positions.

3- Colon: It consists of:

- **Ascending colon**: it is the first part of the colon, extends upwards from the ileocaecal junction to the right colic flexure.
- **Right colic (hepatic) flexure**: it lies in contact with the inferior surface of the right lobe of the liver.
- **Transverse colon:** it extends horizontally from the hepatic flexure to the splenic flexure in a loop below the stomach.
- **left colic (splenic) flexure:** it lies in contact with the spleen.

- **Descending colon:** it extends from the splenic flexure to the pelvic inlet.
- **Pelvic (sigmoid) colon:** it extends from the descending colon at the pelvic inlet to the rectum in front of the third piece of the sacrum. It lies in the pelvic cavity.

4- **Rectum:** it presents in the pelvic cavity in front of the sacrum.

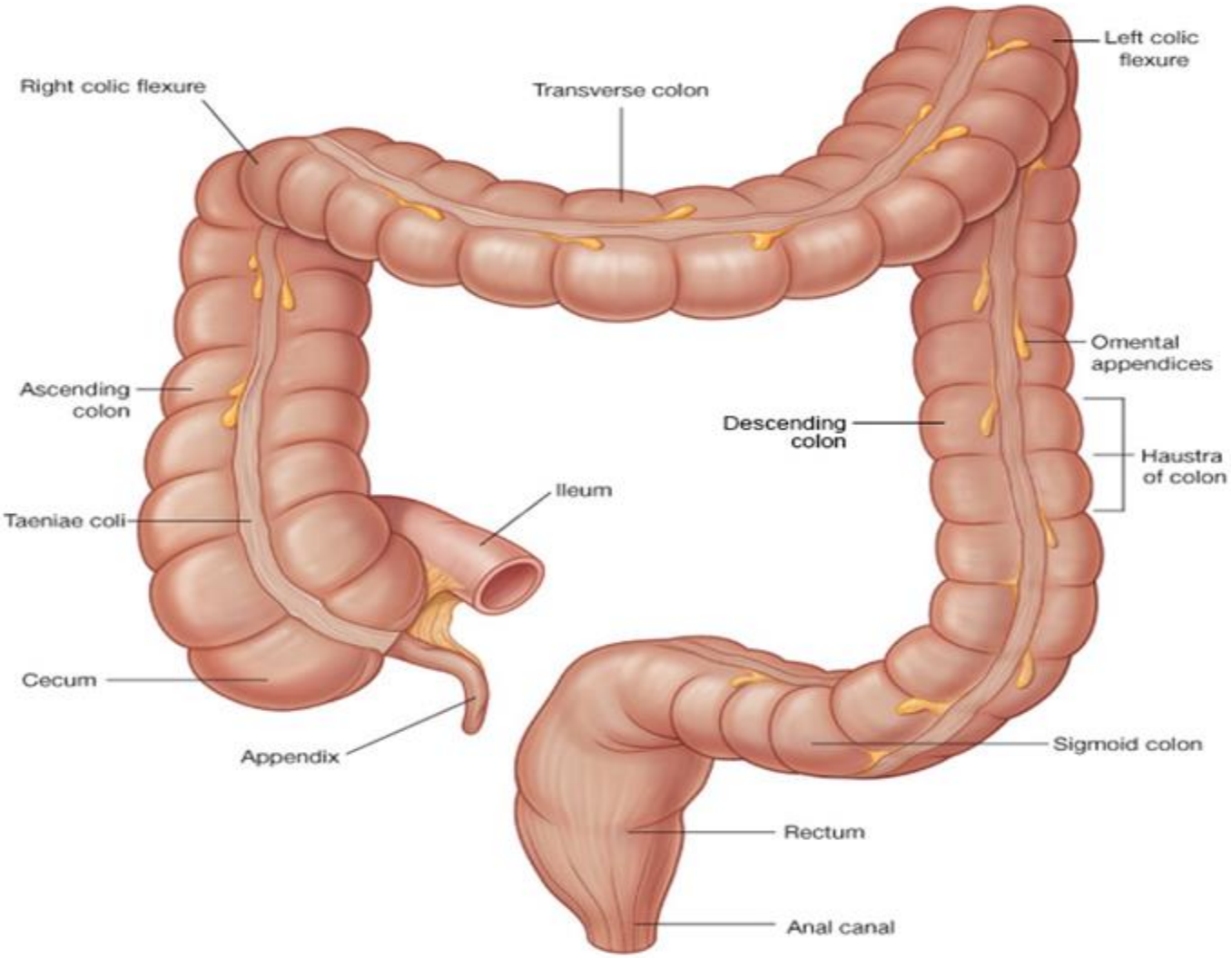
5- **Anal canal:** it is the terminal part of the alimentary tract that is present in perineum and is surrounded by internal and external anal sphincters.

⊡ There are **3 characteristic features** of the wall of the colon:

1- **3 taeniae coli:** these are 3 longitudinal muscular bands.

2- **Sacculations:** The colon is sacculated, due to the three taeniae are shorter than the length of the colon.

3- **Appendices epiploicae:** these are small pouches of peritoneum, filled with fat.

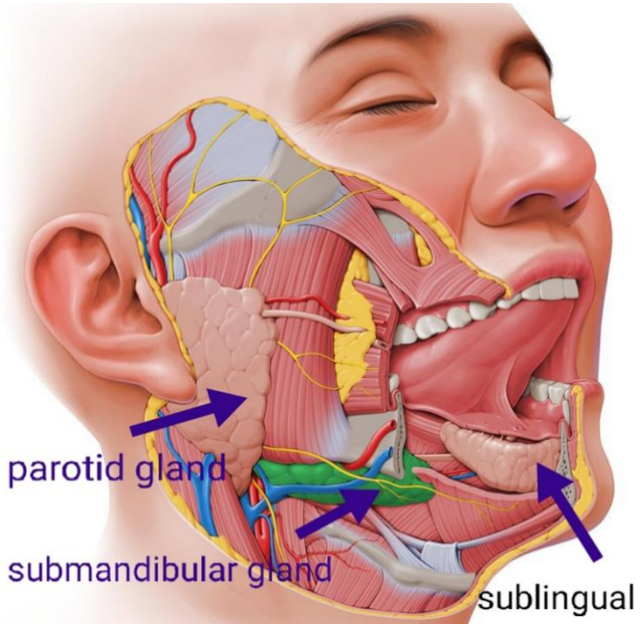


Accessory digestive glands

Salivary glands:

➢ There are **3 pairs of major salivary glands:**

- **Parotid gland:** It is the largest salivary gland which lies below and in front of ear. Each gland is wrapped around the mandibular ramus. Its duct opens into the **vestibule of the mouth opposite the upper 2nd molar tooth.**
- **Submandibular gland:** lies below the mandible in the submandibular triangle and its duct opens in the floor of mouth.
- **Sublingual gland:** lies on the floor of mouth beneath the tongue.



Liver: It is the largest abdominal organ, very vascular & friable.

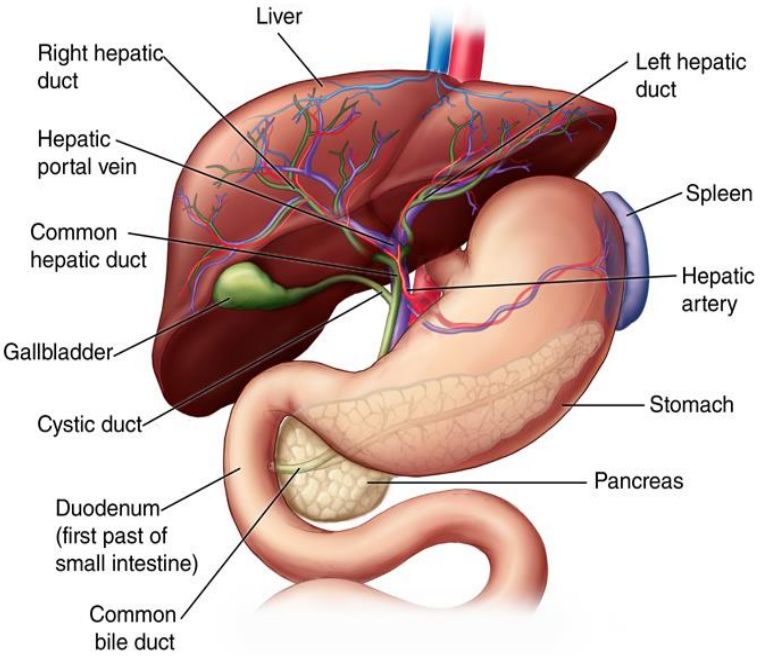
- **Position**: it is a wedge-shaped organ that occupies most of the right hypochondrium and epigastrium.
- **Lobes**: two main lobes; right larger lobe, left smaller lobe and two accessory lobes (caudate & quadrate).
- **Surfaces**:

- Anterior surface → related to the anterior abdominal wall.
- Superior surface → related to the diaphragm.
- Posterior surface → related to IVC.
- Right surface → related to right ribs (7^{th} - 11^{th}).
- Inferior (*visceral*) surface → lies facing abdominal viscera; mainly stomach, duodenum, right kidney, Rt colic flexure & gall bladder.

- **Porta hepatis**: deep, transverse fissure on the undersurface of the right lobe of the liver. It contains **portal vein, hepatic artery & hepatic ducts**.

- **Extrahepatic biliary tract**:

- This tract refers to the path by which **bile** is secreted by the liver then transported to the duodenum.
- It consists of right & left hepatic ducts from corresponding hepatic lobes → union to form common hepatic duct at porta hepatis → which unites with cystic duct of gall bladder forming common bile duct (CBD) → ends with the main pancreatic duct forming ampulla of Vater, that opens into middle of 2nd part of duodenum.



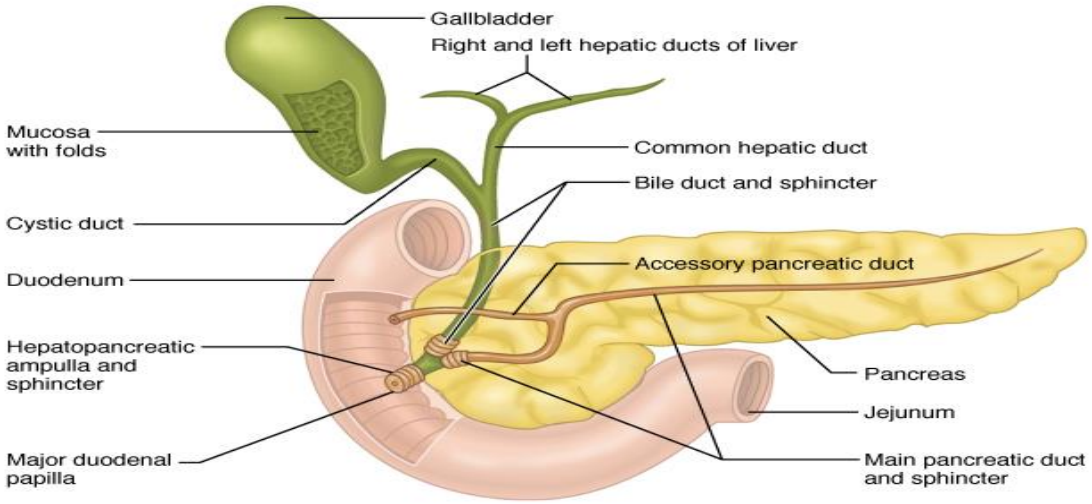
Pancreas:

- Pancreas is a mixed glandular organ with both exocrine & endocrine functions, it is fixed to the posterior abdominal wall.
- The transpyloric plane (L1) is the guide to the surface marking of pancreas. It extends from duodenum to spleen behind the stomach.
- **Parts**:

- The head → lies in the concavity of C-shaped duodenum and related posteriorly to IVC & common bile duct.
- The neck → the next constricted part of pancreas that lies in front of the commencement of the portal vein.
- The body → is the main part of pancreas that passes from the neck to the left, it is related anteriorly to stomach and posteriorly to abdominal aorta & left kidney.
- The tail → small part extends to the hilum of spleen.

- **Ducts of pancreas**:

- Main pancreatic duct is a continuous tube running from the tail to the head and unites with common bile duct to form ampulla of Vater which opens in the middle of 2nd part of duodenum.
- Accessory pancreatic duct drains the lower part of the head and opens in the 2nd part of duodenum above the opening of main duct.

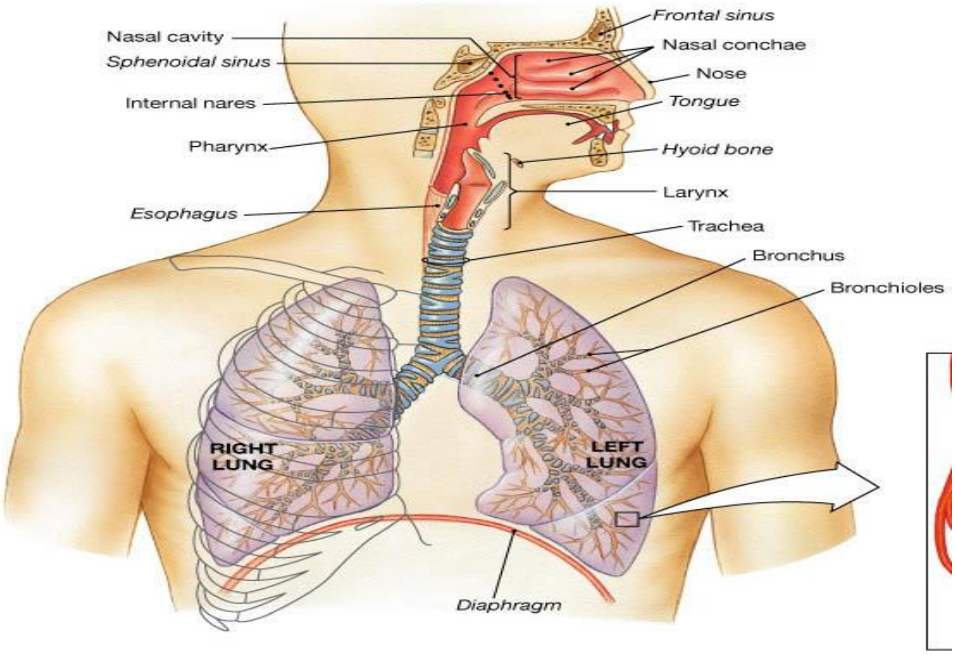


Respiratory System

- It consists of passages that filter the incoming air and transport it from outside the body into lungs where gas exchange takes place.
- **Structurally:**

1. **Upper respiratory system** (Nose, Paranasal sinuses & Pharynx).
2. **Lower respiratory system** (Larynx, Trachea, Bronchi, Lungs & muscles of respiration).

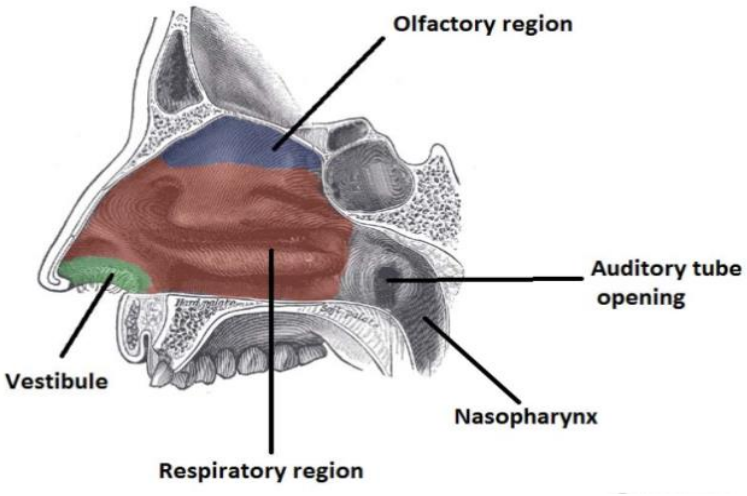
Nose:



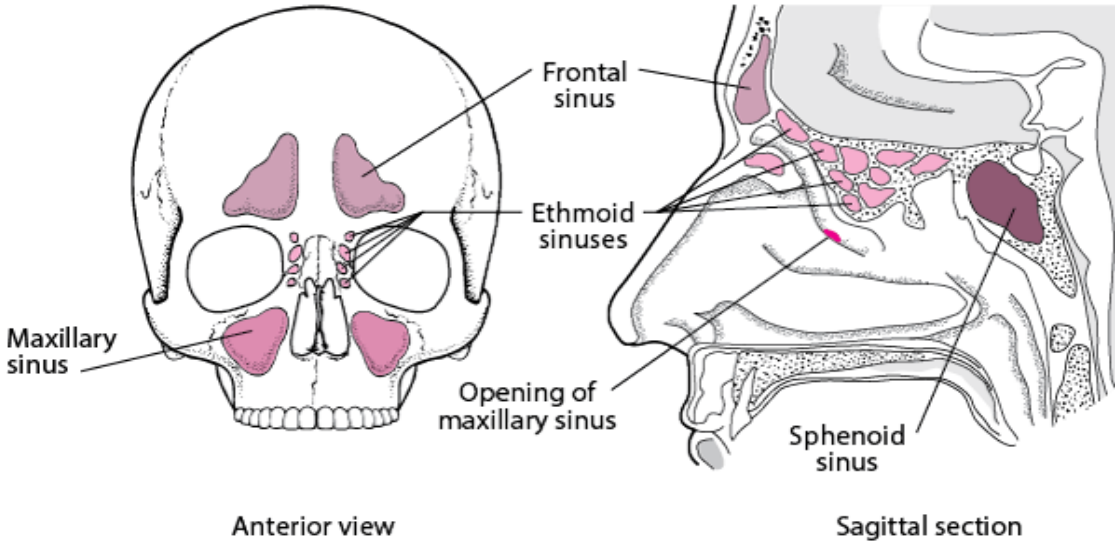
- The **nose** consists of the *external nose* and the *nasal cavity*.
- ***External nose*** projects forwards from the face. Its upper end is the *root*, its lower end is the base. It has 2 orifices called the *nares* (nostrils) which are bounded laterally by ala nasi. It has an osteo-cartilaginous framework covered with muscles and skin.
- The **nasal cavity** is divided into right and left halves by the midline *nasal septum*. It extends from the nares as far back as the posterior nasal apertures or choanae, where the nasal cavity communicates with the nasopharynx.
- **Parts of nasal cavity**: it is subdivided into 3 regions:
  - **Nasal vestibule:** the most anterior part, lined by skin & hairs.
  - **Respiratory part:** next to nasal vestibule, lined by typical respiratory epithelium and contains **3 shelves of bone** project from the lateral wall of nasal cavity called **nasal conchae.**
  - **Olfactory part**: forms the roof of nasal cavity & concerned with smell sensation.

Para-nasal sinuses:

- There are **4 pairs of air cavities** inside the facial & skull bones. They communicate by **small apertures** with the lateral wall of the nasal cavity.
- They are named according to the bones in which they are found (**frontal, ethmoidal, sphenoidal & maxillary sinuses).**



- They decrease skull weight, humidify and warm inhaled air, increase resonance of the voice.



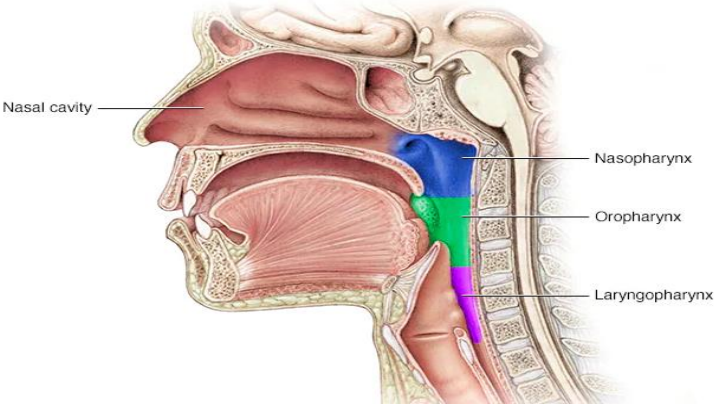
Pharynx:

- It is a funnel-shaped common fibromuscular tube in respiratory and digestive systems.
- It extends from the base of the skull to the level of cricoid cartilage. It lies in front of the vertebral column down to 6th cervical vertebra, behind nose, mouth & larynx.
- It is composed of 3 parts:

1- **Nasopharynx** (upper part): behind nasal cavity. It contains pharyngeal tonsils. It also receives the opening of an auditory (Eustachian) tube which connects it to middle ear cavity.

2- **Oropharynx** (middle part) → behind the oral cavity. It lodges the palatine tonsils on its side wall.

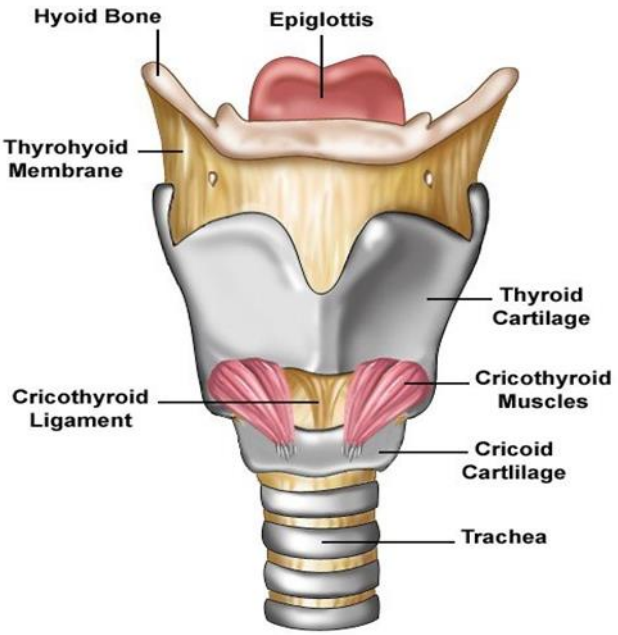
3- **Laryngo-pharynx** (inferior part)→ it leads to laryngeal inlet.



Larynx:

- The larynx lies between the pharynx and trachea, below the hyoid bone in the midline of the neck at the level of C4–6 vertebrae.
- The framework of the larynx consists of cartilages, ligaments and membranes. There are three single cartilages (thyroid, cricoid and epiglottic) and three pairs of cartilages (arytenoid, corniculate and cuneiform).
- **Prominent cartilages** are:

- **Thyroid cartilage**: forms a prominence in the midline of neck (Adam's Apple).
- **Cricoid cartilage**: ring like, present below thyroid cartilage.
- **Epiglottis**: leaf-like elastic cartilage which prevents the entry of food into respiratory passages.
- **Arytenoid cartilages**: attached to vocal cords, which are necessary for sound production.



Trachea:

- The trachea begins at the level of **6th cervical vertebra** in continuity with the larynx.
- It extends down to the level of the **5th thoracic vertebra**. Total length about 10 -12 cm.
- The cervical part of trachea lies in the middle of the neck, in front of esophagus.
- The thoracic part of trachea travels inferiorly into the superior mediastinum.

- The It is formed of **16- 20 C-shaped tracheal rings** of hyaline cartilage; the rings are closed posteriorly by connective tissue and involuntary muscle called **trachealis**.
- At the level of **sternal angle,** the trachea ends by bifurcation into right & left main bronchi.

Bronchial tree:

- **Main (primary) bronchi** (**Right & left)**:

  1- The **right main bronchus** is 2.5 cm long and shorter, wider and more vertical than the left, so the inhaled foreign body tends to be trapped in the right main bronchus.

  2- The **left main bronchus** is 5 cm long, longer, narrower & more horizontal.
- **Lobar (secondary) bronchi**:

  1- The **main right bronchus** gives off the upper lobar bronchus **outside the hilum** and **ends within the hilum** by dividing into middle and lower lobe bronchi.

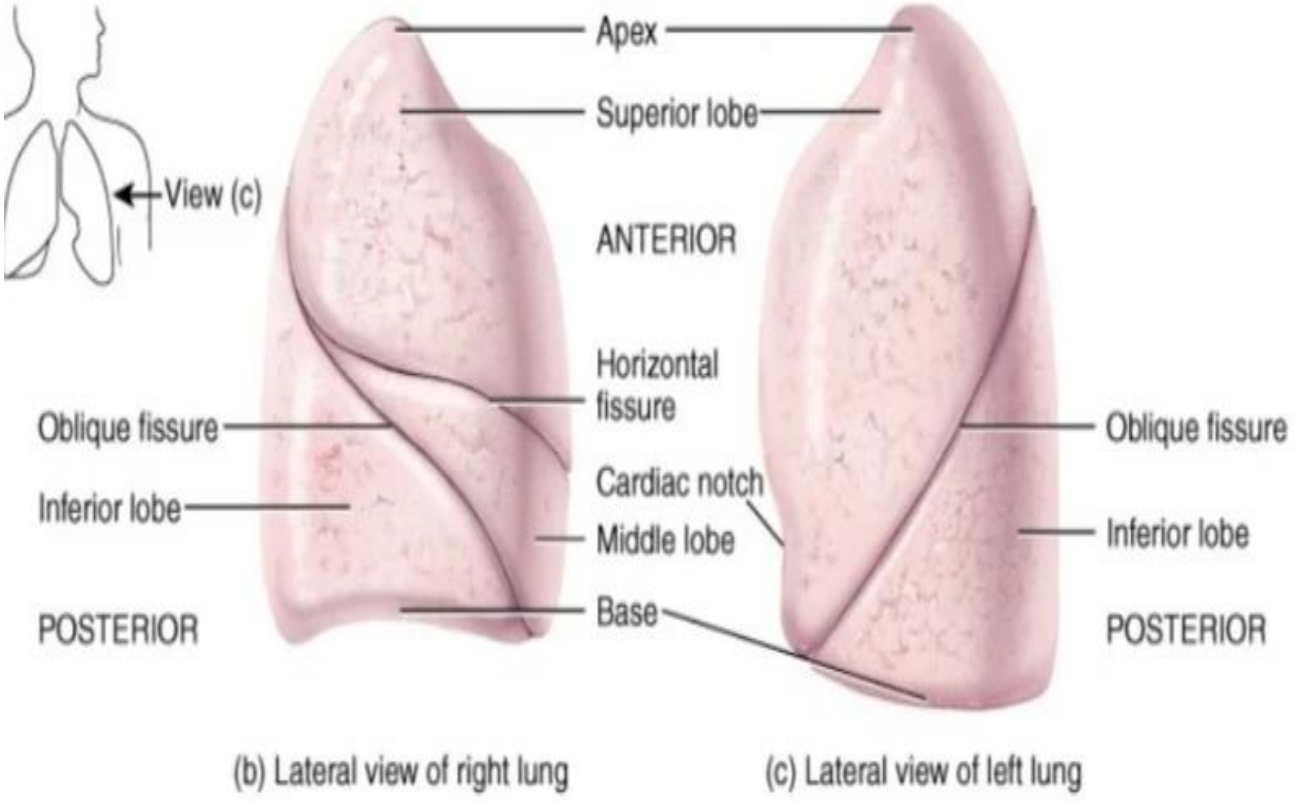
  2- The **main left bronchus** divides within the hilum into upper and lower lobar bronchi.
- **Segmental (tertiary) bronchi**:
  - The lobar bronchi bifurcate into several segmental bronchi, each of which supplies a bronchopulmonary segment.
  - They are **10 in number** → subdivided into → bronchioles →terminal bronchioles → respiratory bronchioles →alveolar ducts & alveoli. **Bronchopulmonary segments** are subdivisions of the lung lobes, and act as the **functional unit of the lung.**

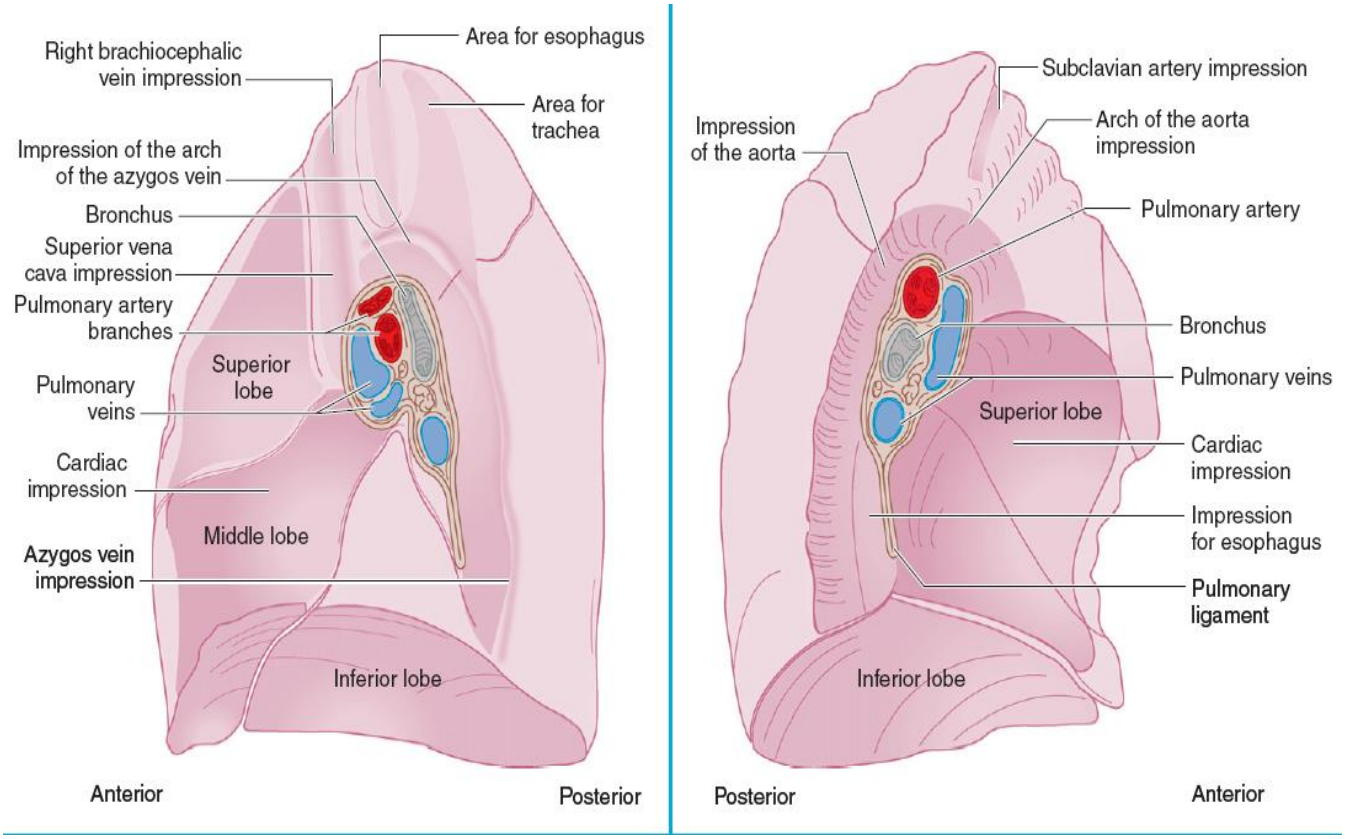
Lungs:

- **Features**:
  - The right & left lungs lie either side of the mediastinum, within the thoracic cavity. Each lung is a cone shaped. It provides oxygen for the blood.
  - **Lung apex** →convex upwards, projects to the root of the neck.

- **Lung base** → concave and set on the diaphragm.
- **Anterior border** → thin, sharp and lies behind the sternum.
- **Posterior border** → rounded and related to vertebral column.
- **Inferior border** → sharp and encircle the lung base.
- **Lateral (costal) surface** → smooth, convex and related to the chest wall.
- **Medial surface** → concave and related to the mediastinum & contains **lung hilum.**
  - **Lung root**: is a collection of structures that suspends the lung from mediastinum. It consists of a **bronchus**, **pulmonary artery**, **2 pulmonary veins**, **bronchial vessels**, **lymph nodes & pulmonary autonomic plexus**. All these structures enter or leave the lung via the **hilum.**

- **Mediastinum**: is the midline space of the thoracic cavity between the two lungs, it contains heart, great vessels, trachea & esophagus.
- **Pleura**: a serous membrane surrounds the lung, composed of:
- **Visceral** layer → invests the lung surface. **Parietal** layer → lines the thoracic wall.
- **Pleural cavity** → is a closed sac, containing a thin film of serous fluid with negative pressure to keep the lungs always inflated.
- **Right lung:**
- It is larger & shorter due to the elevated Rt copula of diaphragm by Rt lobe of liver.
- It has **3 lobes** (superior, middle & inferior), separated by **2 fissures** (oblique & horizontal).
- Its hilum contains **2 bronchi (ep-arterial & hyp-arterial)** and **one bronchial artery.**
- It is formed of **10 broncho-pulmonary segments.**
- **Left lung**:
- It is thinner & taller due to shift of the heart to the left side.
- **Cardiac notch** and **lingula** are present at its anterior border.
- It has **2 lobes** (superior & inferior), separated by **one oblique fissure.**
- Its hilum contains one bronchus and 2 bronchial arteries.
- It is formed of **8 broncho-pulmonary segments.**


View (c)
Apex
Superior lobe
ANTERIOR
Horizontal fissure
Oblique fissure
Inferior lobe
Cardiac notch
Middle lobe
Base
POSTERIOR
Oblique fissure
Inferior lobe
POSTERIOR
(b) Lateral view of right lung
(c) Lateral view of left lung


Right brachiocephalic vein impression
Area for esophagus
Area for trachea
Impression of the arch of the azygos vein
Bronchus
Superior vena cava impression
Pulmonary artery branches
Pulmonary veins
Superior lobe
Cardiac impression
Middle lobe
Azygos vein impression
Inferior lobe
Anterior
Posterior
Subclavian artery impression
Impression of the aorta
Arch of the aorta impression
Pulmonary artery
Bronchus
Pulmonary veins
Superior lobe
Cardiac impression
Impression for esophagus
Pulmonary ligament
Inferior lobe
Posterior
Anterior

Nervous system

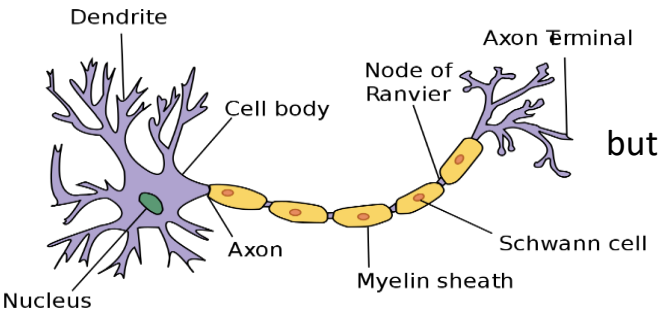
- The nervous system is divided into the **central nervous system (CNS)**, which consists of the brain and spinal cord, and the **peripheral nervous system (PNS)** composed of cranial and spinal nerves, and their associated ganglia.
- The central and peripheral parts of each have **somatic** and **autonomic** components; the somatic are concerned with the innervation of skeletal muscle and the transmission of sensory information, and the autonomic is concerned with the control of cardiac muscle, smooth muscle and glands.
- **Definitions related to nervous system:**

◦ **Neuron:** is the structural & functional unit of the nervous system. It is formed of cell body, dendrites, and axon.

◦ **Nucleus:** the nerve cells collection inside CNS of specific function.

◦ **Ganglion:** the nerve cells collection in the PNS of specific function.

◦ **Synapse:** the point of functional contact not cell continuity that activation of nerve cell propagated to the next one though a synaptic cleft and mediated by chemical neurotransmitter.



but

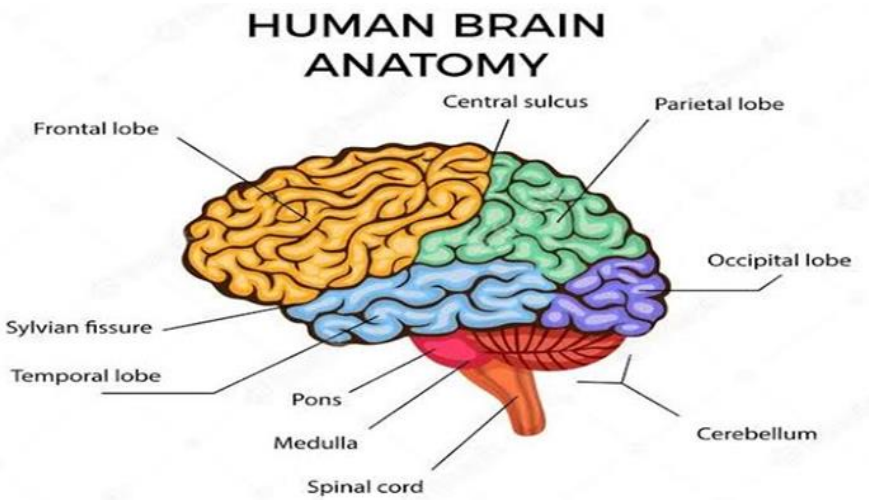
Central nervous system:

⊡ It is composed of **Brain** and **spinal cord**.

The **brain** consists of the following parts:

- **Forebrain:** includes:

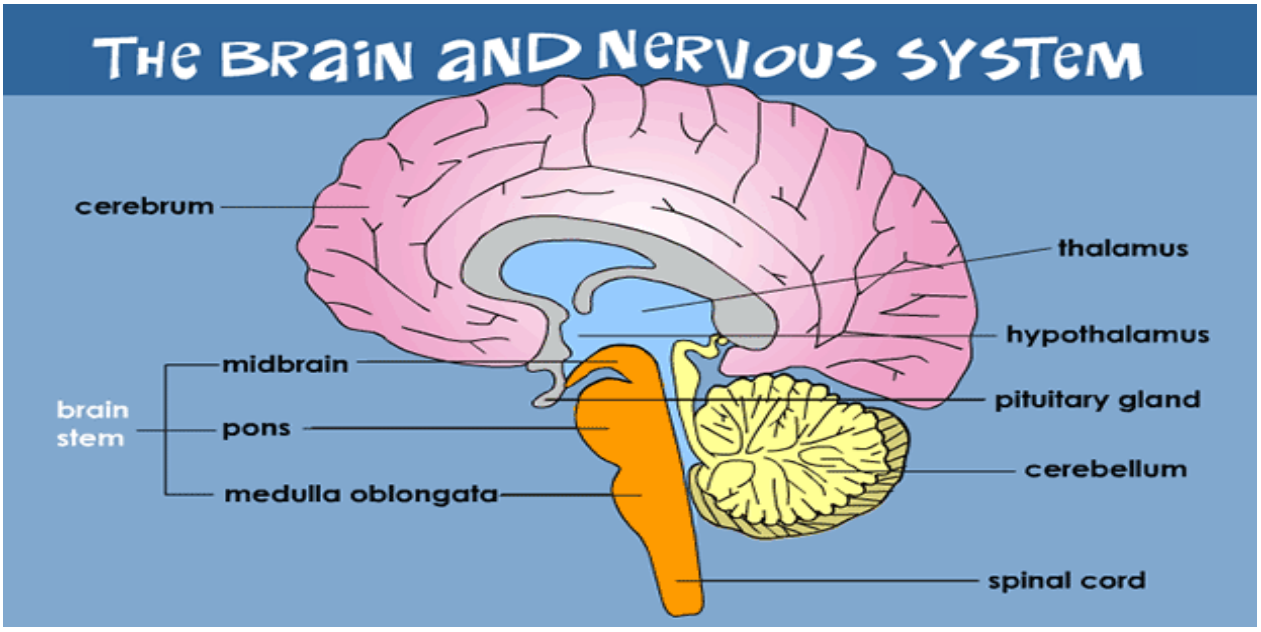
- **Cerebrum:** its cavity is called the lateral ventricle.



- **Diencephalon:** its cavity is called the third ventricle.

- **Midbrain:** its cavity is the cerebral aqueduct.
- **Hindbrain:** it includes **Pons, Medulla oblongata, and Cerebellum**. Its cavity is the fourth ventricle.

N.B. Brainstem is formed of (**Medulla oblongata, Pons** and **midbrain**).



Cerebrum:

- It is largest part of the brain; it lies inside the **cranial cavity.**
- It is formed of **two hemispheres** connected by **corpus callosum.**
- It is consisted of **4 lobes** (Frontal, Parietal, Temporal & Occipital).
- Structure in cut sections:
    1) **Outer grey matter** (**cerebral cortex**): composed of neuronal cell bodies.
    2) **Inner white matter**: It contains myelinated nerve fibres.
- **Cerebral cortex** is formed of irregular elevations called **gyri** and depressions called **sulci.**
- Brain is covered by **3 protective membranes** called **meninges,** named; Dura mater, arachnoid mater and Pia mater, arranged from outward inward respectively.
- Cerebrospinal fluid **(CSF)** circulates in ventricles inside the brain and in subarachnoid space between pia and arachnoid maters.

Cerebellum:

- It is located at the back of the brain, immediately inferior to the occipital and temporal lobes of the cerebrum, behind the pons and medulla oblongata.
- It is concerned with planning and coordination of body movements & equilibrium and balance.

Brainstem:

- The brainstem is the part of the brain connecting the cerebrum and diencephalon with the spinal cord.
- It consists of midbrain, pons and medulla oblongata.
- It extends downward to C1 vertebra just below the foramen magnum.
- The cerebellum projects from its dorsal surface.
- It contains nuclei of lower 10 cranial nerves.

1)- Midbrain:

- It is the most superior part of brainstem.
- It has a central canal called cerebral aqueduct of Sylvius.
- It gives rise to the **3rd and 4th cranial nerves.**

2)- Pons:

- It is the largest part of the brainstem, located below the midbrain, above the medulla oblongata. It is separated from cerebellum posteriorly by 4^{th} ventricle.
- It gives rise to the **5th, 6th, 7th, and 8th cranial nerves.**

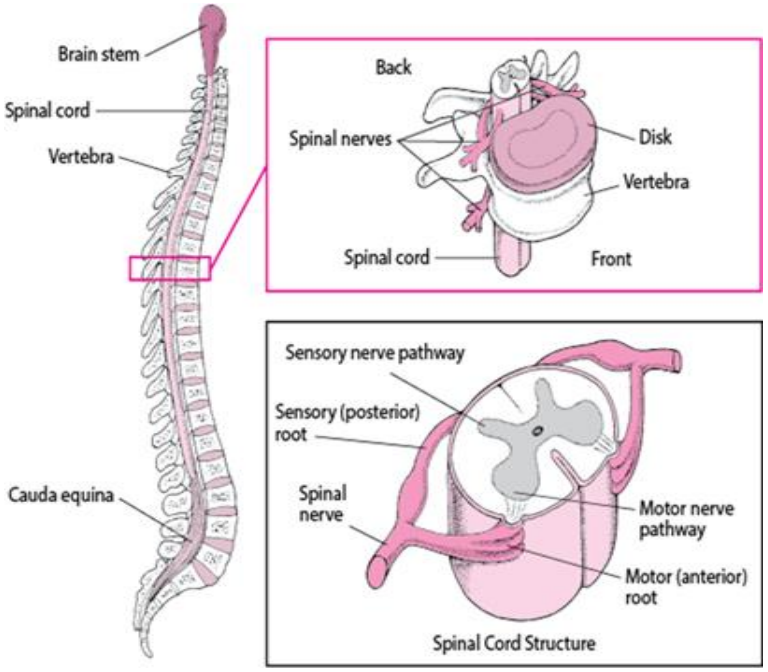
3)- Medulla oblongata:

- It is the inferior part of brainstem and continuous above with the pons and below with the spinal cord.
- It gives rise to the **9th, 10th, 11th, and 12th cranial nerves.**

⊡ Spinal cord (spinal medulla):

- Spinal cord is a cylindrical structure occupies the upper 2/3 of vertebral canal (about 45 cm in length).

- It begins at the lower border of Medulla Oblongata just below foramen magnum and extends downwards to end at the lower border of the 1st lumbar vertebra as conus medullaris.
- It possesses **cervical and lumbar enlargements.**
- It is divided into **31 segments (8 Cervical, 12 Thoracic, 5 Lumbar, 5 Sacral, 1 coccygeal).**
- The spinal cord consists of a central mass of grey matter (cell bodies), surrounding the central canal and outer white matter (myelinated nerve fibres).
- The central grey matter is **H – shaped** and is formed of:



- **Posterior horns** consist of posterior horn cells which have **sensory function.**
- **Anterior horns** consist of anterior horn cells which have a **motor function.**
- **Lateral horns** (not in all segments) consist of lateral horn cells which have an **autonomic function.**

Peripheral nervous system

- It consists of **12** pairs of cranial, **31** pairs of spinal nerves and their associated ganglia.

1)- Cranial nerves:

- The cranial nerves are a set of **12** paired nerves that arise directly from the brain. The first two nerves (**olfactory** and **optic**) arise from the cerebrum, whereas the remaining ten emerge from the brain stem.

- The cranial nerves are numbered by their location on the brain stem (superior to inferior, then medial to lateral) and the order of their exit from the cranial cavity (anterior to posterior).
- The **3rd** & **4th** cranial nerves are attached to midbrain, while the middle **4** cranial nerves are attached to pons, the last **4** cranial nerves are attached to medulla oblongata.
- **Olfactory nerve (I)** → Olfaction.
- **Optic nerve (ii)** → Vision.
- **Oculomotor nerve (iii)** → Eye movement.
- **Trochlear nerve (iv)** → Eye movement.
- **Trigeminal nerve (v)** → Sensory to face skin & motor to muscles of mastication.
- **Abducens nerve (vi)** → Eye movement.
- **Facial nerve (vii)** → Motor to facial muscles.
- **Vestibulocochlear nerve (viii)** → hearing & equilibrium.
- **Glossopharyngeal nerve (ix)** → taste.
- **Vagus nerve (x)** → motor to pharynx and larynx & parasympathetic to heart, respiratory and GIT.
- **Accessory nerve (xi)** → motor to muscles of soft palate and larynx.
- **Hypoglossal nerve (xii)** → motor to tongue muscles.

2)- Spinal nerves:

- **There are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.**
- **Each spinal nerve** is formed by the union of an anterior (ventral) and a posterior (dorsal) root which are attached to the side of the spinal cord.
- The union of two roots gives **mixed nerve trunk** within the intervertebral foramen.
- The **anterior root of every spinal nerve** contains motor (efferent) fibres for skeletal muscle; those from T1 to L2 and from S2 to S4 also contain autonomic fibers.

- The **posterior root of every spinal nerve** contains sensory (afferent) fibers whose cell bodies are in the posterior root ganglion.
- After formation of nerve trunk, it is divided into **larger anterior ramus and smaller posterior ramus.**
- The **posterior rami** supply the skin and muscles of the back of the trunk.
- The **anterior rami** supply the skin and muscles of the front of body. Network of anterior rami in cervical, lumbar, and sacral regions unite to form large bundles of nerves (plexuses).

Autonomic nervous system:

- This is the functional division of the nervous system which controls the organs of involuntary functions (Heart, smooth muscles and glands).
- **The sympathetic division** from lateral horn cells of all thoracic and first two lumbar segments.
- **The parasympathetic division** from nuclei of cranial nerves located in brainstem (III, VII, IX & X) & also from lateral horn cells of sacral segments (S 2, 3, 4).

Cardiovascular system

Heart:

- The heart is a conical, hollow muscular pump responsible for blood circulation.
- It is an organ with four chambers: right and left atria, and right and left ventricles. The two atria receive blood, the left from the lungs and the right from the rest of the body.
- The **right ventricle** propels blood to the lungs, and the **left ventricle** propels blood around the rest of the body (the systemic circulation).
- The heart consists of 3 layers: **Epicardium, Myocardium** = muscular wall of the heart, **Endocardium.**
- It lies in the middle mediastinum in thoracic cavity inside the pericardium.
- **Pericardium:**
  - The pericardium is the serous membrane that surrounds the heart and parts of the great vessels, including the two venae cavae, the pulmonary veins, the pulmonary trunk, and the aorta.
  - is formed of an outer fibrous layer (Fibrous pericardium) & an inner serous sac (Serous pericardium).
  - Serous pericardium is formed of two layers; **visceral layer** is adherent to heart usually called the **epicardium** & **parietal layer** which lines the inner surface of fibrous pericardium.
  - Pericardial cavity is present between visceral & parietal layers containing serous fluid for lubrication of cardiac contraction.

External features of Heart:

- **Sternocostal surface**:

  Facing the inner surface of the sternum & ribs. It is formed of both ventricles (mainly right ventricle), right atrium with its auricle & left auricle.

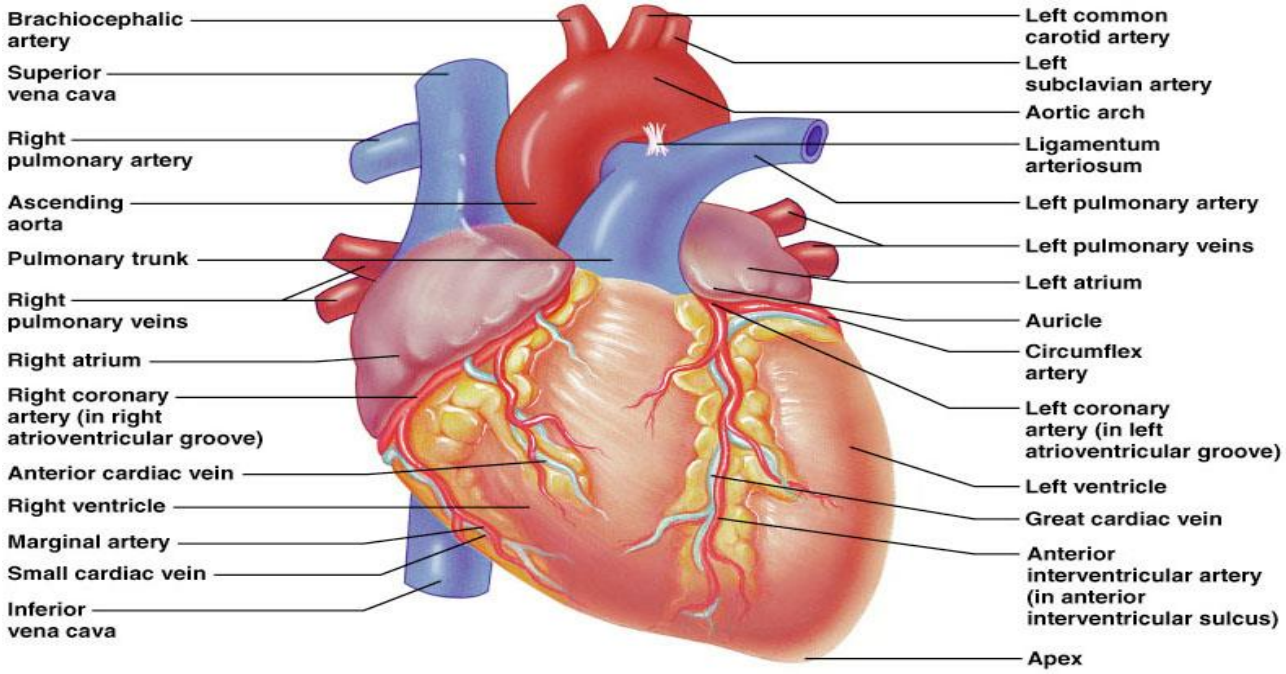
- **Diaphragmatic surface:**

  Facing the upper surface of diaphragm. It is formed of both ventricles (mainly left ventricle).

- **Cardiac apex**: which is formed of **left ventricle only.**

- **Cardiac base**:

- It lies opposite the **middle four thoracic vertebrae.**
- It is formed of **both atria (mainly the left atrium).**



<u>Internal features of Heart:</u>

- **Right atrium**:

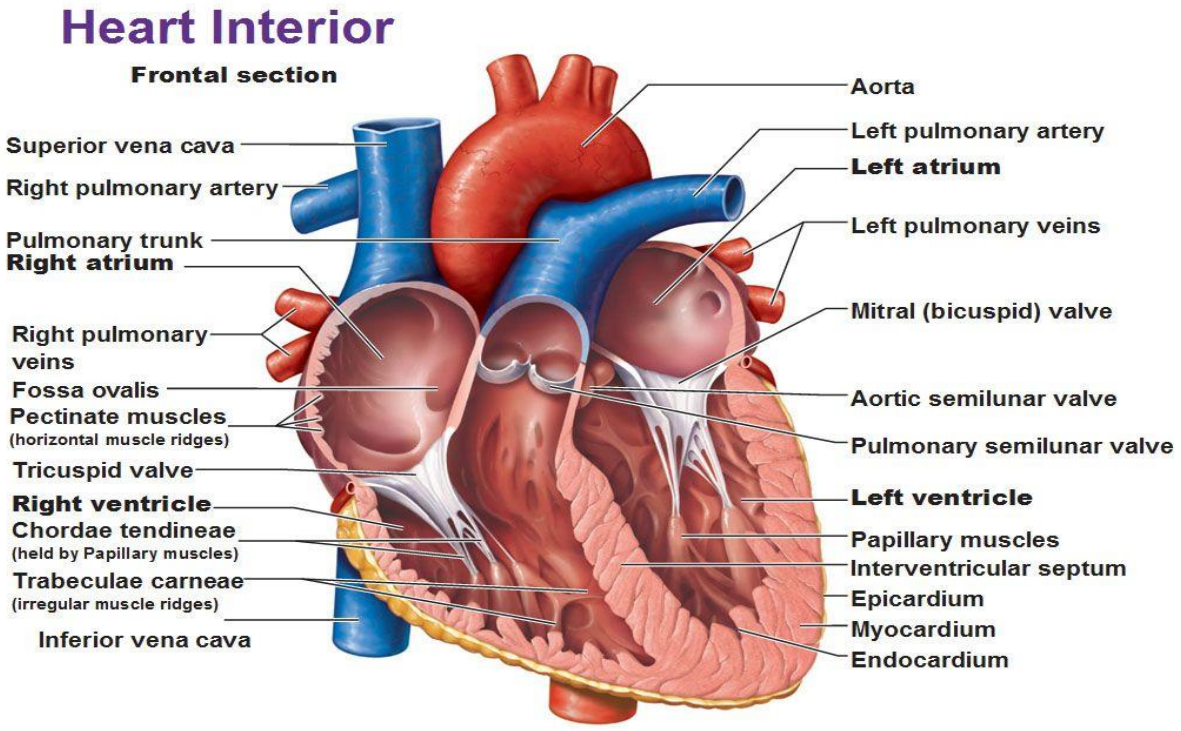
- It has an anterior rough part formed of horizontal muscular ridges (called pectinate muscles) & posterior smooth part, separated by a vertical ridge called the crista terminalis.
- It receives openings of superior vena cava and inferior vena cava, tricuspid orifice & Coronary sinus.
- The interatrial septum has an oval depression in its lower part called **fossa ovalis.**
- **Left atrium**: It receives openings of the four pulmonary veins which carry oxygenated blood from lungs.

- **Right ventricle**:

- It has a rough inflowing part formed of irregular muscular ridges & **3 papillary muscles** that are attached to the margins of **tricuspid valve** which guards the right **atrioventricular (A/V) orifice.**
- It has smooth outflowing part called **infundibulum.**
- It pumps the blood to the **pulmonary artery**, through pulmonary orifice which is guarded by **3 semi-lunar cusps.**

- **Left ventricle**:

- It is thicker by about **3 times** than the right one.
- It has a **rough inflowing part** formed of irregular muscular ridges & **2 papillary muscles** that are attached to the margins of **bicuspid mitral valve** which guards the left atrioventricular (A/V) orifice.
- It has smooth outflowing part called **aortic vestibule.**
- It receives blood from the left atrium through the **left A/V opening.**
- It pumps the blood to the **ascending Aorta**, through Aortic orifice which is guarded by **3 semi-lunar cusps**.



Blood circulation

- **Pulmonary circulation**:

- It starts by pumping blood from right ventricle → pulmonary trunk →right & left pulmonary arteries (one for each lung) → gas exchange → return of oxygenated blood to left atrium via four pulmonary veins (two from each lung).

- **Systemic circulation**:

- Supply oxygen to different body tissues.
- It starts by pumping oxygenated blood of the left ventricle → Aorta → supplying tissues by oxygen → return of deoxygenated blood to right atrium via SVC & IVC.

Blood supply of Heart

- Blood vessels are present in atrio-ventricular (coronary) sulcus, between atria & ventricles.

- **Arteries**: (from ascending Aorta).

Right and left coronary arteries.

- **Veins**:

Coronary sinus is the main venous channel of the heart which ends into the right atrium.

Blood vessels

- **Arteries**:
  - Arteries conduct blood from the heart to the capillary bed of tissues.
  - **Thick-walled**, **reddish, pulsating** and **elastic** vascular tubes, they are **valveless.**
  - Communication between their branches is called **anastomosis.**
  - They are divided into great sized arteries such as aorta, medium-sized arteries as in limbs and small sized arteries called arterioles.
  - The arterioles end up with blood capillaries.

- **Veins**:
  - Veins collect blood from the capillaries towards the heart.

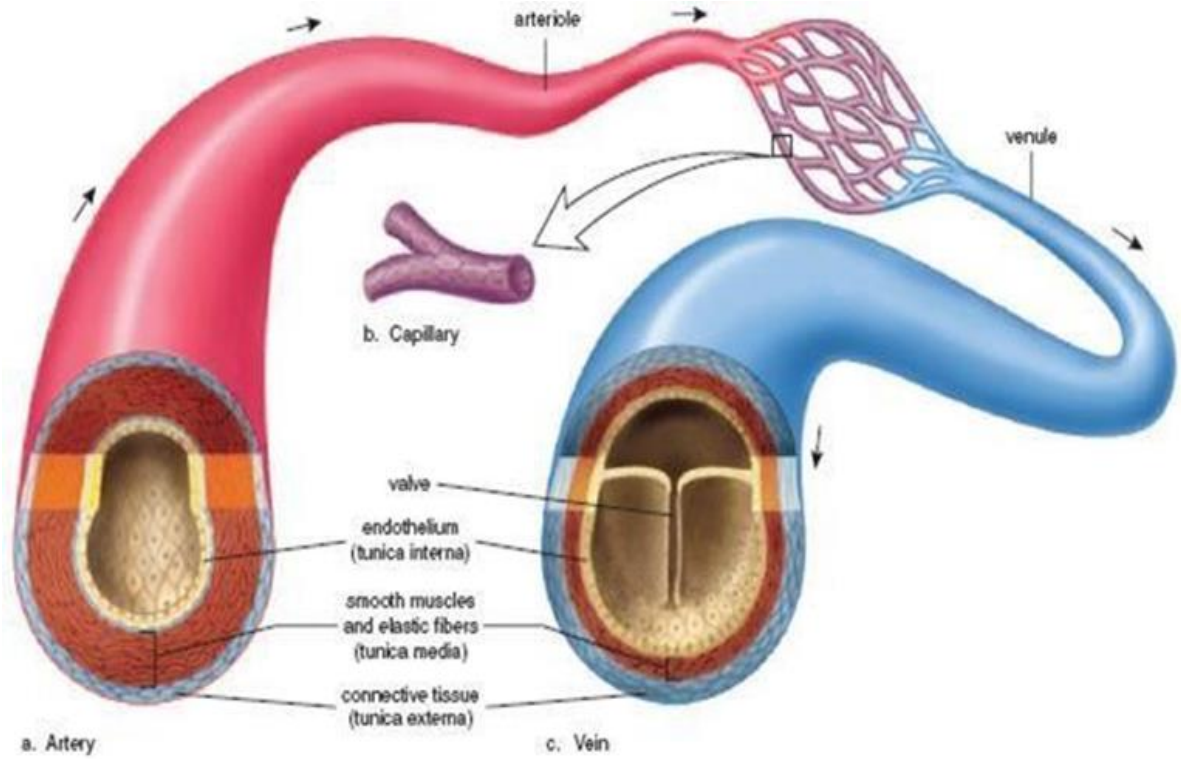
- **Thin-walled, non-pulsating, bluish** and **collapsed** vascular tubes.
- They have valves which prevent reflux of blood.
- They start from capillaries into venules to end by large veins.
- Connections between veins form **a plexus.**
  - The branches being called **tributaries.**

Connections between arteries and veins through:

1- **Blood capillaries**:
   - Capillaries are the smallest vessels. Their walls consist only of flattened endothelial cells.
   - Capillaries form an anastomotic network in most tissues.
   - Certain structures, such as the cornea of the eye and hyaline cartilage, are devoid of capillaries.

2- **Sinusoids** are wide capillaries which have a fenestrated endothelium. They are numerous in the liver, spleen, adrenal medulla and bone marrow.

3- **Direct Arteriovenous shunts** are short channels between terminal arterioles and primary venules. They are plentiful in the skin.



Lymphatic system

- **Lymph** is a clear colorless fluid present in most tissues of the body **except** CNS, cornea & cartilage.
- It is an interstitial fluid that filtered out of blood vessels, like blood plasma, no erythrocytes or platelets, less proteins, more WBCs.
- lymph capillaries collect this fluid.

Lymph vessels:

- They are tubes that assist the CVS in the removal of interstitial fluid from tissue spaces and return this fluid to the blood.
- They have beaded appearance owing to the presence of valves.

➢ **Lymph capillaries**: a blind end microscopic vessel, larger than blood capillaries with wide pores.

➢ **Afferent lymph vessels**: formed by collection of lymph capillaries & they carry lymph to lymph nodes.

➢ **Efferent lymph vessels**: carry lymph after its filtration in lymph nodes.

➢ **Lymph trunk**: formed by union of efferent vessels & carry lymph towards lymph ducts.

➢ **Lymph ducts**: Two lymph ducts are present:

1- **Right lymphatic duct** → carry lymph from right side of the head & neck, right hemi-thorax & right upper limb → ends into right innominate vein.

2- **Thoracic duct** → longest lymphatic channel, carry lymph from the greater remaining parts of the body → ends into left innominate vein.

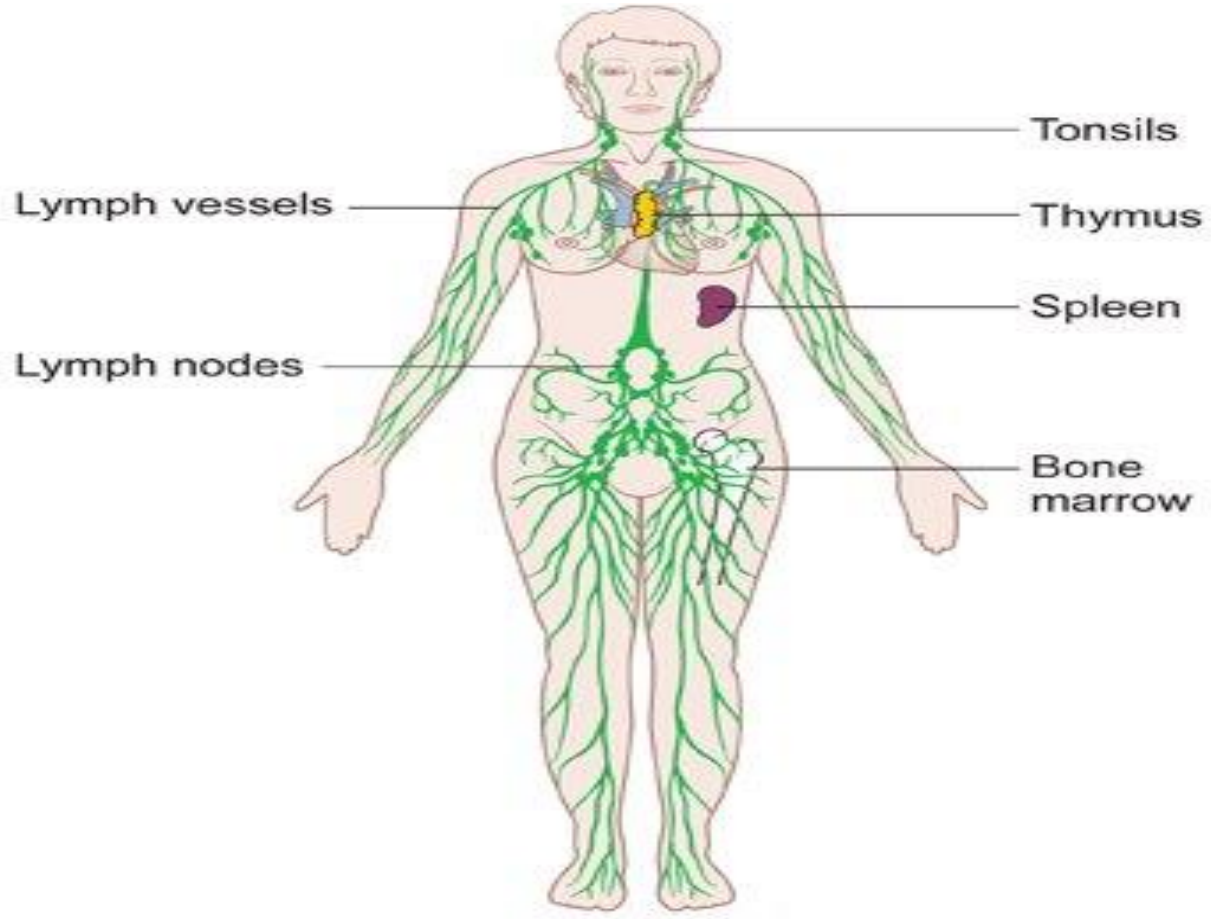
Lymphoid tissues: They are organized structures that support immune responses.

1- **Primary lymphoid tissues (organs):**

- They are concerned with production and maturation of lymphocytes.
- Examples: **Bone marrow** (as in sternum, ribs, vertebrae, bony pelvis and epiphyses of long bones), and **Thymus** (located behind sternum).

2- **Secondary lymphoid tissues (organs):**

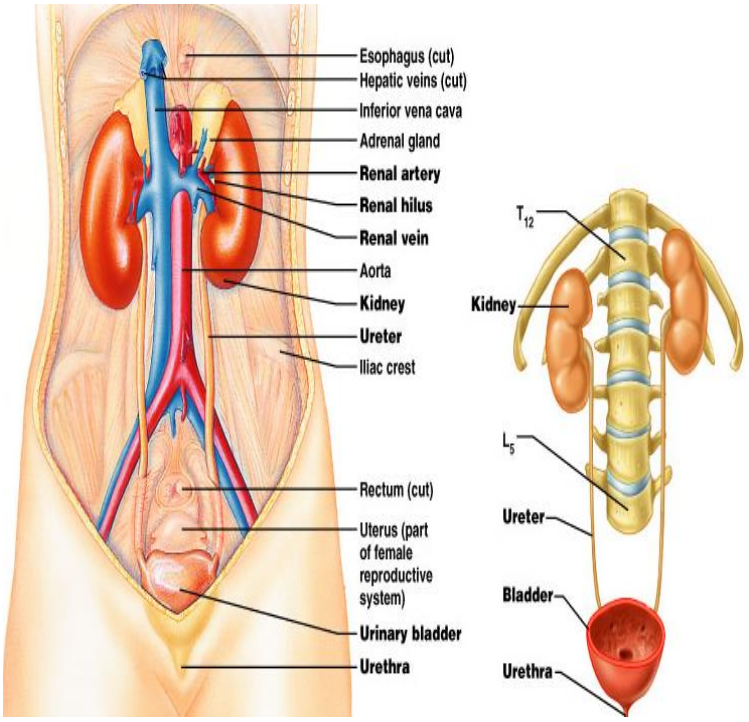
- They are concerned with filtering and trapping of antigens.
- Examples**:**
  - **Lymph nodes:** which are encapsulated been shaped structures, act as a filter during lymphatic circulation.
  - **Spleen:** largest lymphoid organ, situated high in the left abdominal cavity. It filters the blood and traps the blood-borne antigens.
  - **Waldeyer's peri pharyngeal lymphoid ring of tonsils (palatine, lingual, nasopharyngeal and tubal)**.
  - **Peyer's patches in the ileum.**



Urinary system

Structure of urinary system

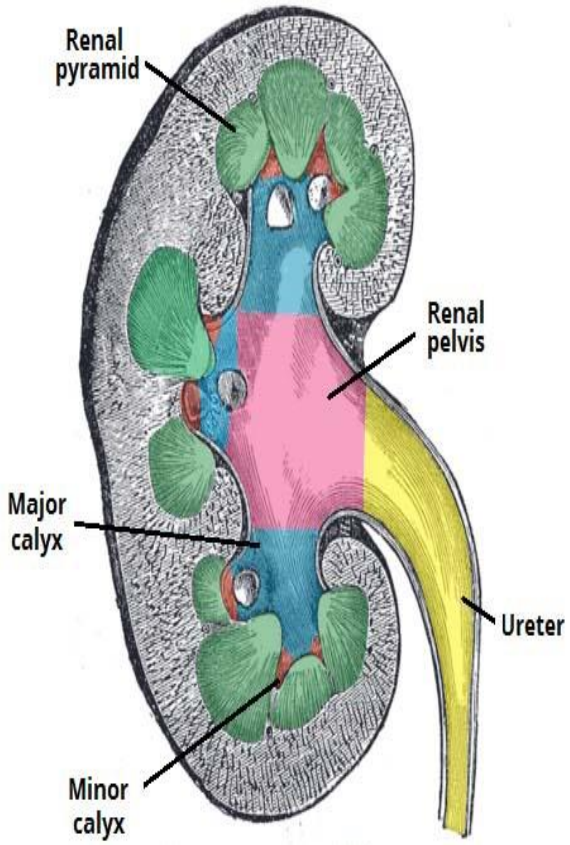
- The urinary system consists of **2 kidneys** (right and left), **2 ureters** (right and left), **urinary bladder** and **urethra**.
- Its main function is elimination of the waste products from the body, regulation of blood pressure and electrolyte balance via producing and excreting of urine.

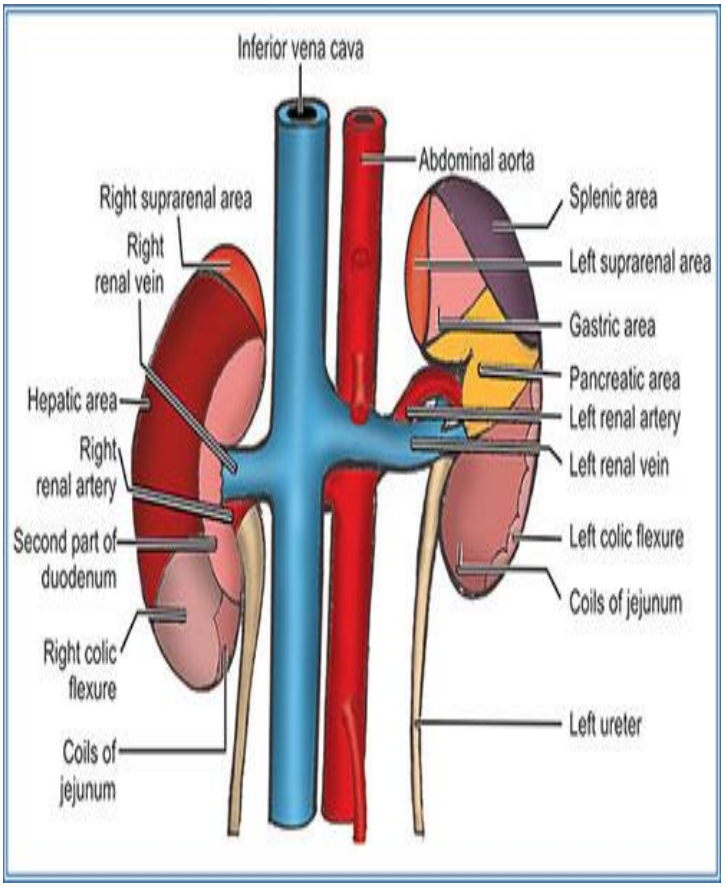


Kidneys:

- **Size & position**:
  - The kidneys are bilateral bean-shaped organs, soft reddish-brown in color (12cm length, 6cm width & 3 cm thickness).
  - It is located on each side of the vertebral column, at level between T12 to L3 vertebrae. The left kidney is higher than the right one.
  - It is fixed to the posterior abdominal wall (retroperitoneal structure).
- **Structure**:
  - It has **2 poles** (superior & inferior), **2 surfaces** (anterior & posterior) and **2 borders** (lateral convex & medial concave).
  - **Renal cortex:** containing about a million nephrons.
  - **Renal medulla:** containing the collecting tubules of urine → renal pyramids → to minor calyces → to major calyces → renal pelvis (flattened and funnel-shaped structure) → finally, the urine drains to ureter.
  - **Renal hilum:** is the site of entrance of renal artery and exit of renal vein & ureter, it is present on the medial border of the kidney.

- **Anterior relations**:
  - **Right kidney** → Rt suprarenal gland, Rt lobe of liver, 2nd part of duodenum & Rt colic flexure.
  - **Left kidney** → spleen, pancreas, stomach & Lt colic flexure.
- **Posterior relations**: are the same of both kidneys → diaphragm, quadratus lumborum, psoas major and transversus abdominis muscles.
- **Renal coverings**: They are arranged from deep to superficial; Tough fibrous capsule, Peri-renal fat, Renal fascia and pararenal fat.





Ureters:

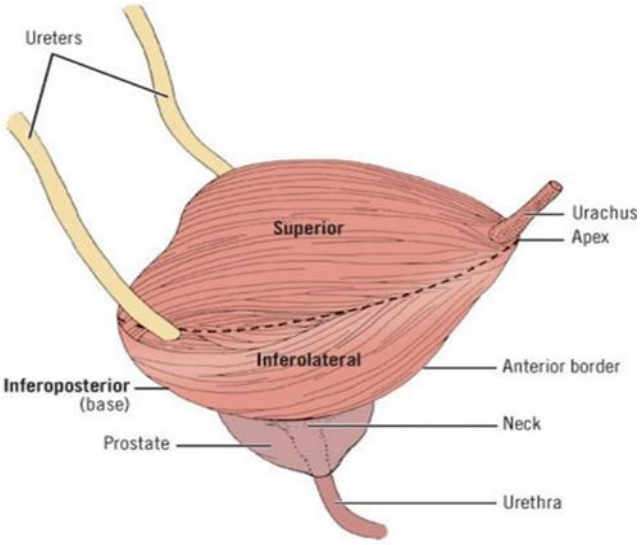
- They are narrow muscular tubes, 25cm in length. It arises from the pelvis of the kidney and terminates into urinary bladder in the pelvic cavity
- The anatomical course of the ureter can be divided into **3 parts; abdominal part** which descends on the posterior abdominal wall, **pelvic part** runs within pelvic

cavity and **intramural part** ends into wall of urinary bladder by oblique segment to prevent urine regurgitation back to the kidney.

- It has **3 constrictions in its course:**
  - At its beginning, at the pelvi-ureteric junction.
  - At its middle, when crosses the pelvic brim.
  - At its end (an oblique course within the bladder wall).

Urinary bladder:

- Urinary bladder is a hollow muscular organ in the pelvic cavity, just above & behind pubic bones.
- It acts as a reservoir of urine and contracts to excrete it.
- The shape of an empty bladder is a flattened three-sided pyramid, with its apex pointing forwards to the top of the pubic symphysis and a triangular base facing backwards in front of the rectum or vagina.
- There are two **inferolateral surfaces.**
- A **superior surface** on which the small intestine and sigmoid colon or uterus lie.
- It is related **posteriorly** to the rectum in male & the vagina in female.

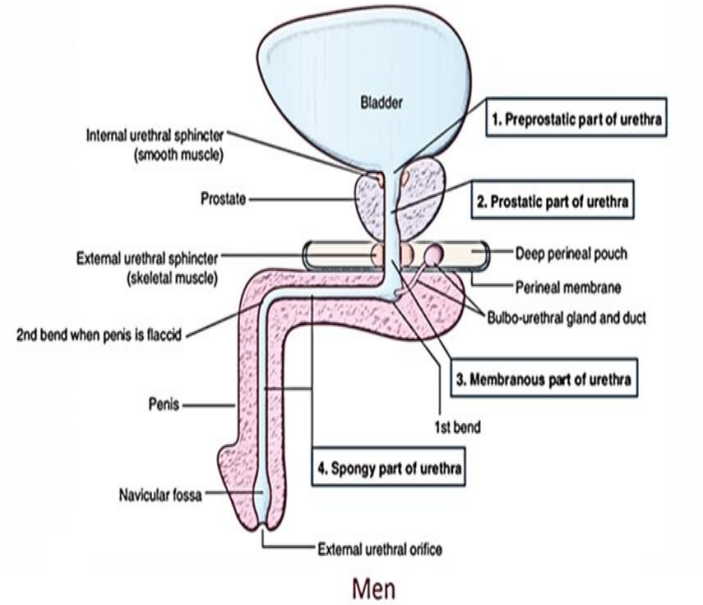


- Its **lower end** is called the **neck**, which is continuous inferiorly with urethra and most fixed part of urinary bladder.
- There are **3 orifices** open in urinary bladder: 2 ureteric orifices at superolateral angles, internal urethral orifice inferiorly.

Urethra:

- It is a tubular passage extending from the neck of urinary bladder to the external urethral meatus, for the removal of urine outside the body.

- **Female urethra**: it is about 4 cm long and 6 mm in diameter.it begins at the internal urethral orifice, embedded in the anterior wall of the vagina. It has an external urethral sphincter. It opens into the vaginal vestibule.
- **Male urethra**:
  - It is about 20 cm in length.
  - Male urethra transmits urine & semen.
  - It has **3 parts:**
    - **Prostatic urethra** (3cm) →It is the widest and most dilatable part of male urethra. It begins at the internal urethral orifice, extends through the prostate & receives **2 openings of ejaculatory ducts.**
    - **Membranous urethra** (2cm) → It is the shortest and narrowest part of male urethra. It traverses the urogenital diaphragm. The **bulbourethral glands** (of Cowper) lie one on each side of the membranous urethra.
    - **Penile (spongy) urethra** (15 cm) → The or penile part passes through the bulb and corpus spongiosum of the penis. It opens at external urethral meatus on the tip of glans penis. The bulbourethral glands and urethral glands of Littre open into the penile urethra.



Men

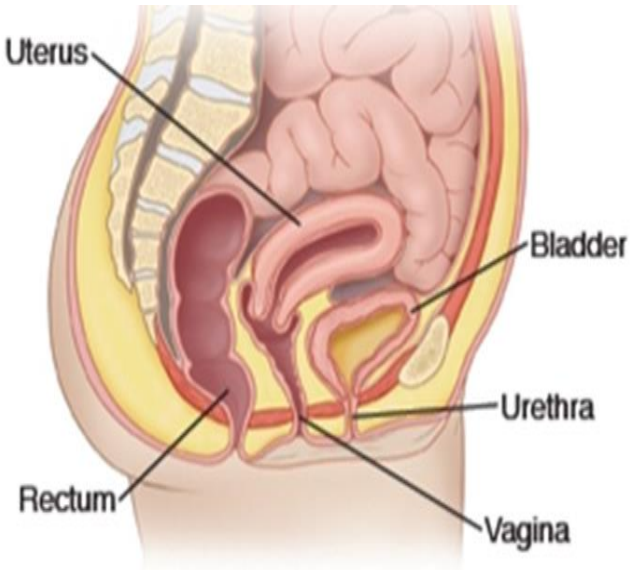
- ***Urethral sphincters:***
  - **Internal urethral sphincter** → smooth muscle, surrounds the internal urethral orifice, supplied by sympathetic nerves. It prevents retrograde ejaculation of semen into urinary bladder.
  - **External urethral sphincter** → skeletal muscle surrounds the membranous urethra, supplied by somatic nerves.

Female genital system

External genital organs:

1- Valva: formed of labia majora, labia minora & clitoris

2- Breast (mammary gland).



Internal genital organs:

3- 2 Ovaries.

4- 2 Fallopian tubes.

5- Uterus.

6- Vagina.

Ovary:

- The ovary is a primary sex organ in female. It lies in the ovarian fossa, on the side wall of the pelvis.
- It is ovoid (almond) in shape, smaller than the testis. It is about 3 cm long, 2 cm wide and 1 cm thick.
- Functions: (Mixed gland); Endocrine (production of estrogen & progesterone hormones) & Exocrine (production of ova).

Fallopian tubes:

- 10 cm in **length.**
- **Site** of fertilization. Transport zygote to the uterine cavity.
- **Openings:**
  1) Medial opening into the uterine cavity.
  2) Lateral opening into the peritoneal cavity & related to the ovary.

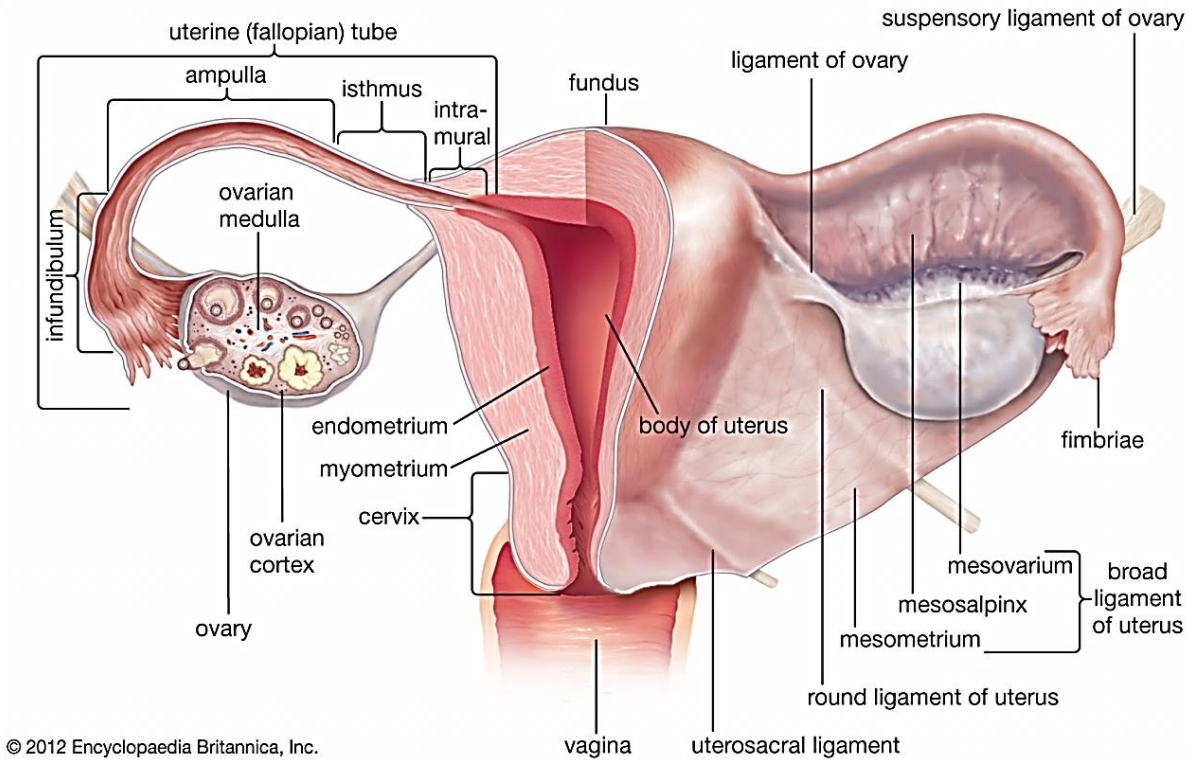
- **Parts:**

1- Infundibulum: funnel-shaped expansion of the uterine tube. It is characterized by fimbriae which sweep the surface of the ovary to capture the ovum.

2- **Ampulla:** the **most dilated and longest part**. It is a **site of fertilization.**

3- **Isthmus:** medial to ampulla, rounded and muscular part of the tube.

4- **Intra-mural (uterine) part:** it runs within the myometrium of the uterus. It is the narrowest part of the tube & opens into the uterine cavity.



Uterus:

- The uterus is a muscular pelvic organ whose function is to provide nidus for the developing embryo. In the virginal state it is the shape of a flattened pear.
- Its size is about 8 × 5 × 3 cm.
- It possesses a **fundus, body and cervix**. It receives the uterine tubes, and the cervix protrudes into the vault of the vagina where it opens.
- **Location:** It lies in the pelvic cavity between the urinary bladder with utero-vesical pouch of peritoneum anteriorly, and the rectum with recto-uterine pouch (Douglas) of peritoneum posteriorly.
- **Normal position*:*** Anteverted, Anteflexed. Anteversion angle is anterior right angle between the uterus & vagina. Anteflexion angle is an obtuse angle between the body & cervix of the uterus.

- **Parts:**

1) **Fundus:** the uppermost convex part of the uterus above insertion of fallopian tubes.
2) **Body:** the main part about two inches, pear shaped part, has two surfaces (anterior & posterior) and Rt &Lt lateral borders (which are attached to lateral pelvic wall by broad ligament).
3) **Cervix:** one inch in length, formed of two parts: supra vaginal & vaginal parts. The cervix is the most fixed part of the uterus.

- Supra-vaginal part → opens into uterine cavity by internal os.
- Vaginal part → opens into the upper part of vagina by external os.

- **Layers:**

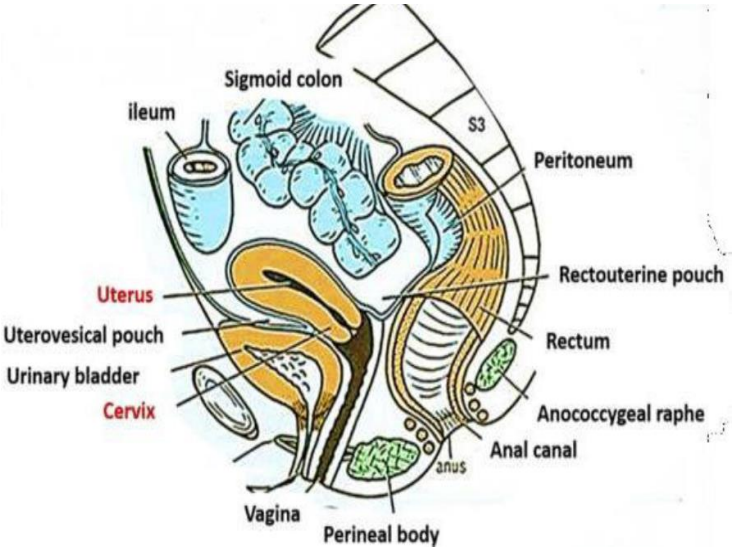
1) **Epimetrium:** the outer peritoneal covering.
2) **Myometrium**: the middle main part, formed of smooth muscles.
3) **Endometrium:** the innermost layer, formed of 3 layers**:**

- **compact layer** → the most superficial.
- **Spongy layer** → contains endometrial blood vessels & endometrial glands.
- **Basal layer** → adherent to myometrium.
- **Compact & spongy layers** are called the **functional layer** & are shedding during menstruation. Implantation occurs into the functional layer.

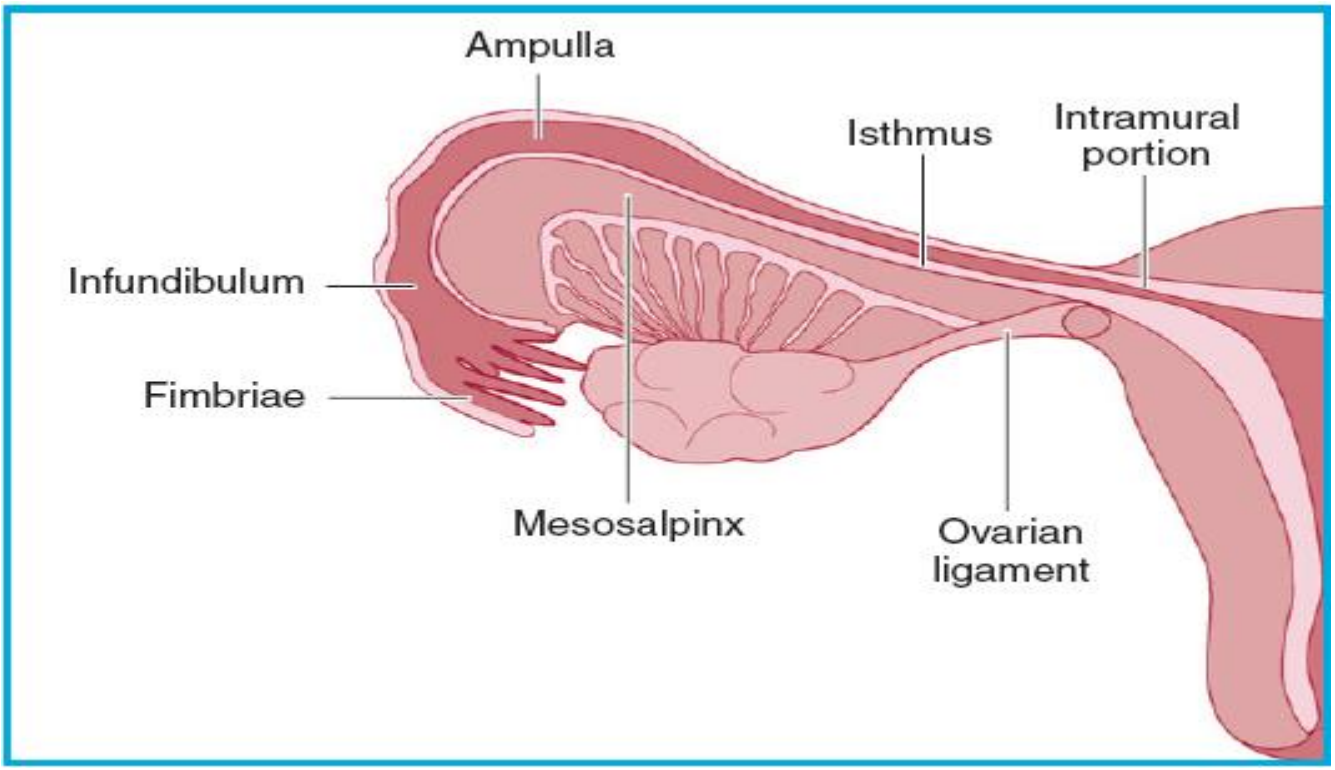
Vagina:

- It is a fibro-muscular canal that extends **upwards and backwards** from its lower end, the vaginal orifice to the cervix at its upper end.
- The vaginal orifice is partially closed in virgins by **hymen.**
- The long axis of vagina makes the angle of ante-version with the uterus.
- The upper part is related to the vaginal part of the cervix which is surrounded by circular groove called the vaginal fornices.

- The anterior wall is 7.5 cm, while the posterior wall is 9 cm.
- Since the cervix penetrates the anterior vaginal wall, the anterior wall is shorter than the posterior vaginal wall
- The vagina passes through the urogenital diaphragm to end in the vestibule of the vagina in the perineum.



- It is related anteriorly to urethra & urinary bladder base & posteriorly to Douglas pouch and rectum.



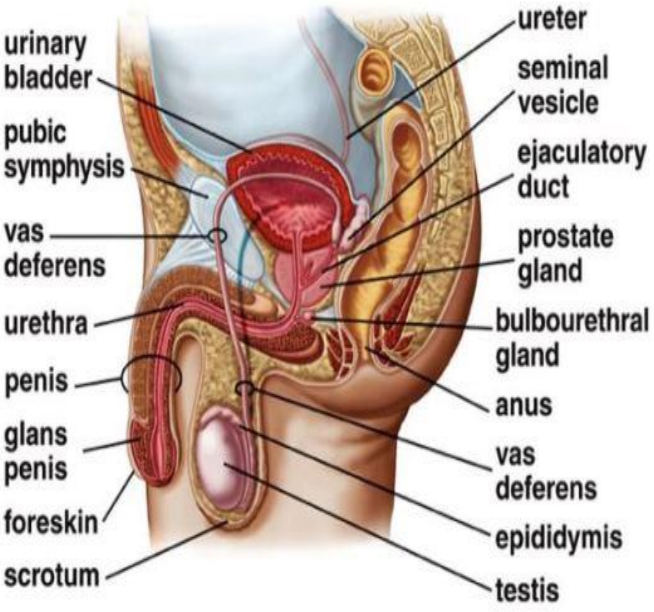
Male genital system

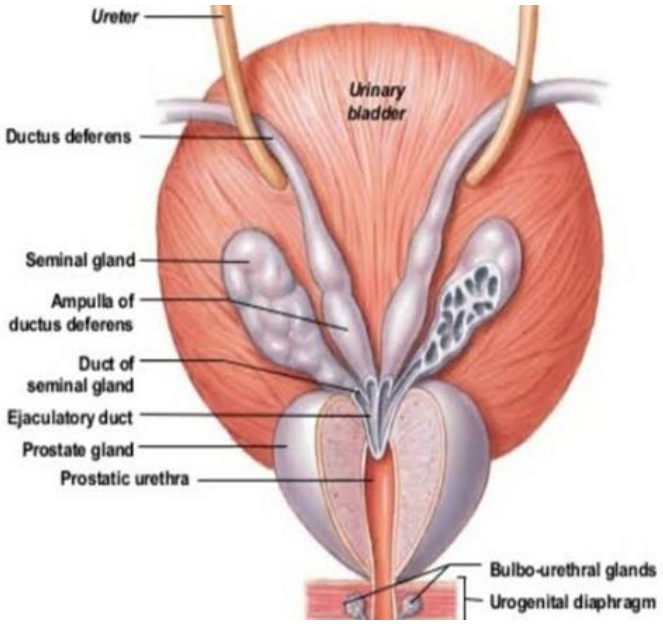
External genital organs:

- **Penis:** is the copulatory organ, the penile urethra runs through the whole length of the penis to its expanded external end which is called glans penis.
- **The scrotum:** is a pouch of skin containing the testes and spermatic cords. The subcutaneous tissue has no fat but contains dartos muscle.
- **Testis:** is the primary sex organ.

Internal genital organs:

- Duct system: Epididymis, Vas deferens, Ejaculatory duct & Urethra.
- Glands: Prostate, Seminal vesicles & Bulbourethral (Cowper's) glands.

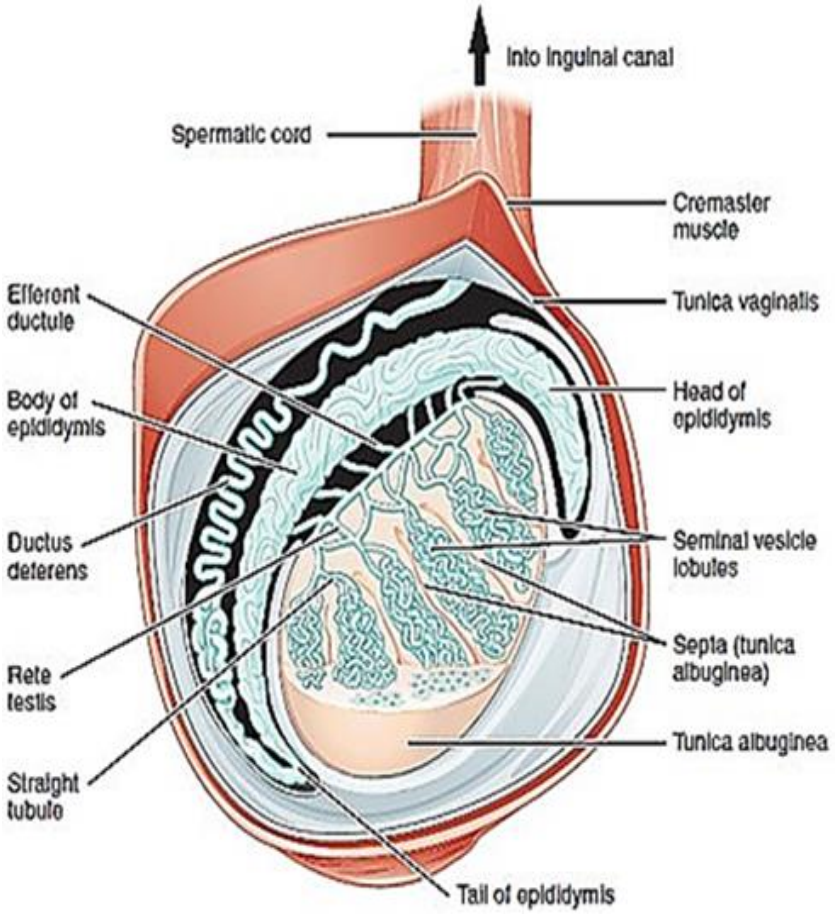




Testis:

- The testis is an oval, primary sex organ, it is a mixed gland:
  - Endocrine → secreting testosterone hormone.
  - Exocrine → secreting sperms.
- **Structure:** the testis is divided by fibrous septa into **200–300 lobules**, each of which contains 1–4 highly convoluted **seminiferous tubules,** they are sites of sperm formation (spermatogenesis).

- The seminiferous tubules open into the **rete testis**, which is a network of intercommunicating channels lying in the mediastinum testis.
- From the rete 12–20 **vasa efferentia** enters the commencement of the canal of the epididymis, thus attaching the head of the epididymis to the testis.
- The seminiferous tubules have several layers of cells. The outermost layer consists of **spermatogonia**, which divide to produce the primary spermatocytes. These are divided into **secondary spermatocytes**. They divide immediately to form **spermatids.** These do not divide but undergo a metamorphosis into **spermatozoa.** The whole process of producing spermatozoa from spermatogonia is called **spermatogenesis.**
- **Supporting cells of Sertoli** present inside seminiferous tubules for nutrition of sperms.
- **Interstitial cells of Leydig** present in between seminiferous tubules for secretion of testosterone hormone.
- **Coverings:**
  - Tunica vaginalis: is the outer serous sac (an extension of peritoneum).
  - Tunica albuginea: inner fibrous capsule. It sends septa to divide the testis.



Epididymis:

- A highly convoluted duct (about 6 meters in length), formed of head, body & tail. It is attached to the posterolateral surface of the testis. It receives vasa efferentia.
- Functions: site for sperm maturation.

Vas deferens:

- It is a muscular tube that starts as a continuation of the tail of epididymis & ends by joining with the duct of seminal vesicle to form ejaculatory duct.
- Its length is about 45 cm & its lumen 0.7 mm.
- Function: sperm transport from epididymis to prostatic urethra.

Ejaculatory ducts:

- Each duct is about 2cm long & is formed by the union of the duct of seminal vesicle and the lower end of ampulla of the vas deferens. It ends in the prostatic urethra.

Male sex glands:

- **Prostate:**
  - The prostate is a partly glandular, partly fibromuscular organ which lies beneath the bladder and above the urogenital diaphragm and is penetrated by the proximal part of the urethra. The prostate is related posteriorly to the rectum.
  - Functions: it secrets alkaline fluid to neutralize the vaginal acidity.
  - It produces about 40% of seminal fluid.
- **Seminal vesicles:**
  - They are a pair of thin-walled, elongated, coiled, blind-ending tubes of about 5 cm long. It lies between the bladder base and the rectum.
  - The vas deferens, which combine with the duct of the seminal vesicle to form the ejaculatory duct, which subsequently drains into the prostatic urethra.
  - It produces about 60% of seminal fluid which is nutritive to sperms.
- **Bulbourethral (Cowper's) glands:**
  - The **bulbourethral glands** are paired glands which lie one on each side of the membranous urethra.
  - They open into the bulb of the penile urethra.
  - Functions: lubricate urethra to allow smooth flow of semen.

Human chromosomes

- **karyotyping**: A laboratory procedure to examine human cell chromosomes.
- **Structure of normal chromosomes.**

  The chromosome is formed of two chromatids attached together at the point of centromere.

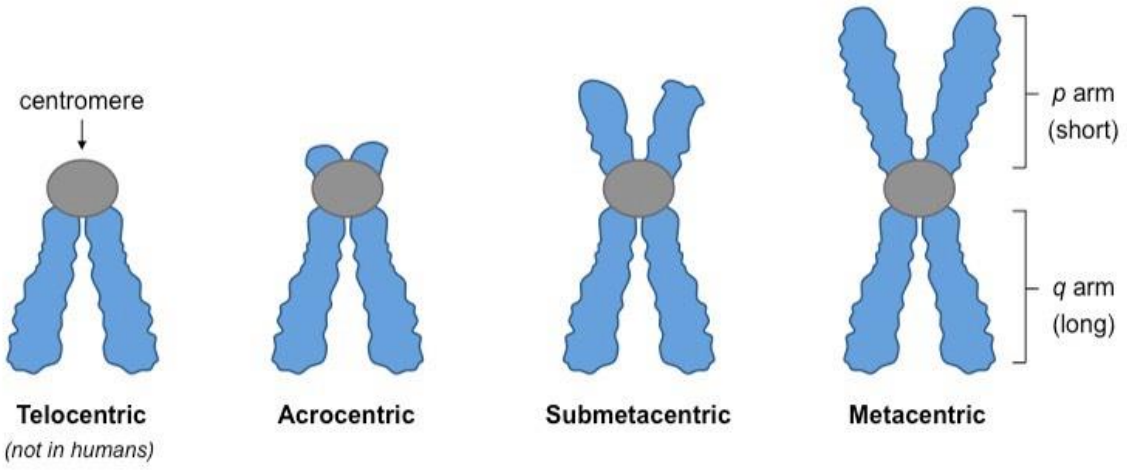
According to the position of centromere, they are classified into:

1- **Metacentric:** the centromere is central.

2- **Submetacentric:** the centromere is near to the center.

3- **Acrocentric:** the centromere is near to the end.

4- **Telocentric:** centromere is at the end of chromatids.



Number of human chromosomes:

- **In somatic cell** is diploid number (23 pairs): 22 pairs of somatic chromosomes and one pair of sex chromosomes.
- **In gamete cell** is haploid number (23): 22 somatic chromosomes and one sex chromosome (either Y or X).

Groups of human chromosomes:

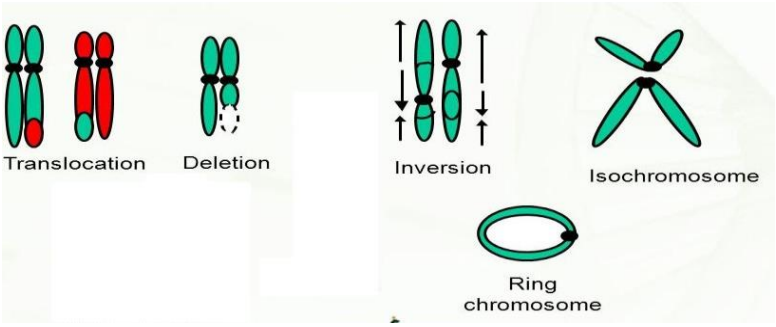
- According to their size and position of the centromere they are 7 groups:
  - **Group A: 1st, 2nd, 3rd pairs.**
  - **Group B: 4th, 5th pairs.**

- **Group C: 6th: 12th pairs, and X- chromosome.**
- **Group D: 13th, 14th, 15th pairs.**
- **Group E: 16th, 17th, 18th pairs.**
- **Group F: 19th, 20th pairs.**
- **Group G: 21st, 22nd pairs and Y- chromosome.**

Anomalies of chromosomes:

1. structural anomalies:

- **Deletion:** loss of piece of chromatid.
- **Translocation:** adding extra piece of chromatid.
- **Inversion:** reciprocal reattachment of piece of chromatid.
- **Ring chromosome:** fusion of its tip in ringlike structure.
- **Iso-chromosome:** transverse separation of centromere.



2. **Numerical anomalies**

- **Duplication,** of chromosomal number (tri-ploidy, tetra-ploidy, polyploidy).
- **Extra chromosome**, 3 copies of chromosome, (trisomy).
- **Reduction,** of one copy of chromosome, (monosomy).

<u>Nondisjunction:</u>

- Failed separation of two chromatids during Anaphase of cell division.
- One of daughter cells will have 3 copies and the other cell will have only one copy.
- Clinical example: (Trisomy 21 or Down syndrome).

a) In somatic chromosomes:

Down syndrome

- Genetic structure: 45 + XX or XY (3 copies of 21st chromosome).
- Features:
  - Low birth weight.
  - Flattening of the occiput.
  - Upward slanting of the lateral eye angle.
  - Mental retardation.
  - Abnormal hand creases.

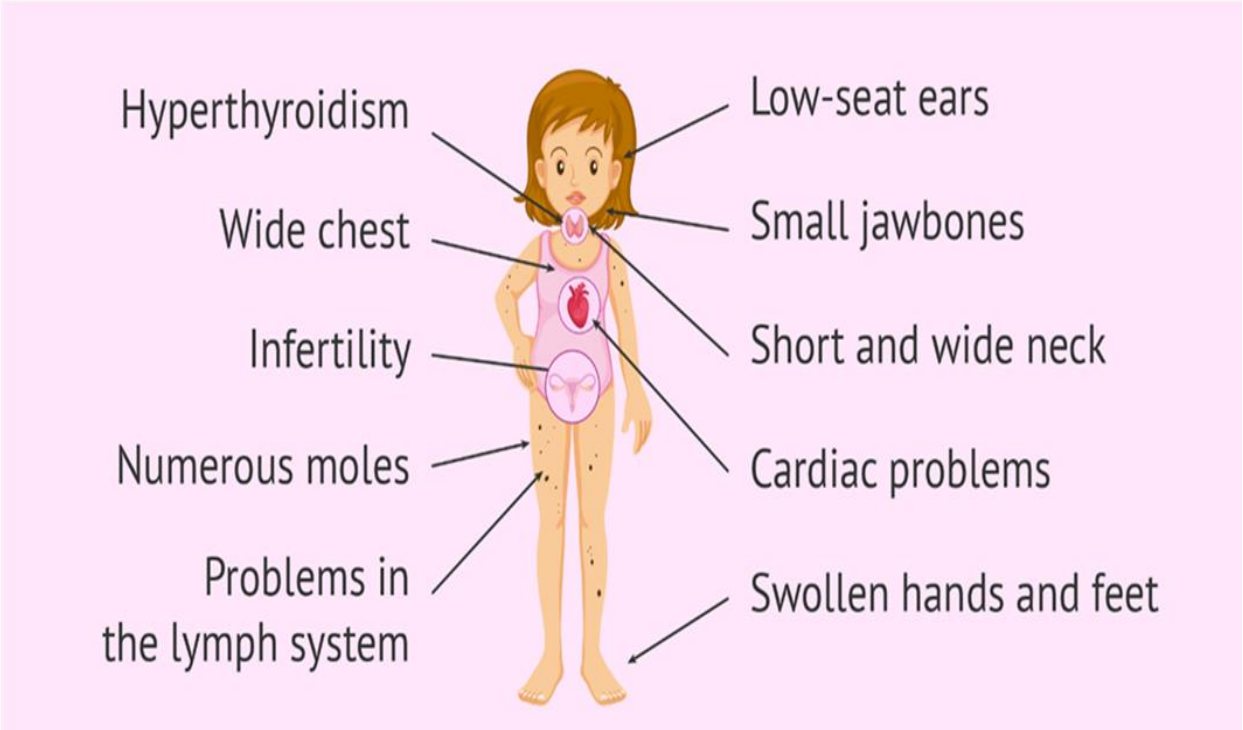
b) In sex chromosomes

⊡ KLINEFELTER SYNDROME

- The clinical features of Klinefelter syndrome, found only in males and usually detected at puberty, are sterility, testicular atrophy, hyalinization of the seminiferous tubules, and usually gynecomastia.
- The cells have 47 chromosomes with a sex chromosomal complement of the XXY type **(trisomy of sex chromosome)**. Non-disjunction of the XX homologues is the most common causative event.

⊡ TURNER SYNDROME

- Turner syndrome, with a 45, X karyotype, is the **only monosomy compatible with life**. Even then, 98% of all fetuses with the syndrome are spontaneously aborted.
- The few that survive are female in appearance and are characterized by the absence of ovaries, short stature, webbed neck, skeletal deformities, and a broad chest with widely spaced nipples.



SPERMATOGENESIS

- It is the series of changes by which the primitive germ cells (spermatogonia) are transformed into mature sperms.
- Formation of mature sperms with haploid number of chromosomes.
- **Site:** Seminiferous tubules of the testis.
- **Time:** From puberty till old age.
- **Duration:** About two months (60 days).
- **Sperms** are stored and become functionally mature in the Epididymis.
- **Significance of spermatogenesis:**
  - Reduction of chromosomal material by half (Meiosis).
  - Variations in humans.
  - Change the shape of gamete cell to be suitable for its function.
- **Four stages:**

1) **Proliferation:** Increase in number of spermatogonia. Spermatogonia divide by mitosis into daughter spermatogonia.
2) **Growth:** increase in size of spermatogonia. Daughter spermatogonia enlarge to form primary spermatocytes (which is the largest germ cell in seminiferous tubules).
3) **Maturation:** 2 successive maturation divisions:

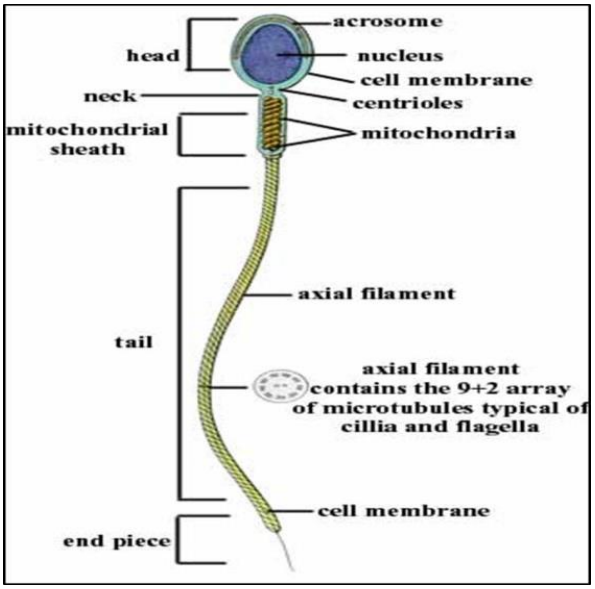
- First maturation division (Meiosis I) Each **Primary spermatocyte** divides by meiosis I into **2 secondary spermatocytes** (contains haploid number of chromosomes).
- Second maturation division (Meiosis II): each **secondary spermatocyte** divides by meiosis II into **2 spermatids** (contains haploid number of chromosomes). Meiosis II reduces quantity of DNA strands in chromosomes.

4) **Spermiogenesis:**

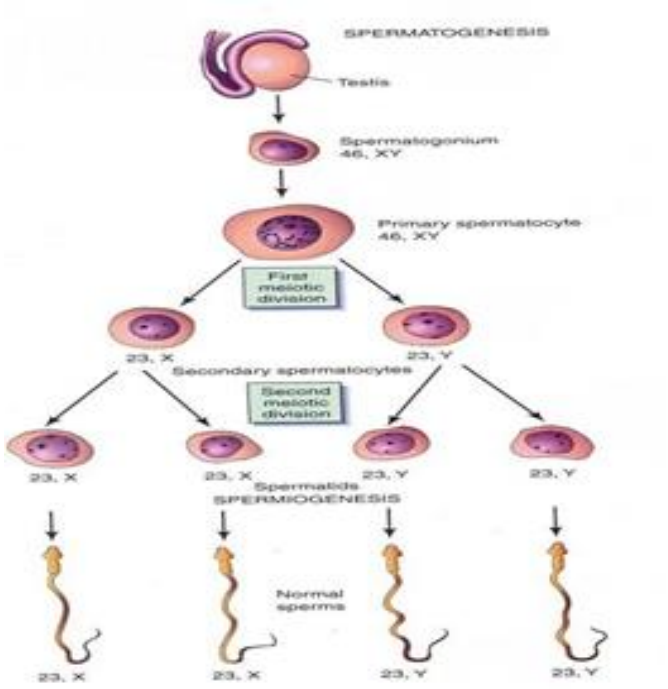
- It is change in shape (metamorphosis) through which **Spermatids** are transformed into **mature Sperms**:
- **Steps:**
  - Nucleus is condensed and forms most of the head.
  - Golgi apparatus forms the Acrosome.
  - Mitochondria form a spiral sheath.
  - Centriole elongates to form the axial filament.

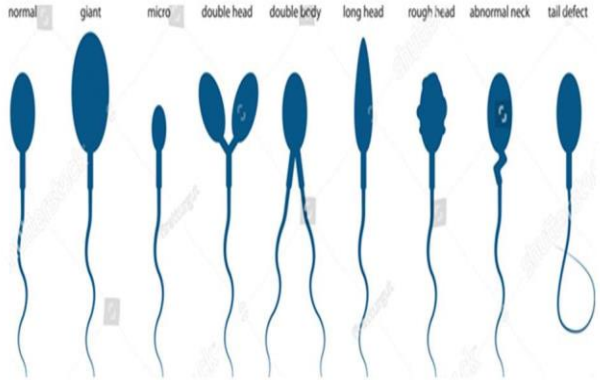
- Shedding of the most of cytoplasm.

- **<u>Features of the mature sperm</u>:** The sperm consists of 4 parts:
  1) **Head**: which has Nucleus and Acrosomal cap (contains the nucleus with haploid number of chromosomes, covered by the acrosomal cap contains proteolytic enzymes for fertilization).
  2) **Neck**: (formed of centrioles).
  3) **Middle piece:** made by spiral mitochondria.
  4) **Tail:** motile flagellum.



- **<u>Abnormal forms of sperms:</u>**
  - Giant sperm (large sized).
  - Dwarf sperm (small sized).
  - Double head (two heads & one tail).
  - Double tail (two tails & one head).





- **<u>Seminal fluid:</u>**

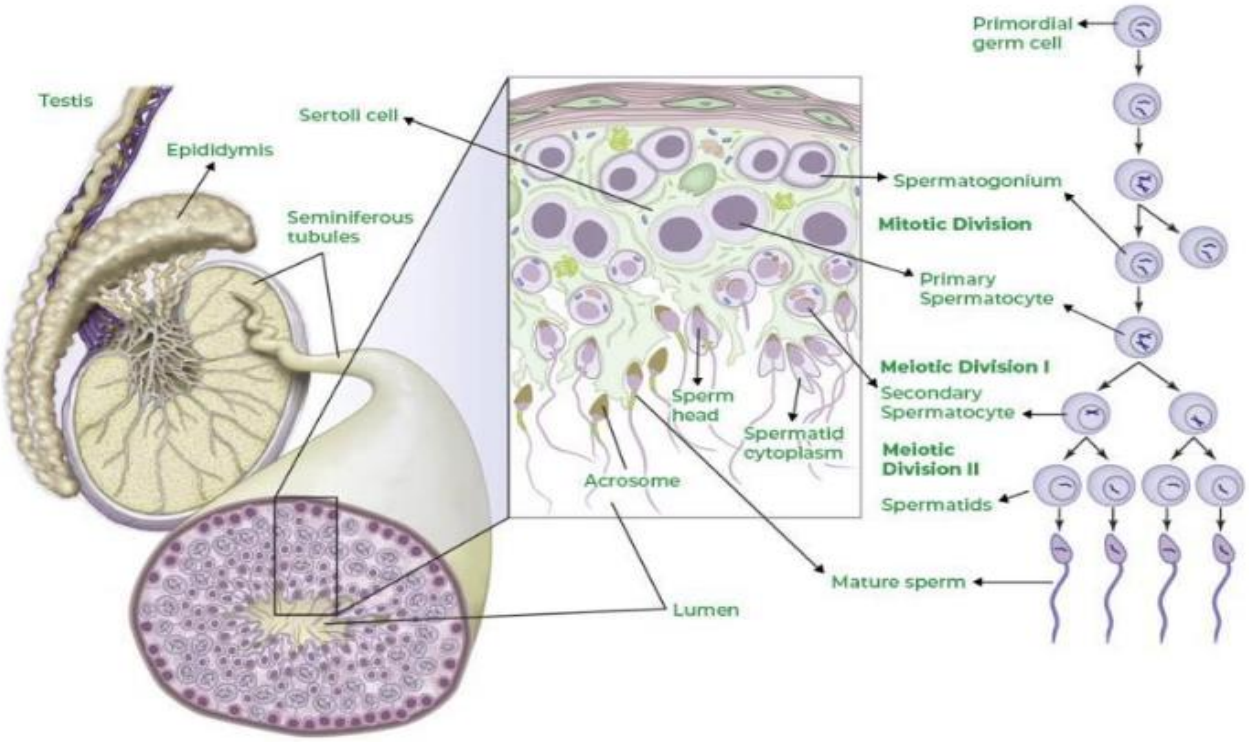
- Volume: 3-5 ml.
- Sperm count: 60-120 million/ml.
- Composition:

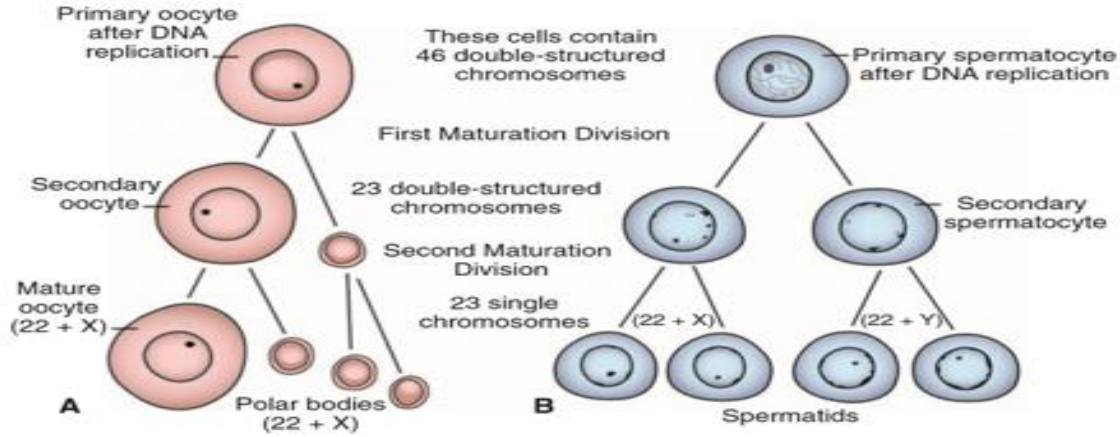
  60% of seminal fluids are from seminal vesicles.

40% of seminal fluids are from prostate.

Less than 1% sperm constituent.

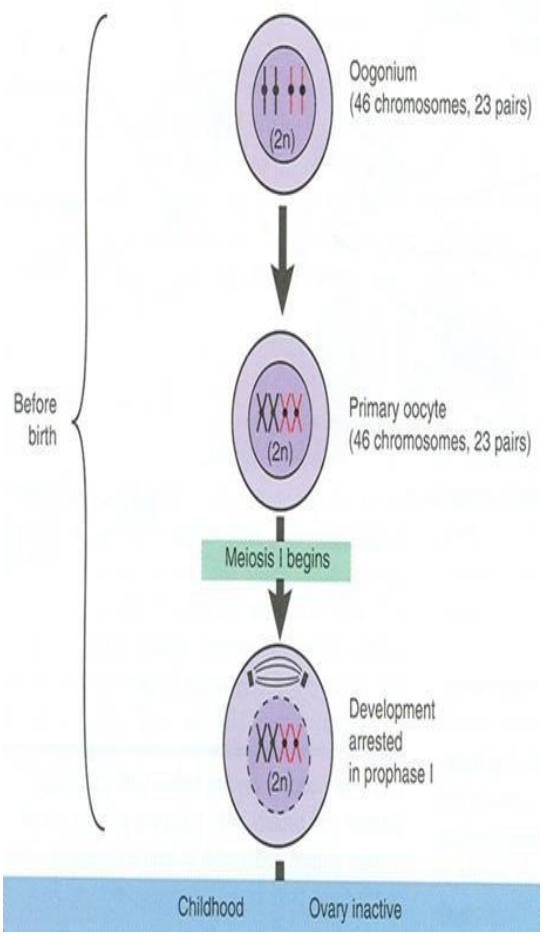
- **Anomalies:**
  - **Azoospermia:** semen contains no sperms.
  - **Oligospermia**: low sperm count (<10 million /ml).
  - **Necrospermia:** semen contains dead sperms.





OOGENESIS

- **Definition:** The process by which primitive female germ cells (oogonium) is transformed into an ovum.
- **Site:** begins in the cortex of ovary and completed in uterine tube.
- **Start:** from 3rd month of intrauterine life and arrested at birth, then reactivated at puberty (menarche 11-13 years) every month.
- **Ends:** at menopause (45 – 50 years).
- **Stages: 3 Steps**



I- <u>Before Birth</u>:

- **Proliferation:** During early fetal life, primitive ova (Oogonia). Proliferate by mitotic division to form **daughter oogonia.**
- **Growth:** Enlarge to form **Primary Oocytes** (46) which is surrounded by a single layer of flat cells (primordial follicle)
- **Maturation**: At Birth all primary oocytes have completed the **<u>prophase</u>** of the 1st meiotic division and remain arrested and do not finish their first meiotic division until at puberty.
- **N.B**: At birth the ovary contains only primary oocytes (no oogonia at all)

II- At Puberty.

A) Reactivation of first maturation division (Meiosis I)

- Occurs at puberty once every month in either ovary.
- About **15 to 20 primary follicles** are triggered but only one matures

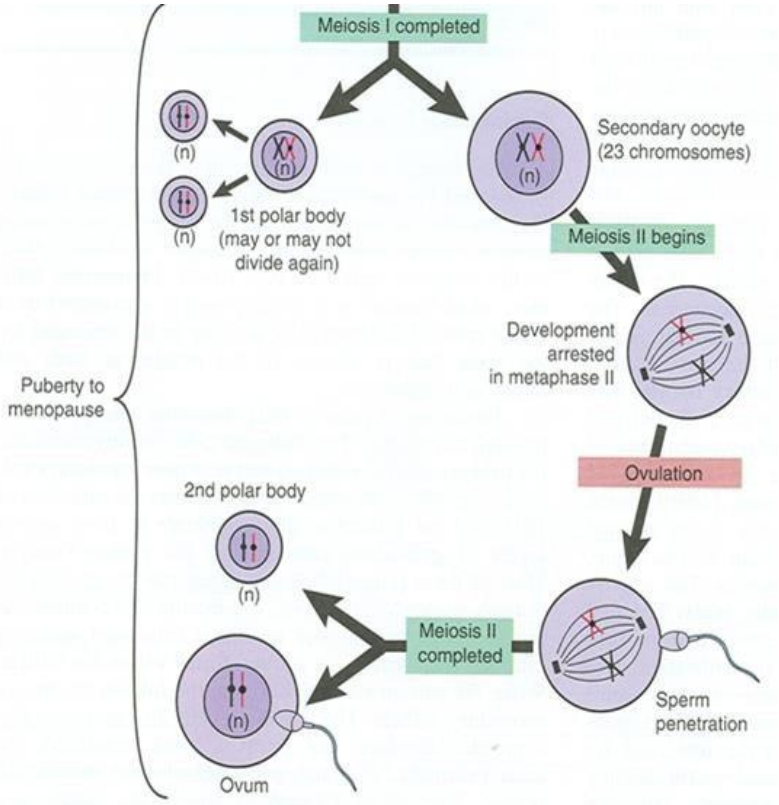
  Shortly before ovulation, the Primary Oocyte completes its 1st meiotic division to give **Secondary Oocyte (23) & First Polar Body.**
- The Secondary Oocyte receives almost all the cytoplasm.

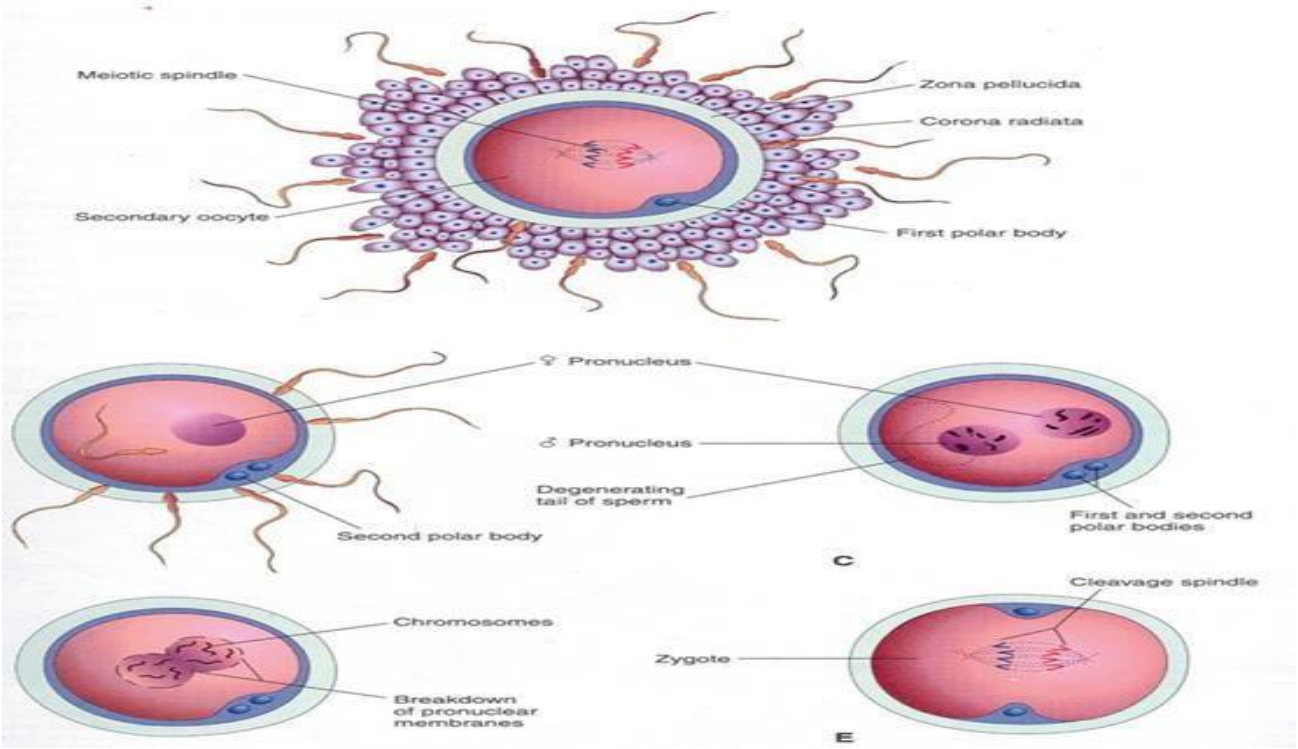
- The First Polar Body receives very little. It is small nonfunctional cell that soon degenerates.

B) Second maturation division (Meiosis II): Occurs in the uterine tube.

III- At ovulation

- The secondary oocyte begins the second meiotic division but progresses only to **metaphase** where division is arrested.
- If the secondary oocyte is fertilized, the second meiotic division is completed, otherwise it degenerates 24 hours after ovulation.
- Most of the cytoplasm is retained by the Mature Oocyte (Fertilized Oocyte).
- The rest is in the 2nd Polar Body which soon degenerates.

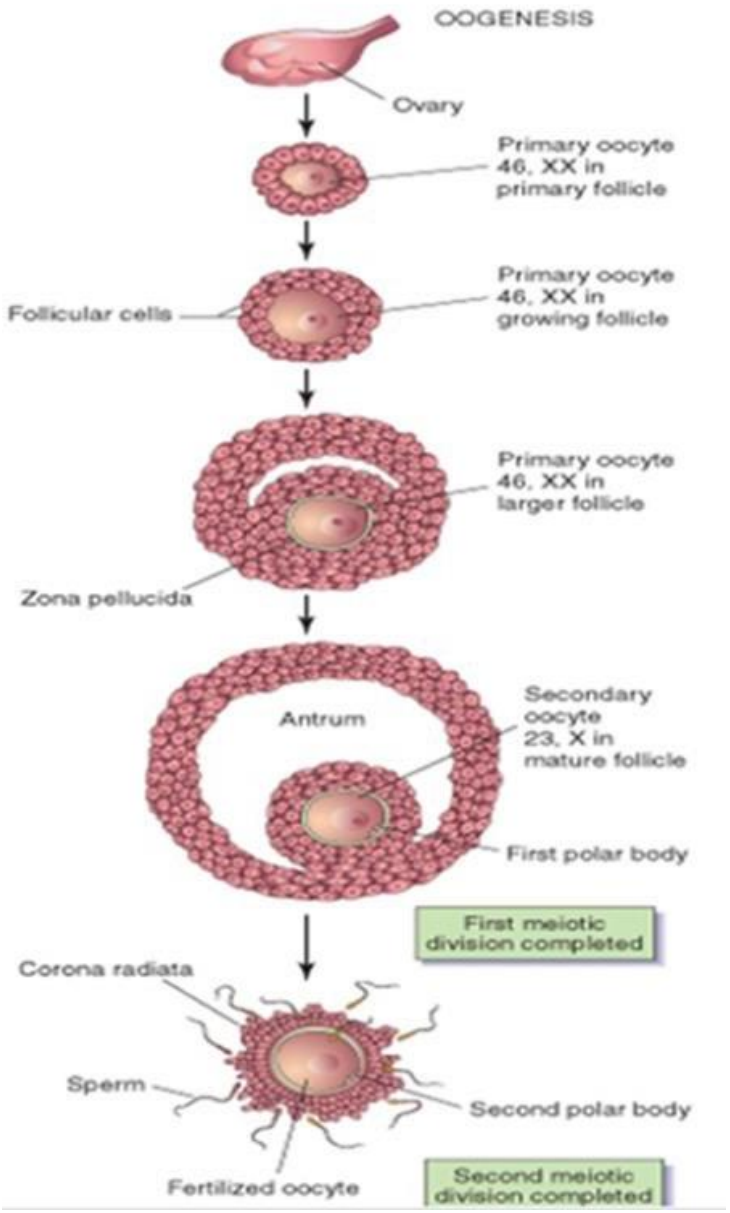




- **<u>Maturation of primary follicle</u>**

- Begins **<u>at puberty</u>** hand in hand with maturation of primary oocyte:

1) Primary follicle: has **<u>one layer</u>** of cubical cells.
2) Secondary follicle: has **<u>multiple layers</u>** of (granulosa cells.
3) Tertiary follicle: contains **<u>many cavities</u>** between granulosa cells.
4) **Mature Graafian follicle**: **<u>3 parts</u>**
   - **Stratum granulosum**: the peripheral layer of the follicle.
   - **Cumulus oophorous**: cells that surround the secondary oocyte.
   - **Antrum**: cavity filled with fluid.
   - Within the Graffian follicle, secondary oocyte is surrounded by **<u>3</u> <u>coverings:</u>**

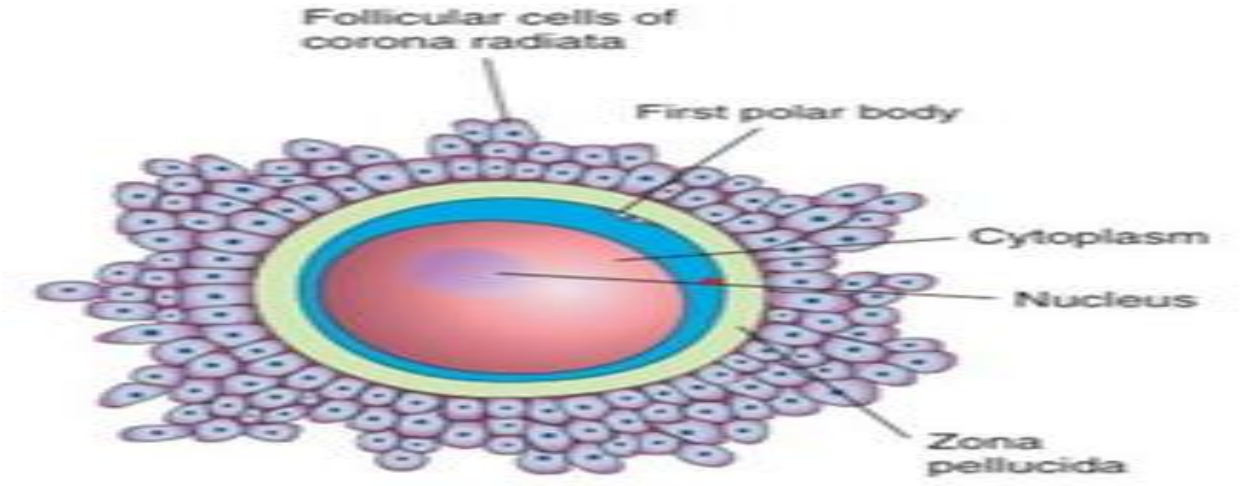


1) **Vitelline membrane**: the membrane of secondary oocyte.
2) **Zona pellucida:** Coat of glycoprotein.
3) **Corona radiata:** the most inner layer of cumulus oophorous.

- The **<u>secondary oocyte with the above 3 covering</u>** is the structure which liberates from the ovary at ovulation

Difference between Spermatogenesis and Oogenesis

Characteristics	Spermatogenesis	Oogenesis
Location	Occurs in testes	Occurs inside the ovary
Number of gametes	Number of gametes produced is 4.	Number of gametes produced is 1
Production rate	Sperm production is in millions every day.	Only one ovum is released once a month.
Size of gametes	Small (Motile).	Large (non-motile).
Timing	The initiation of the process starts at puberty.	Initiation of the process starts before birth.
Cell division	The division is equal and helps in the formation of four haploid spermatids.	The division of the cell is unequal and helps in the formation of one haploid ovum and two polar bodies.
Type of gamete	Produces genetically diverse sperm cells through meiosis and recombination.	Produces genetically identical daughter cells due to the lack of recombination during meiosis

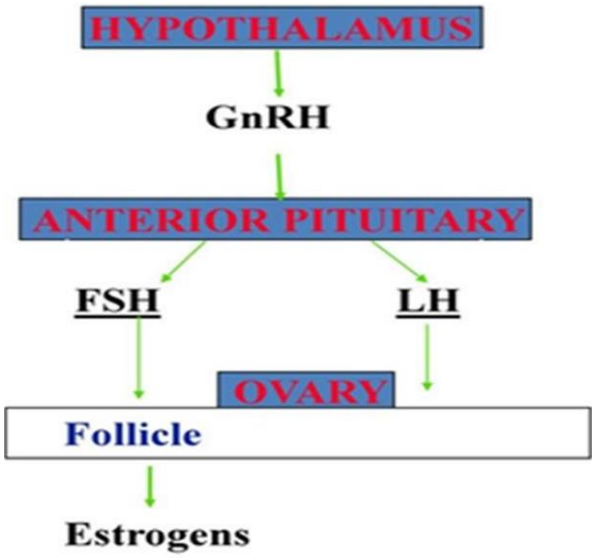


ABNORMAL GAMETOGENESIS:

- During gametogenesis, homologous chromosomes sometimes fail to separate, **nondisjunction**, and as a result, some gametes have 24 chromosomes and others only 22.
- If a gamete with 24 chromosomes unites with a normal one with 23 chromosomes, a zygote with 47 chromosomes results in neonates with Down syndrome (This condition is called **trisomy 21,** because of the presence of **three copies chromosome** instead of the usual two.
- If a gamete with only 22 chromosomes unites with a normal gamete, a zygote with 45 chromosomes results. This condition is called **monosomy**, because only **one copy of chromosome** is present.

Ovarian cycle – Ovulation

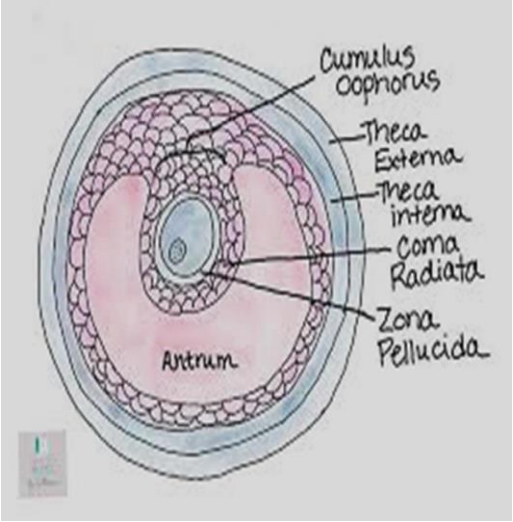
- **Definition:** monthly changes in the ovary from time of **puberty** till menopause (every 28 days ± 7 days).
- **Control:** Under the control of **Gonadotropin releasing hormone (GnRH)** produced by the hypothalamus, which acts on the anterior pituitary to secrete **follicle stimulating hormone** (FSH) & **luteinizing hormone** (LH).

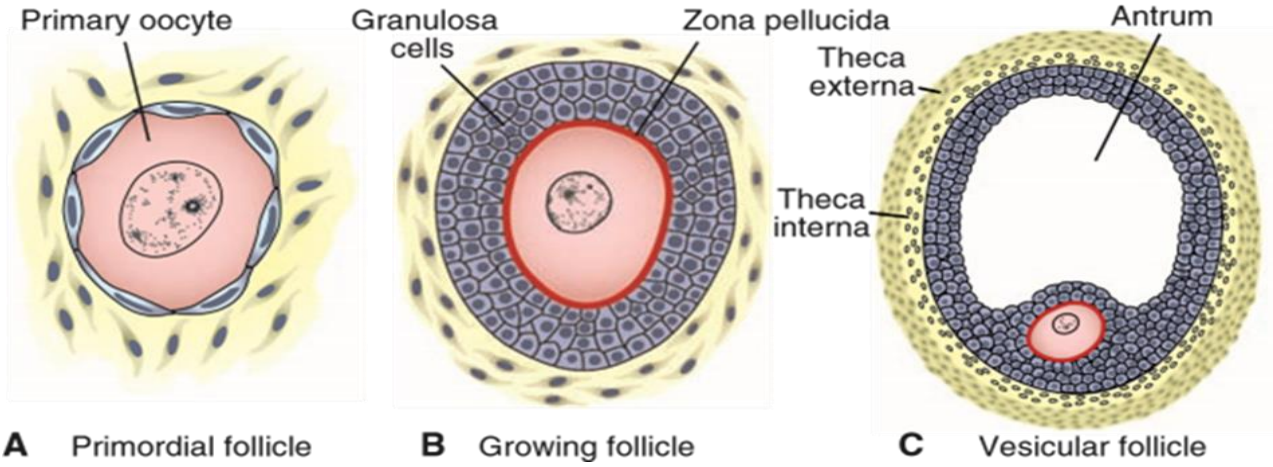


- **Results:**
  - Production of ovum.
  - Production of hormones (estrogen and progesterone).
- **Phases of ovarian cycle**

1- Follicular phase:

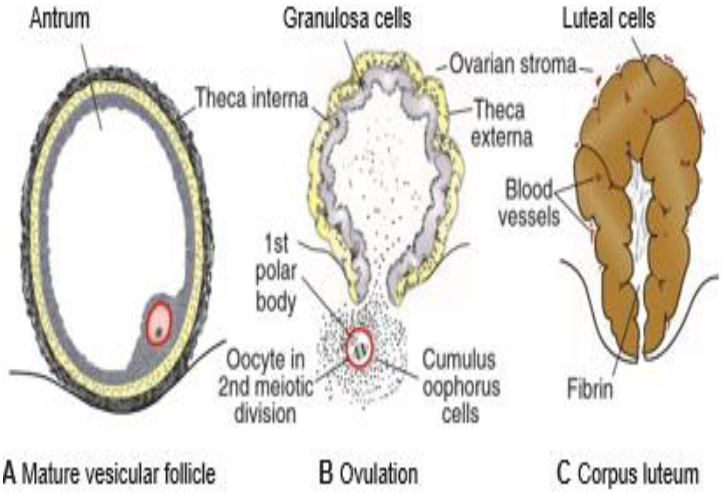
- Under control of FSH.
- It takes about 14 days
- It starts by stimulation of about 15-20 primary follicles, only one forms the mature (Graafian) follicle which ovulates.
- **Graafian (vesicular) follicle** contains large cavity (antrum) filled with estrogen, the follicular cells are called cumulus oophorus and compressed ovarian cells (theca cells).
- Follicular cells secret estrogen hormone.





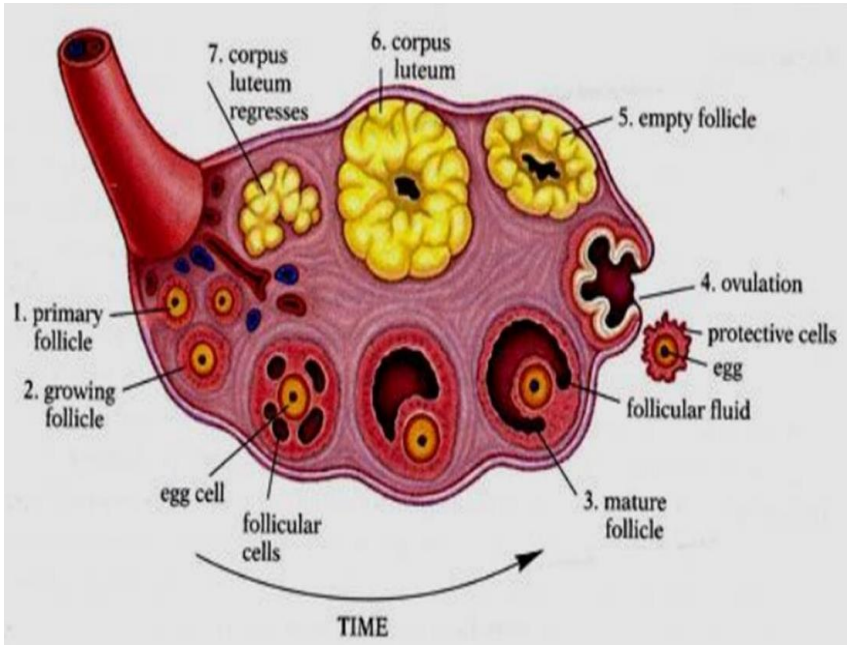
2- Ovulation:

- Due to LH –surge (sharp rise of LH level) before time of ovulation by 36 hours.
- It occurs about 14th day.
- Rupture of mature graafian follicle with release of secondary oocyte surrounded by zona pellucida (translucent glycoprotein membrane) and corona radiata (remnants of follicular cells) to be picked up by movement of fimbriae of fallopian tube.
- **Signs of ovulation**



- Positive Result on an Ovulation Predictor kit.
- Secretions near the cervix, known as cervical mucus, increase.
- Body temperature rises slightly.
- Just before ovulation, the cervix moves higher.
- Breast tenderness.
- Some women get ovulation lower abdominal pain every month

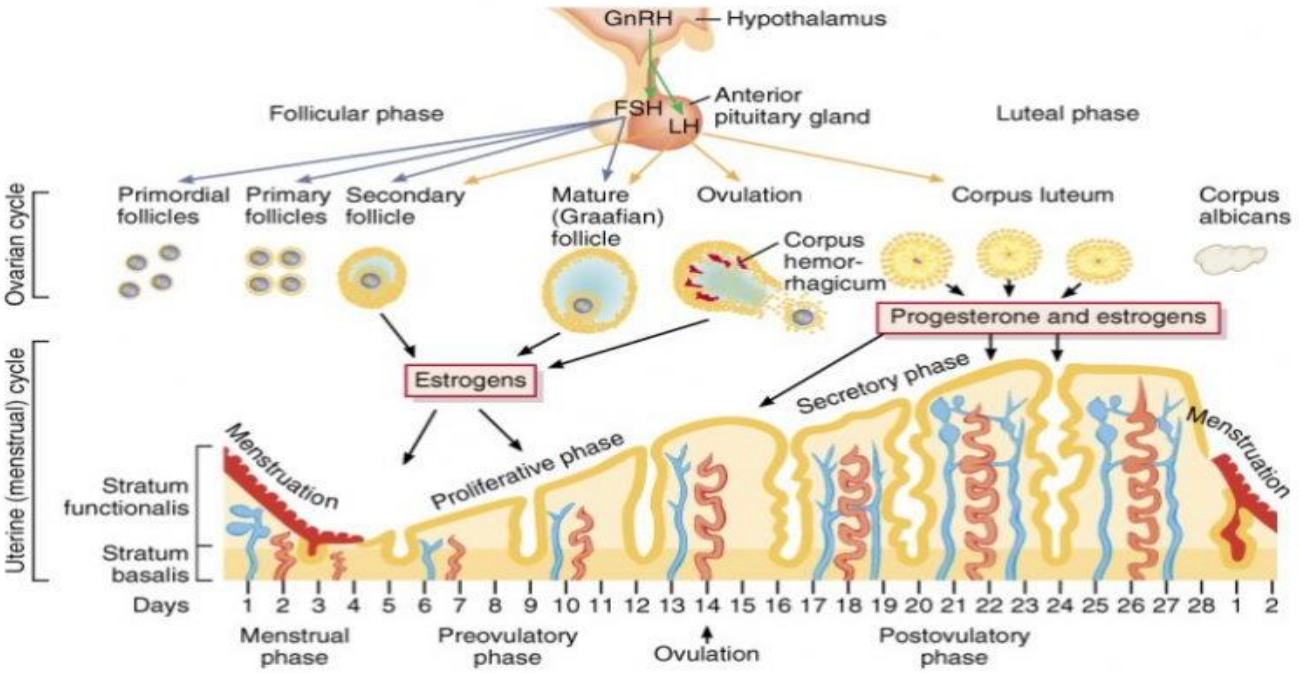
3- Corpus luteum phase:



- Under control of LH.
- It takes about 14 days.
- Follicular cells and theca cells (surrounding ovarian cells) acquire yellow pigments.
- Luteal cells secret both progesterone & estrogen hormones. If pregnancy doesn't occur, the corpus luteum lives 9 days then it shrinks gradually forming the corpus albicans. If pregnancy occurs corpus luteum persists till **4th month**.

Uterine (menstrual) cycle

- **Definition:** monthly changes in the endometrium from time of puberty till menopause (every 28 days ± 7 days).
- **Control:** Estrogen & progesterone from ovarian follicles.
- **Results**: preparing the uterus for pregnancy.
- **3 Phases:**
  1) **Menstrual phase:** (3 to 7 days).
     - It is characterized by bloody secretions from vagina (about 50 ml).
     - Shedding of functional layer of endometrium due to cessation of estrogen & progesterone hormones.
  2) **Proliferative phase:** (9 to 12 days).
     - Under control of estrogen hormone from follicular cells.
     - It is characterized by regeneration & proliferation of the functional layer of endometrium (endometrial thickness is 4 mm).
  3) **Secretory phase:** (about 14 days).
     - Under control of progesterone & estrogen hormones from corpus luteum cells.
     - It is characterized by increased thickness of the functional layer of endometrium; endometrial glands are filled with secretions with tortious high endometrial blood vessels ready for pregnancy (endometrial thickness is 8 mm).



Fertilization

- **Definition:**
  - It is the process during which the male gamete (**sperm**) unites with the female gamete (**oocyte**) to form a single cell (**zygote**) which is a highly specialized, **totipotent cell**, which can differentiate into any type of cell.
  - It lasts about 24 hours.
- **Site of Fertilization:**
  - Usually occurs in the **ampullary part of uterine tube**, which is the longest and widest part. Fertilization may occur in other parts of tubes.
  - Does not occur in the uterine cavity.
  - Chemical signals from oocyte attract the sperms. (Sperm chemotaxis).
- **Rupture of the mature Graafian follicle:** results in liberation of secondary oocyte which is surrounded by 3 coverings:

  1- Vitelline membrane: the membrane of secondary oocyte.

  2- Zona pellucida: Coat of glycoprotein.

  3- Corona radiata: the most inner layer of cumulus oophorus.
  - (The secondary oocyte with the above 3 covering is the structure which liberates from the ovary at ovulation).
- **Steps of Fertilization:**

  Preparatory steps: events occurring prior to fertilization:

  1) **Sperm maturation and storage**: It is the biological process by which immature sperm cells develop into fully functional spermatozoa capable of fertilization, occurring in the **epididymis.**

2) **<u>Capacitation of the sperm</u>:**

- Capacitation is a period of conditioning in the female reproductive tract that in the human lasts approximately **7 hours**.
- **Much** of this conditioning occurs **in the uterine tube**.
- During this time **a glycoprotein coat and seminal plasma proteins** are removed from the plasma membrane that overlies the acrosomal region of the spermatozoa.
- **Only capacitated sperm** can pass through the **corona radiata cells** and undergo the acrosome reaction.

3) **<u>Acrosomal reaction</u>,** which occurs after binding to the zona pellucida, is induced by zona proteins. This reaction culminates in the release of enzymes needed to penetrate the zona pellucida, including acrosin and trypsin-like substances. Multiple openings develop in the acrosomal cap of sperms to release enzymes like acrosin that facilitate penetration of secondary oocyte.

- **The phases of fertilization include:**

1- Phase 1: Penetration of the Corona Radiata:

- Of the 200 to 300 million spermatozoa normally deposited in the female genital tract, **only 300 to 500 reach the site of fertilization**. Only one of these fertilizes the egg. Capacitated sperm pass freely through corona cells

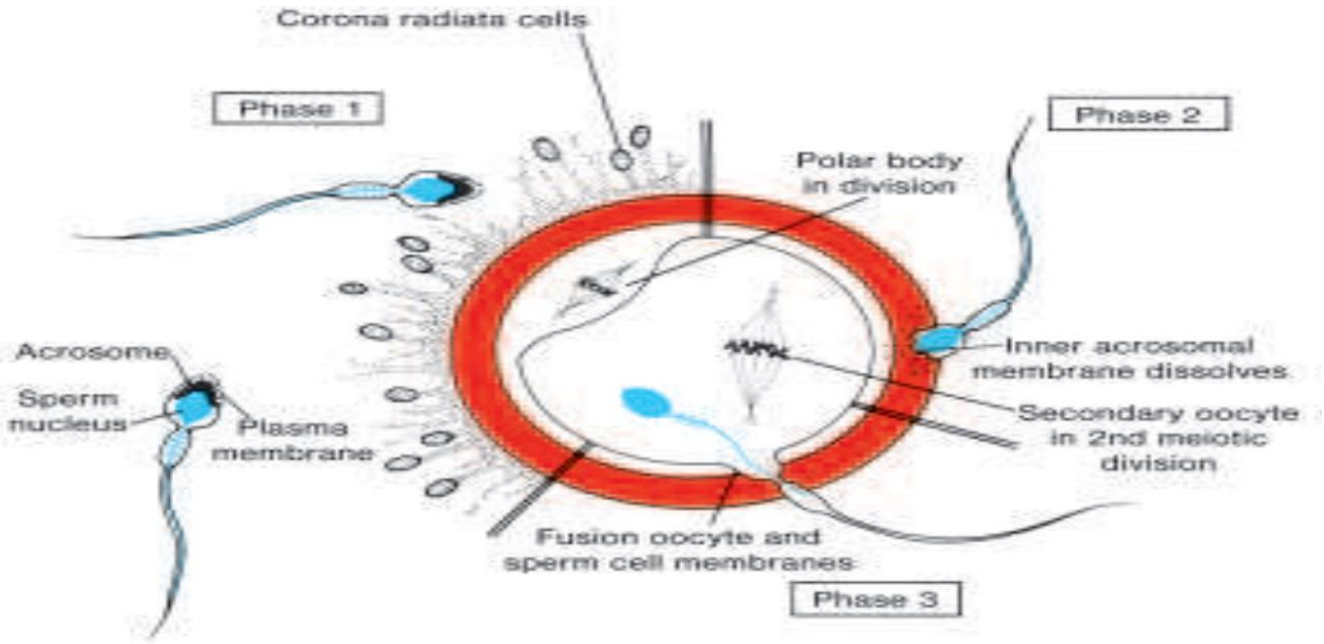
2- Phase 2: Penetration of the Zona Pellucida:

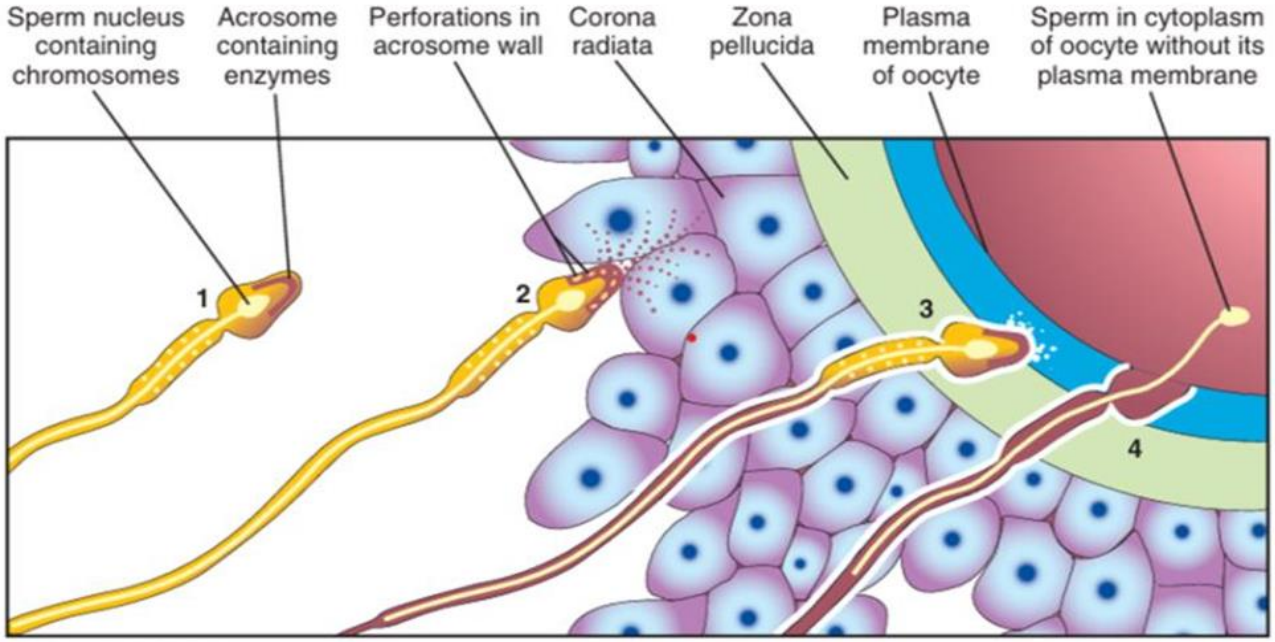
- The zona is a glycoprotein shell surrounding the egg that facilitates and maintains sperm binding and induces the acrosome reaction.
- Both binding and the acrosome reaction are mediated by the ligand ZP3, a zona protein.

- Release of acrosomal enzymes (acrosin) allows sperm to penetrate the zona.
- Permeability of the zona pellucida changes when the head of the sperm meets the oocyte surface. This contact results in release of lysosomal enzymes from **cortical granules** lining the plasma membrane of the oocyte.
- These enzymes alter properties of the zona pellucida **(zona reaction)** that make zona pellucida impermeable to other sperms **(prevent polyspermy).**

3- Phase 3: Fusion of the Oocyte and Sperm Cell Membranes:

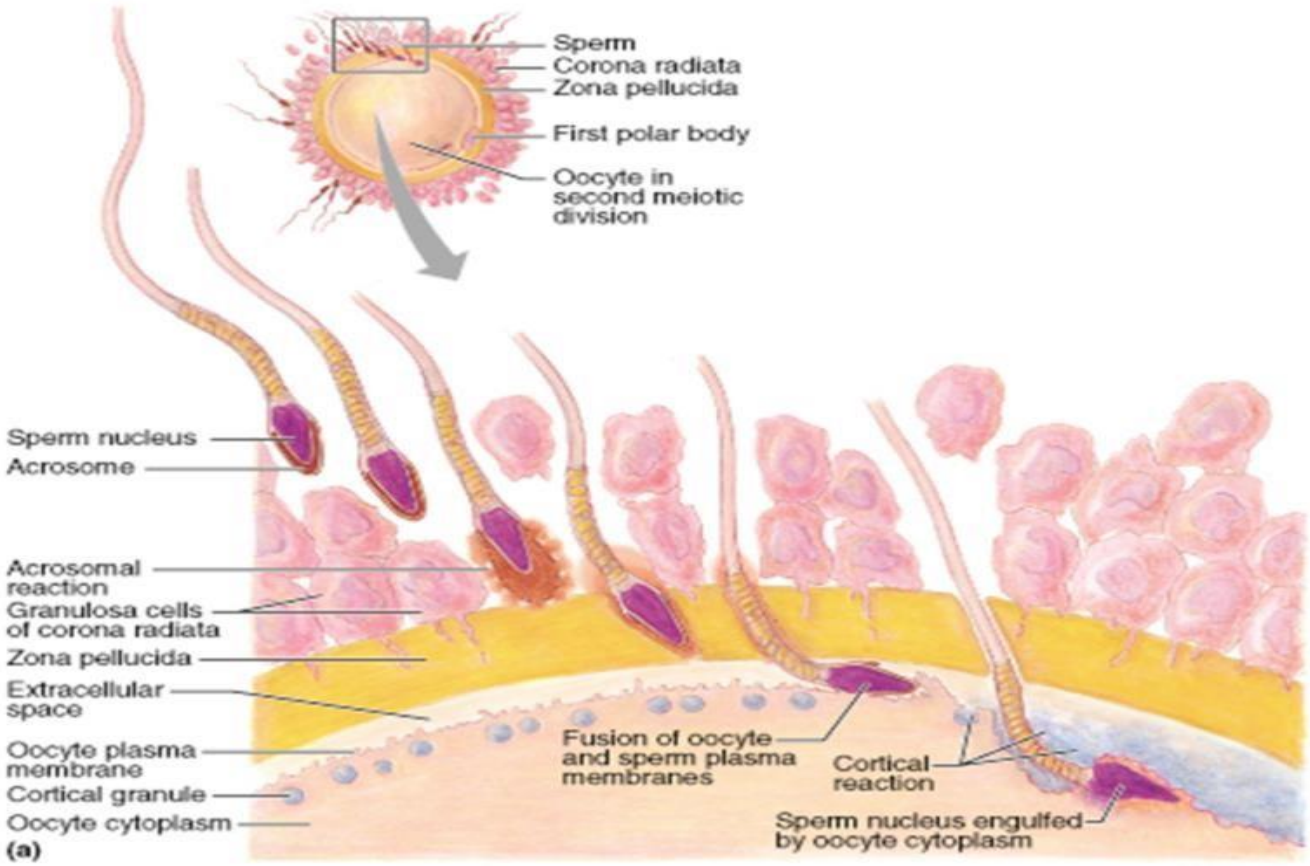
- After adhesion, the plasma membranes of the sperm and egg fuse. Because the plasma membrane covering the acrosomal head cap disappears during the acrosome reaction, actual fusion is accomplished between the oocyte membrane and the membrane that covers posterior region of the sperm head
- Both the **head and tail** of the spermatozoon enter the cytoplasm of the oocyte, but the plasma membrane is left behind on the oocyte surface.





- **What is the response of the 2ry oocyte to the entry of the sperm?**
  - Cortical and zona reaction.
  - Completion of the 2nd meiotic division.
  - Formation of the **female pronucleus and 2nd polar body.**
  - Formation of the **male pronucleus** and the **tail** detaches and degenerates.

- **The male and female pronuclei** fuse and lose their nuclear envelopes after replication of their DNA.

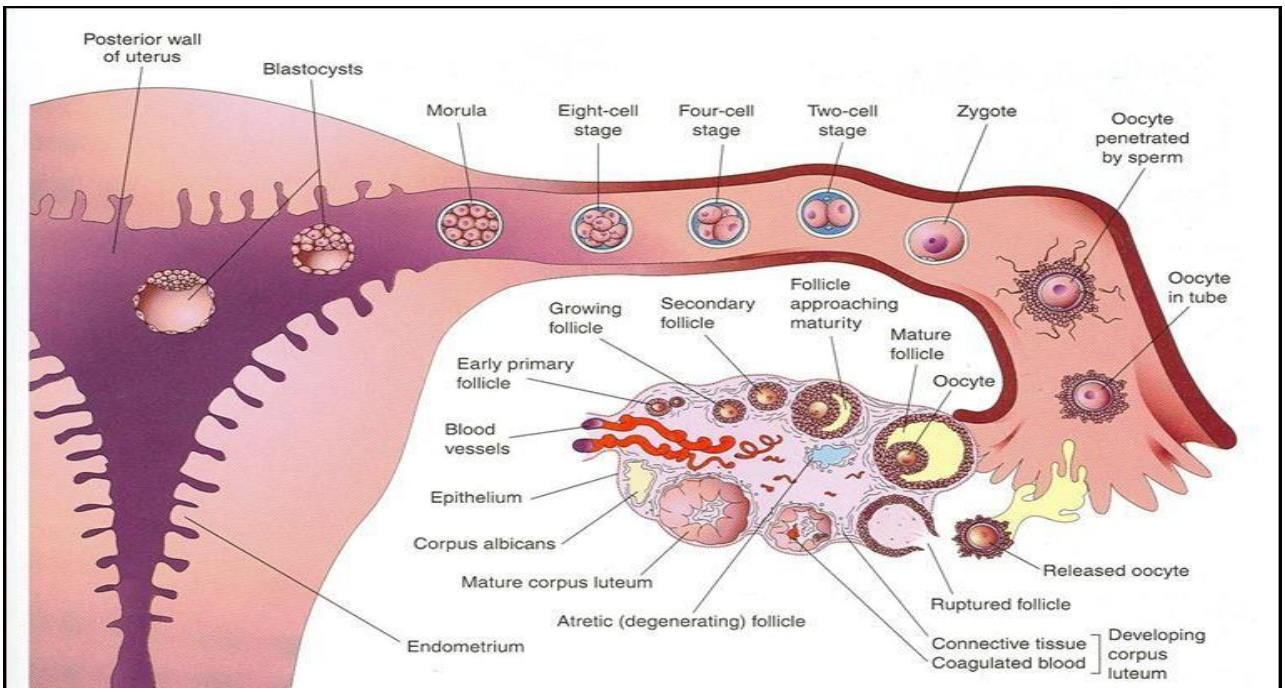


- **The main results of fertilization are as follows:**
  - **Restoration of the diploid number of chromosomes** (**46**)**,** half from the father and half from the mother.
  - **Determination of the sex of the new individual.** Sex is determined by the type of **sperm (X or Y)** that fertilizes the **oocyte (X),** producing a female (XX) embryo or a male (XY) embryo.
  - **Initiation of cleavage of the zygote.**
  - After fertilization, **Ovulation** and **Menstrual cycle** usually stop.
  - **Corpus luteum** enlarges and forms corpus luteum of pregnancy.
  - The **secretory phase of the endometrium** forms **decidua of pregnancy**.

Cleavage – Blastocyst formation

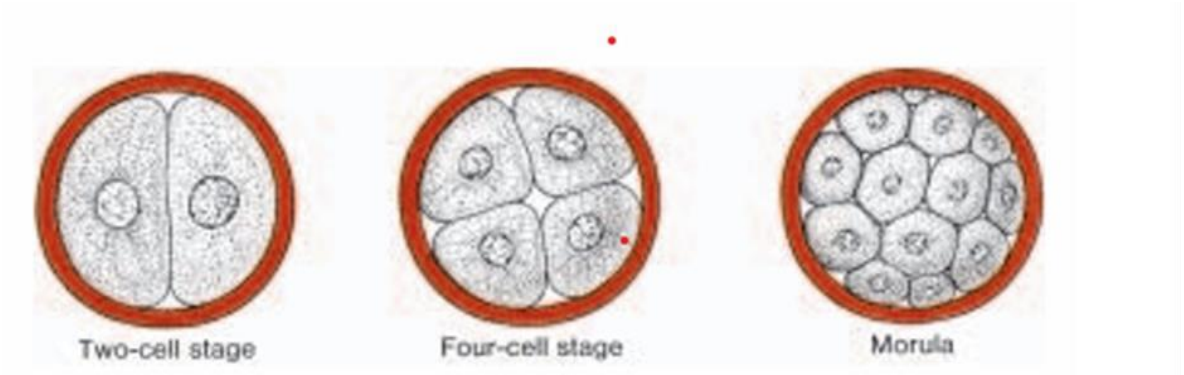
▪ Cleavage of Zygote:

- It begins about **30 hours after fertilization.**
- Normally occurs in the **uterine tube** during the journey of zygote in the uterine tube towards the uterine cavity.
- Once the zygote has reached the two-cell stage, it undergoes **a series of mitotic divisions**, increasing the numbers of cells **within the zona pellucida.**
- These cells, which become smaller with each cleavage division, are known as **blastomeres.**
- Blastomeres maximize their contact with each other, forming **a compact ball** of cells held together by tight junctions.
- Approximately **3 days after fertilization**, cells of the compacted embryo divide again to form **a 16-cell morula (mulberry).**



▪ Morula:

- **Morula** is a 16-cell stage. It resembles mulberry morula.
- Spherical Morula is formed about 3 days after fertilization.
- **Blastomeres** of Morula are surrounded by the zona pellucida, which disappears at the end of the **4th day**. Morula has no cavity inside it.
- The Morula reaches the uterine cavity by the **4th day** after fertilization & remains free for one or two days. Fluid passes from uterine cavity to the Morula.



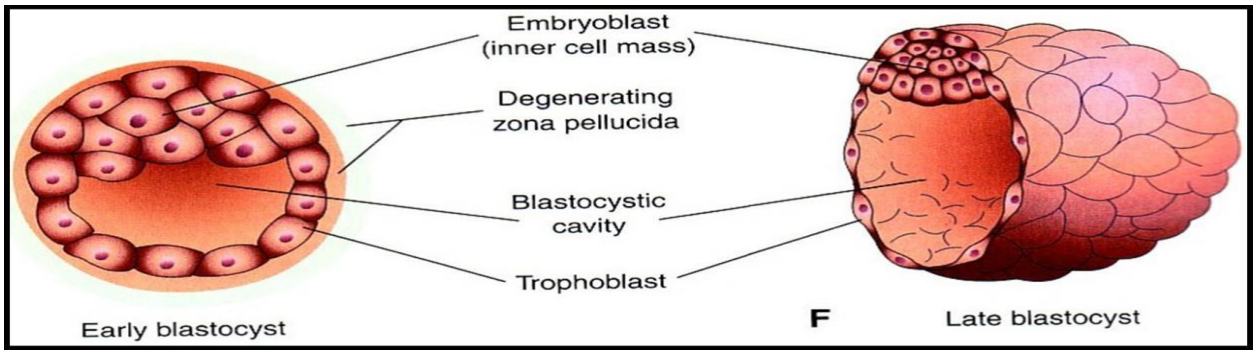
▪ Blastocyst formation:

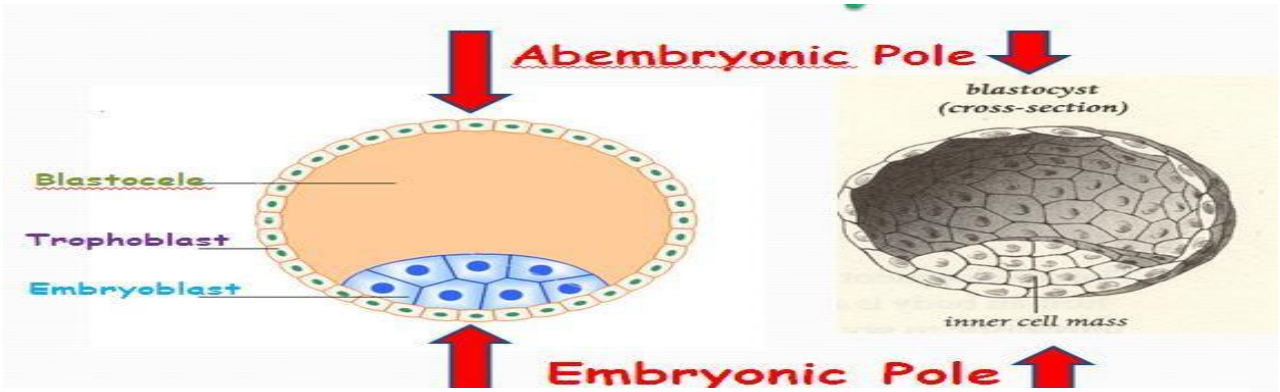
- About the time the morula enters the uterine cavity, fluid begins to penetrate

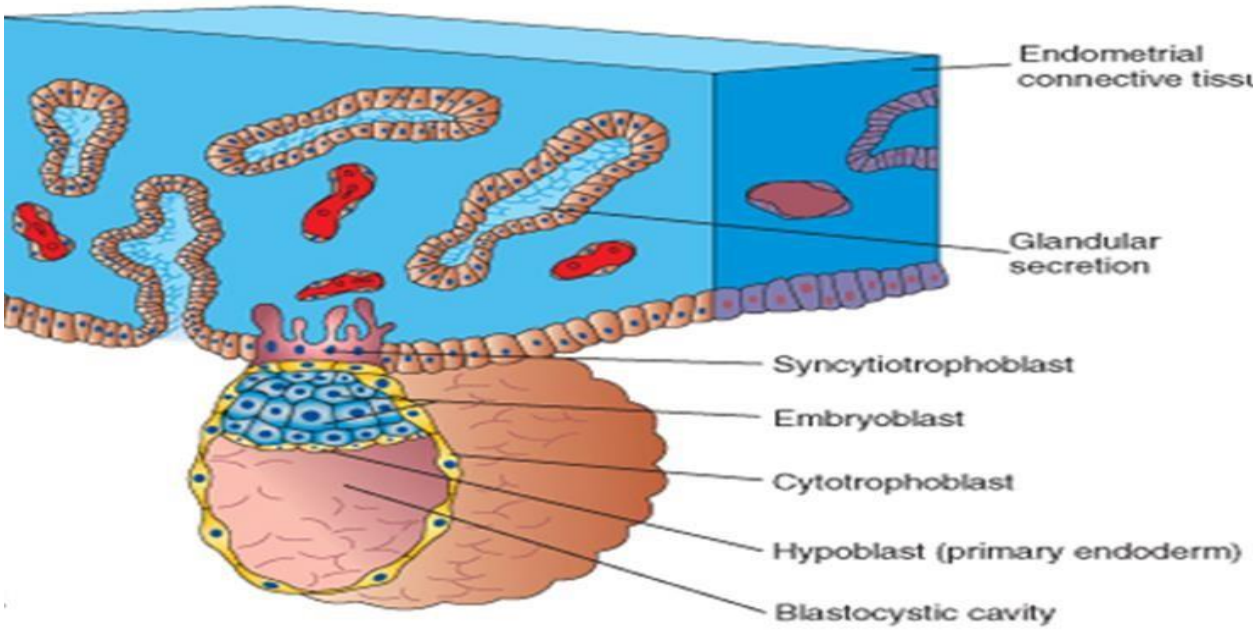
  through the zona pellucida into the intercellular spaces of the inner cell mass.
- Gradually the intercellular spaces become confluent, and finally a single cavity,

  Called **blastocele.**
- Currently, the embryo is a blastocyst. Cells of the inner cell mass, now called the **embryoblast,** are at one pole, and those of the outer cell mass, or **trophoblast**, form the epithelial wall of the blastocyst (nutrition of the embryo).
- **Zona pellucida** has disappeared, allowing implantation to begin.

- **Trophoblastic cells** over the embryoblast pole begin to penetrate between the epithelial cells of the uterine mucosa about the sixth day.
- **By the end of the first week of development**, the human zygote has passed through the morula and blastocyst stages and has begun implantation in the uterine mucosa.



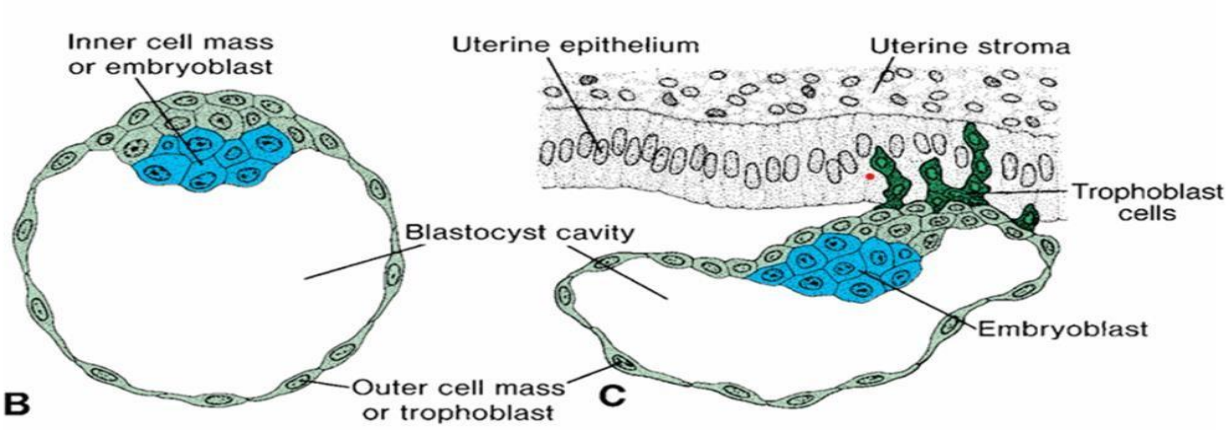


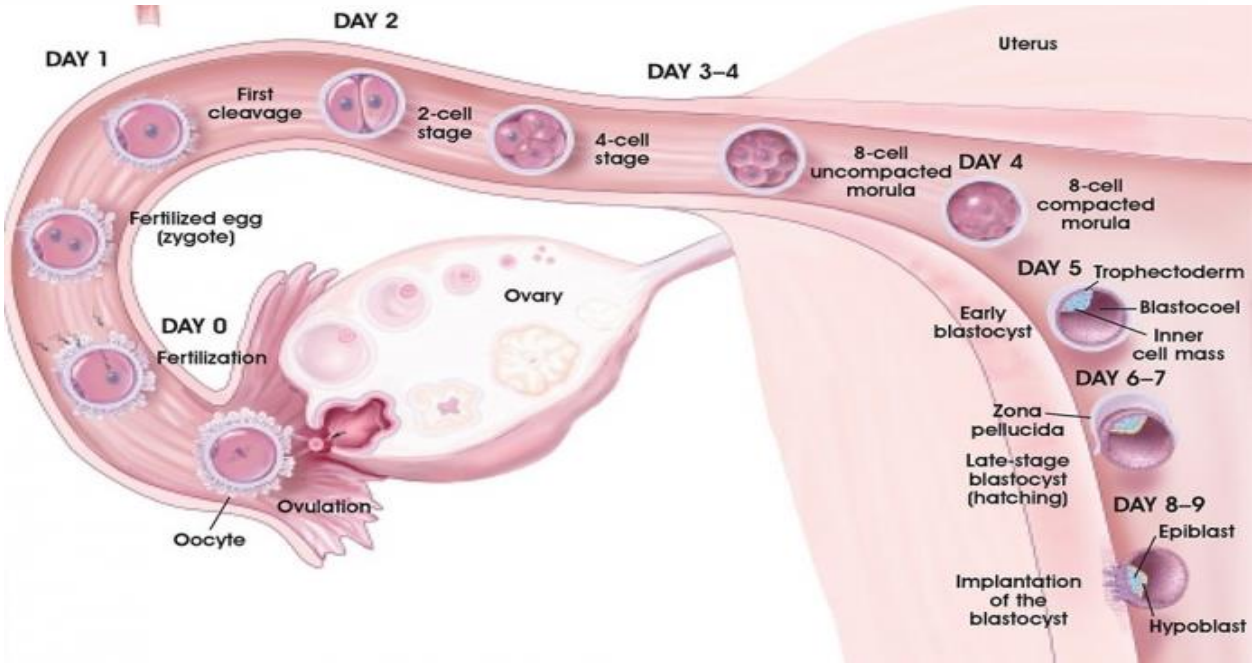


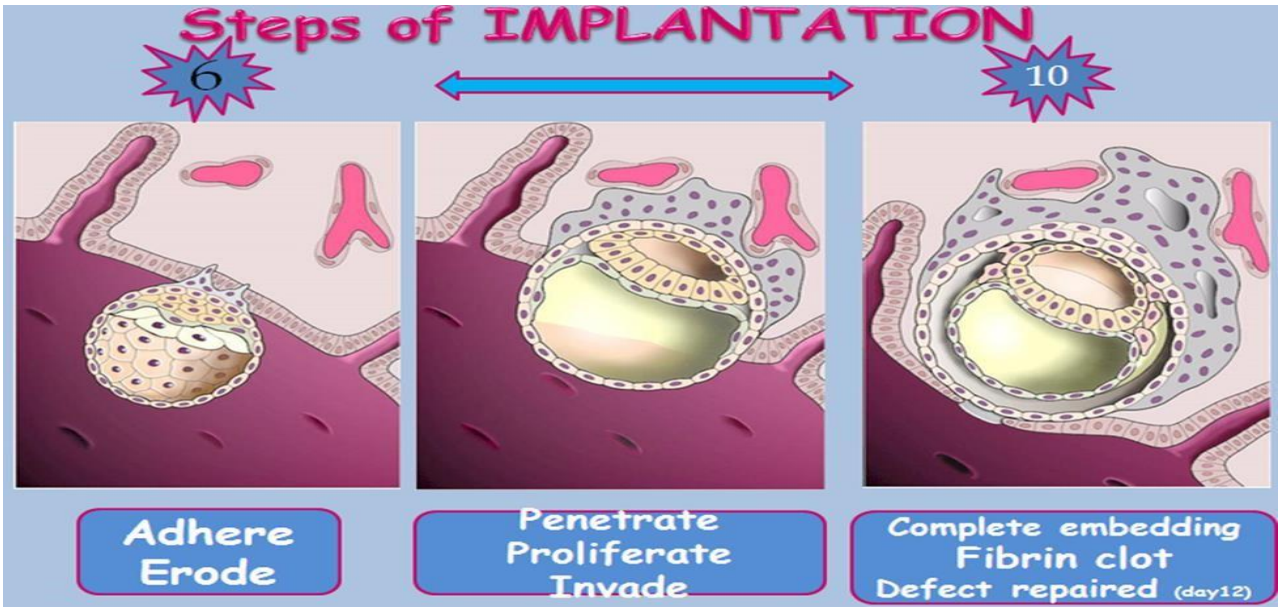
Uterus at time of implantation

- The "**implantation**" is the process of attachment and invasion of the endometrium by the blastocyst.
- This process begins at the end of **1st week** (about the **6th day**) and continues through the **2nd week** (completed by the **10th to 12th day**) of development.
- **Normal Implantation Site:** in upper part of posterior uterine wall near the fundus.
- **Steps:**
  - The **zona pellucida** must degenerate for implantation to occur.
  - By the **6th day,** the blastocyst adheres to the endometrium by its embryonic pole.
  - By the **7th day**, Trophoblast proliferates and differentiates into **2 layers:**
    1- **Cytotrophoblast**, an inner layer of mononucleated cells, mitotically active.
    2- **Syncytiotrophoblast** (outer multinucleated mass, with indistinct cell boundary. shows many finger-like processes which starts invading the endometrial epithelium and underlying connective tissue.

    - By the end of the 1st week, blastocyst is superficially embedded in the compact layer of the endometrium.
    - Just after fertilization, the endometrium starts a **decidual reaction** which becomes more marked after embedding of the blastocyst.
    - The blastocyst invades into the endometrium. After implantation is completed, the site of entry of the blastocyst is closed by a fibrin clot followed by endometrial healing & epithelial regeneration.
    - The basal layer remains to regenerate the other layers during the next cycle.
- Implantation can be detected by: **Ultrasonography & HCG** (human chorionic gonadotrophin which is secreted by the Syncytiotrophoblast) about the end of 2nd week.


Inner cell mass
or embryoblast
Uterine epithelium
Uterine stroma
Trophoblast
cells
Blastocyst cavity
Embryoblast
Outer cell mass
or trophoblast
B
C


DAY 1
DAY 2
DAY 3–4
Uterus
First
cleavage
2-cell
stage
4-cell
stage
8-cell
uncompacted
morula
DAY 4
8-cell
compacted
morula
Fertilized egg
(zygote)
Ovary
DAY 0
Fertilization
DAY 5
Trophectoderm
Blastocoel
Early
blastocyst
Inner
cell mass
DAY 6–7
Zona
pellucida
Late-stage
blastocyst
(hatching)
Ovulation
Oocyte
DAY 8–9
Epiblast
Implantation
of the
blastocyst
Hypoblast


Steps of IMPLANTATION
6
10
Adhere
Erode
Penetrate
Proliferate
Invade
Complete embedding
Fibrin clot
Defect repaired (day12)

Abnormal sites of implantation:

- **Intrauterine: (Placenta previa)** Implantation occurs at **the lower uterine segment near to the cervix.**

- **Three types:**

A. **Placenta previa centralis →** Placenta is completely covering the internal os of the cervix.
B. **Placenta previa marginalis →** Placental margin covers the internal os.
C. **Placenta previa lateralis (Parietalis) →** Placental margin is near to the internal os.

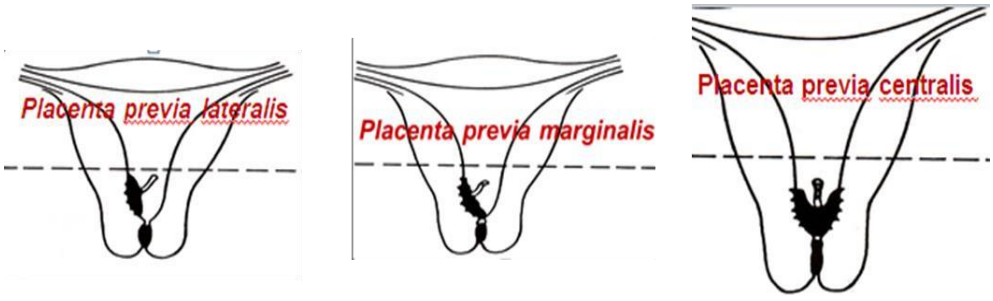
- **Extra-uterine implantation (ectopic pregnancy):** Implantation occurs outside the uterine cavity.

Types:

1- **Tubal pregnancy:**
   - **95% of ectopic pregnancies** occur in the uterine tube, and most of these are in the ampulla.
   - Incidence: 10-20 /1000 pregnancy (high).
   - The tube can't withstand distension & ruptured during the 2nd month of pregnancy with fatal hemorrhage.

2- **Ovarian pregnancy**: implantation on the surface of the ovary.

3- **Intestinal (abdominal) pregnancy:** implantation on the surface of the intestine or rectouterine pouch of Douglas.



Decidua:

- **Definition**: Decidua is the endometrium after implantation. Stroma cells enlarged and filled with glycogen & lipids (decidua cells). It becomes highly vascular & secretory to nourish the embryo.

Parts of the Decidua

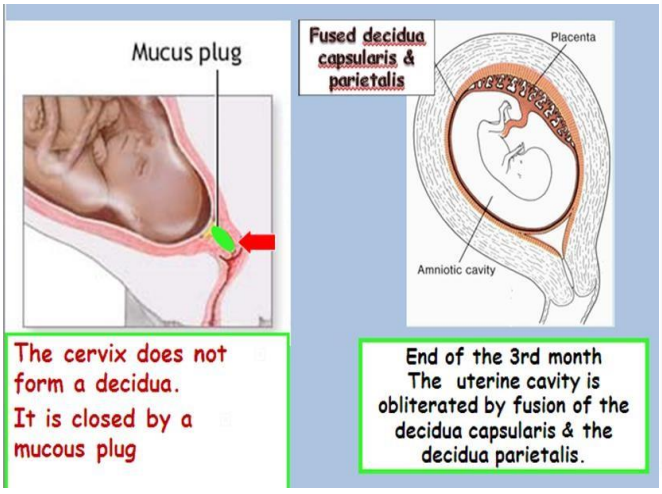
1) Decidua **basalis** : The part that lies deep to the blastocyst (its base) between blastocyst & muscle wall of uterus (myometrium)

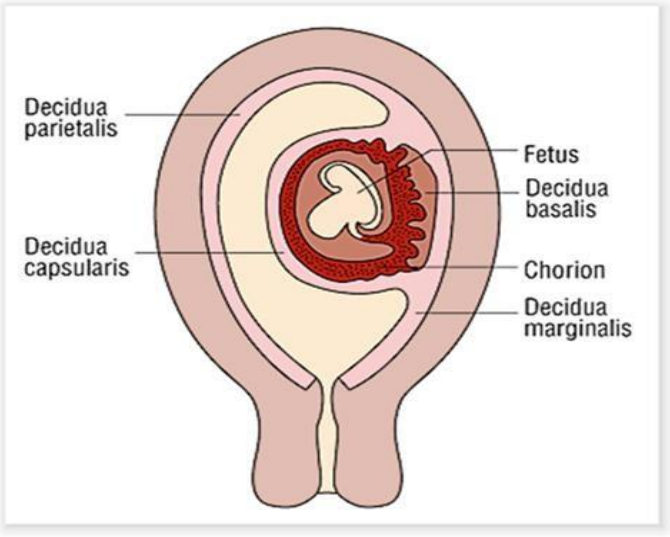
2) Decidua **capsularis** : The part that lies superficial

3) Decidua **parietalis** : The part that lines the wall of uterine cavity (away from remaining blastocyst) End of the 3rd month uterine cavity is occluded by fusion of decidua parietalis & capsularis.

- **The Decidua is shedded completely at the time of childbirth.**

- **The cervix does not form a decidua. It is closed by a mucous plug.**
- **The decidua basalis** is the decidual layer over the **embryonic pole** of the blastocyst.
- The **decidua capsularis** is the decidual layer over the **ab-embryonic pole** of the blastocyst





2nd week of development

- **Events of The Second Week**
  - Completion of implantation.
  - Formation of Bilaminar Embryonic Disc.
  - Formation of the yolk sac and amnion.
  - Formation of The Extra-embryonic Mesoderm.
  - Development of The Chorionic Villi So the second week is the week of two:

  • **Two cavities (Amnion & Yolk sac).**

  • **Two layers of inner cell mass (Epiblast & Hypoblast).**

  • **Two layers of outer cell mass (cytotrophoblast & syncytiotrophoblast).**

- **Changes in the outer cell mass:**

point	Syncytiotrophoblast	Cytotrophoblast
formation	Fused external cell mass with no separating cell membranes in between	Inner layer of cells with well-defined cell boundaries.
function	Concerned with: 1. Secretion of proteolytic enzymes to invade into the endometrium during implantation. 2. Production of hCG (human chorionic gonadotrphin) which is a hormone of LH-like activity that maintain the corpus luteum of pregnancy till the 4th month.	Immature form & continuously dividing to form the Syncytiotrophoblast.

Further changes in the trophoblast:

- The trophoblast proliferates to form **finger like** projections called the **primary villi** to increase its surface area.

- The cytotrophobast proliferates inward to form another cell layer called: the **extraembryonic mesoderm**.
- Due to proteolytic activity, spaces filled with maternal blood, called **lacunae** appear within the syncytiotrophoblast with starting of the placental circulation

- **Changes in the inner cell mass:**

- The inner cell mass or **embryoblast** differentiates into:

(1) The **epiblast** (tall columnar cells, dorsal layer)

(2) The **hypoblast** (low cubical cells, ventral layer), together forming a bilaminar embryonic disc.

Resulting in formation of Bilaminar Embryonic Disc

A small cavity appears within the epiblast (Amniotic cavity).

point	Epiblast	Hypoblast
formation	A dorsal layer of tall columnar cells facing the amniotic cavity.	A ventral layer of low cuboidal cells facing the yolk sac cavity.
function	Concerned with formation of the 3 germ layers during 3rd week: 1. Ectoderm. 2. Mesoderm. 3. Endoderm.	Of unknwon function & displaced out into the fetal membranes.

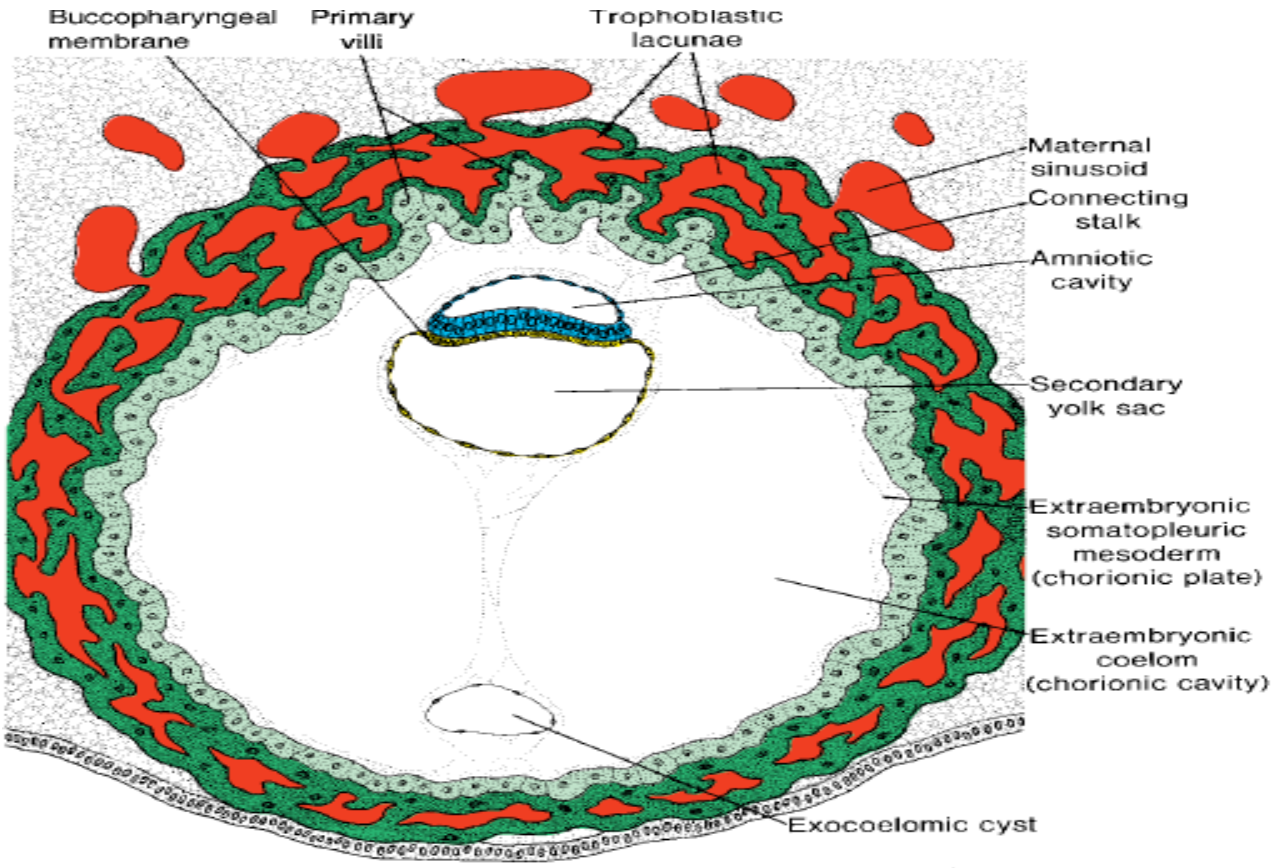
- **Embryonic cavities during second week:**

point	Amniotic cavity	Yolk sac cavity
formation	A dorsal cavity, related to the epiblast.	A ventral cavity, related to hypoblast.
boundaries	• Roof → amnioblast cells. • Floor → epiblast layer.	• Roof → hypoblast layer. • Floor → exocelomic membrane.
function	The cavity progressively enlarges to surround the whole embryo.	It divides into smaller secondary yolk sac (~ 13th day), then after folding of the embryo (by 4th week), the definitive yolk sac remains outside the fetus body &finally degenerates

- **Extraembryonic cavity during second week (chorionic cavity):**

- **Formation:**
  - From the inward proliferation of the cytotrophoblast.
  - On the **9th day**, small cavities appear within the extraembryonic mesoderm.
  - On the **13th day**, these cavities collect to form a single cavity called the extraembryonic **(Chorionic) cavity**. Now the blastocyst is called **Chorionic vesicle.**
  - The embryonic vesicle is separated from the trophoblast **except** at the site of **connecting stalk** which forms the **future umbilical cord**.
  - The secondary yolk sac has an extension into the connecting stalk called **Allantois** which is involved in development of the **urinary bladder** later.
  - **Layers:**
    - **Visceral (Splanchnic) layer → covers the secondary yolk sac.**

- **Parietal (somatic) layer → covers the amniotic cavity, forms the connecting stalk & lines the cytotrophoblast.**



Third Week of Development

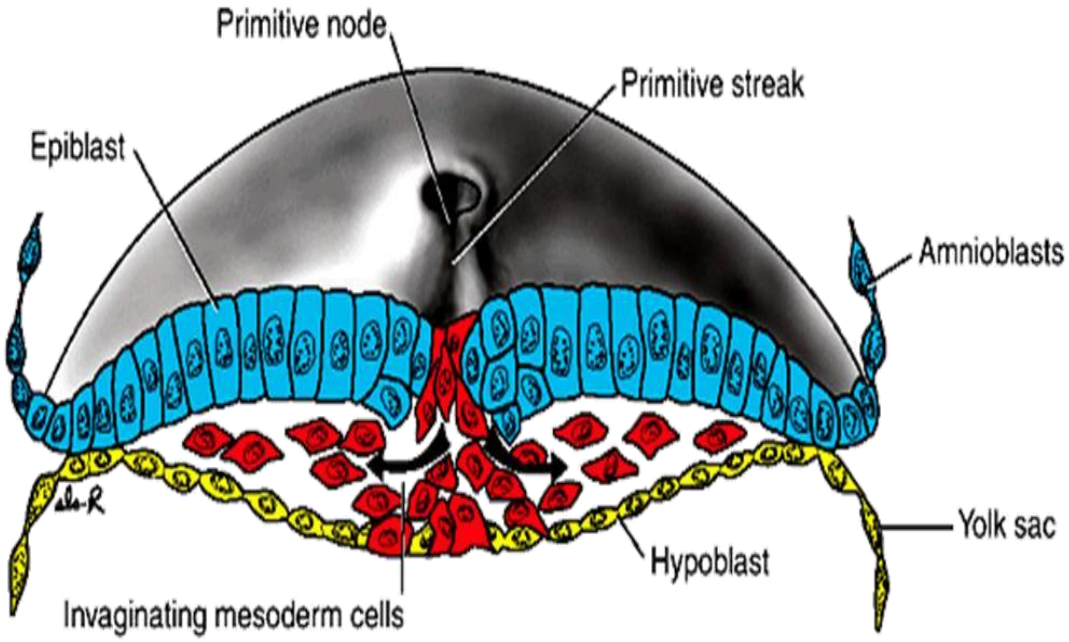
- **Events of The Second Week:**

➢ The third week is the week of formation of three:

- **Three cavities (Amnion, Yolk sac & chorionic cavity).**
- **Trilaminar germ disc (Ectoderm, Mesoderm & Endoderm).**
- **Three types of chorionic villi (primary, secondary & tertiary).**

Gastrulation:

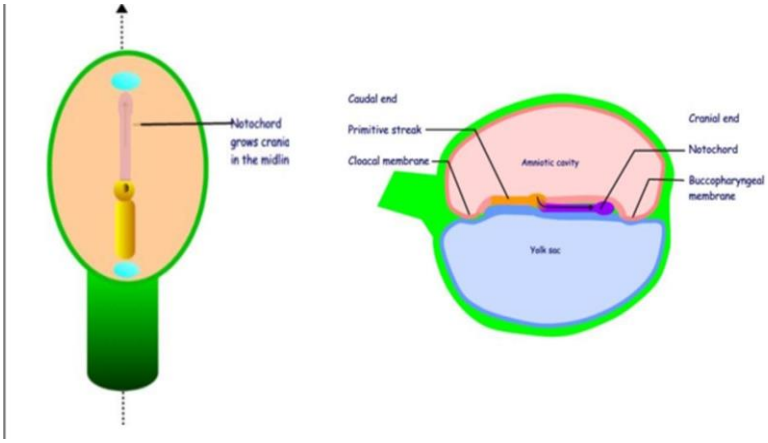
- The process of formation of trilaminar germ disc (ectoderm, mesoderm and endoderm).
- It occurs during 3rd week of pregnancy.
- This process preceded by formation of **6 midline structures** in the **embryonic disc.**

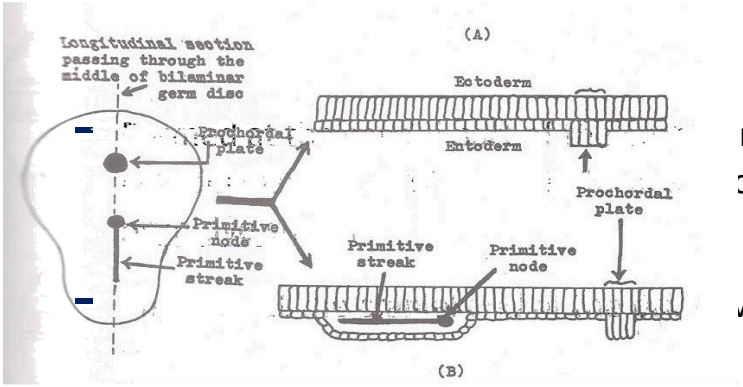


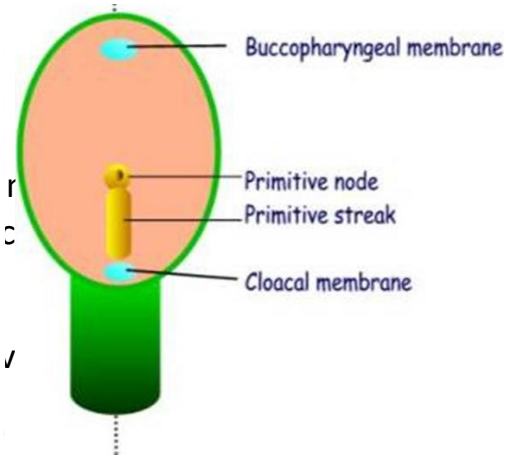
- **Six midline structures preceding formation of intraembryonic mesoderm:**

1- Prechordal plate (oropharyngeal membrane)

- It is formed at the cranial end of the embryonic disc, where some midline endodermal cells become columnar and fuse tightly with the overlying ectoderm.
- It is the site of future mouth.
- They disappear by the end of 4th week.







3- Cloacal membrane

- It is a midline circular area caudal to the primitive streak where there is a tight fusion between the endoderm and ectoderm.
- It is the site of future anus.

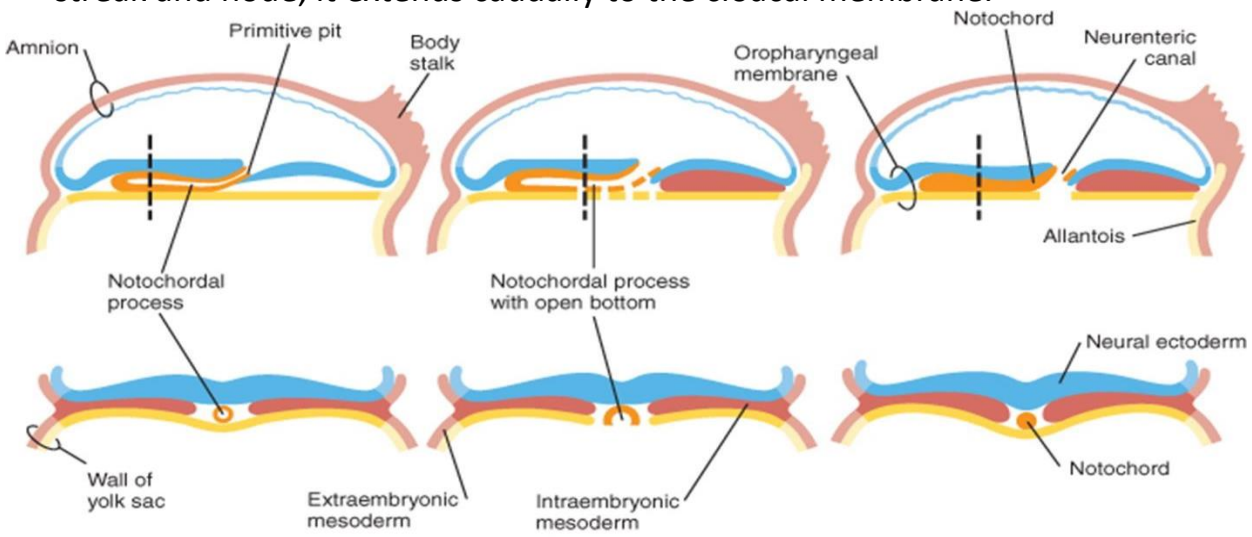
4-Notochord

- Cells of the primitive node proliferate and form a median cellular cord called the notochordal process, which insinuates itself between the ectoderm and endoderm.
- Notochordal process is transformed into notochordal plate, which infolds to form the definitive notochord.
- **Functions of notochord:**
  a) Define the axis of embryo.

b) Provides temporal support for developing embryos.
c) Vertebral column develops around it.
d) Induces formation of the neural tube.
e) Its remnants give the nucleus pulposus of every intervertebral disc and apical ligament of 2nd cervical vertebra (axis vertebra).

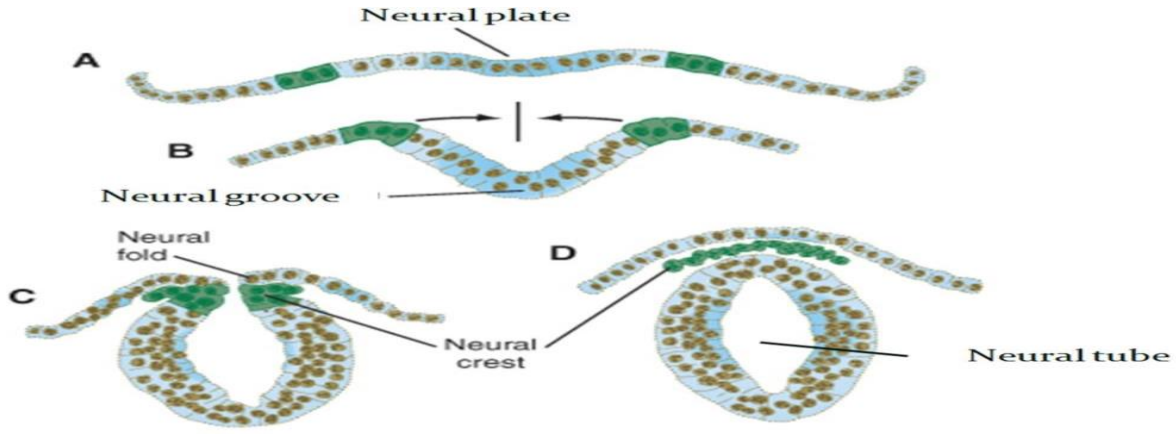
➢ **Extension of notochord:**

At first, it extends between prechordal plate (cranial to it) and primitive node and streak (caudal to it), with degeneration of the primitive streak and node, it extends caudally to the cloacal membrane.

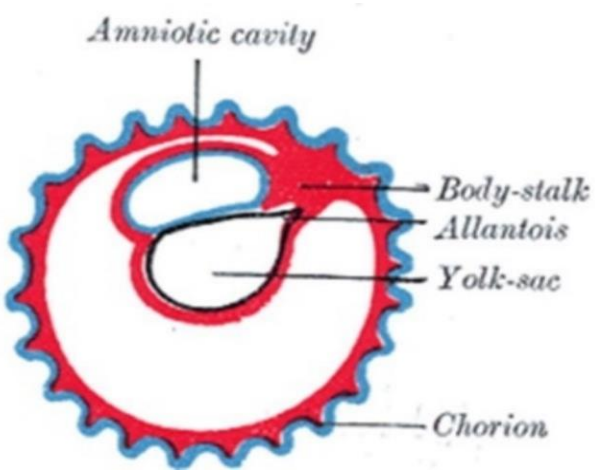


5- Neural tube and neural crest

- The cranial part of ectoderm thickens to form the neural plate.
- The neural plate transformed into neural groove.
- The neural folds fuse with each other to form the neural tube.
- Ectodermal cells lateral to each neural fold thicken and separate from the surface ectoderm and come to lie on the sides of the neural tube to form **neural crest**.



6- Allantois



- It is dorsocaudal diverticulum, derived from the yolk sac and projects into the connecting stalk.
- It will form part of urinary bladder.

Growth of the Embryonic Disc

- The embryonic disc, initially flat and almost round, gradually becomes elongated, with a broad cephalic and a narrow caudal end.
- Expansion of the embryonic disc occurs mainly in the cephalic region. Growth and elongation of the cephalic part of the disc are caused by a continuous migration of cells from the primitive streak region in a cephalic direction.
- Invagination of surface cells in the primitive streak and their subsequent migration forward and laterally continues until the end of the fourth week. At that stage, the primitive streak shows regressive changes, rapidly shrinks, and soon disappears.
- That the primitive streak at the caudal end of the disc continues to supply new cells **until the end of the fourth week** has an important bearing on development of the embryo.
- In the cephalic part, germ layers begin their specific differentiation by the middle of the third week, whereas in the caudal part, differentiation begins by the end of the fourth week.

Further development of the Trophoblast

- Small cavities appear in this mesoderm, that coalesce together to form a single cavity called the extra-embryonic coelom (chorionic cavity), which splits the mesoderm into two layers:

1. **An outer layer**: lining the trophoblast and covering the amnion, is called **somatic or parietal layer** of extraembryonic mesoderm.
2. **An inner layer:** covering the yolk sac, is called **visceral (splanchnic) layer** of extraembryonic mesoderm.

- The trophoblast & the underlying somatic extra-embryonic mesoderm is called chorionic plate, and the blastocyst is now called (Chorionic vesicle).
- Cavities develop in extra-embryonic mesoderm.
- All cavities unite into one space called: extra-embryonic coelom (Chorionic Cavity) except at the caudal end of embryo Connecting Stalk.

Development of chorionic villi

- The wall of the chorionic vesicle is termed the **chorion**; it is composed of 3 layers (from outside to inside):

1- **Syncytiotrophoblast.**
2- **Cytotrophoblast.**
3- **Somatic layer of primary (extraembryonic) mesoderm.**

- The outer surface of the chorionic vesicle shows many proliferations of the cytotrophoblast toward syncytiotrophoblast termed (**Chorionic villi**).
- The villi lying opposite the decidua basalis are well-developed and branched, are termed (**Chorion frondosum**).
- The villi lying in contact with the **decidua capsularis** are less developed (**atrophic**) and are termed (**Chorion laeve**).

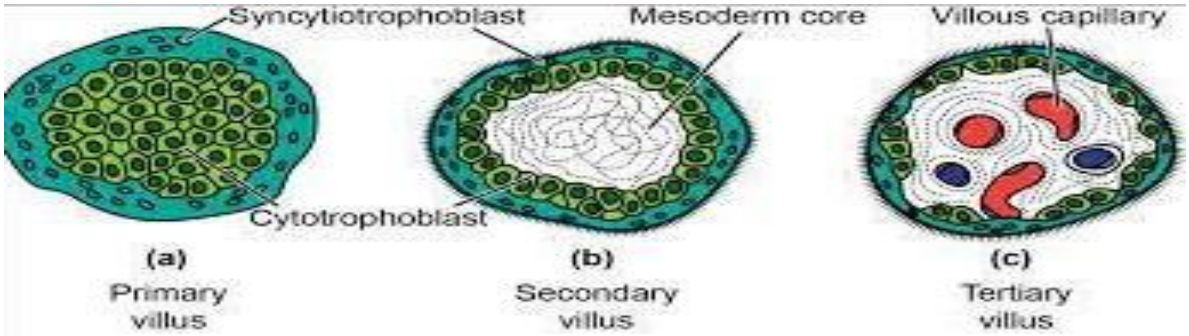
Types of chorionic villi

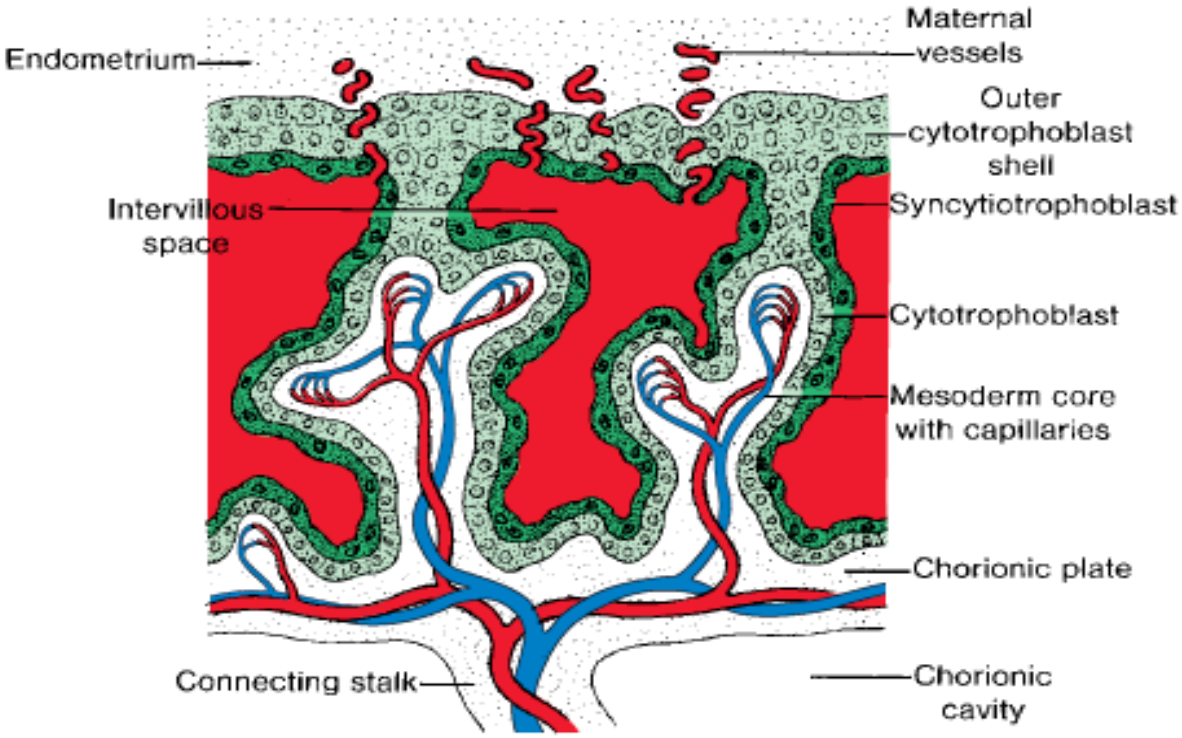
- There are 3 types of villi according to their **structure**:

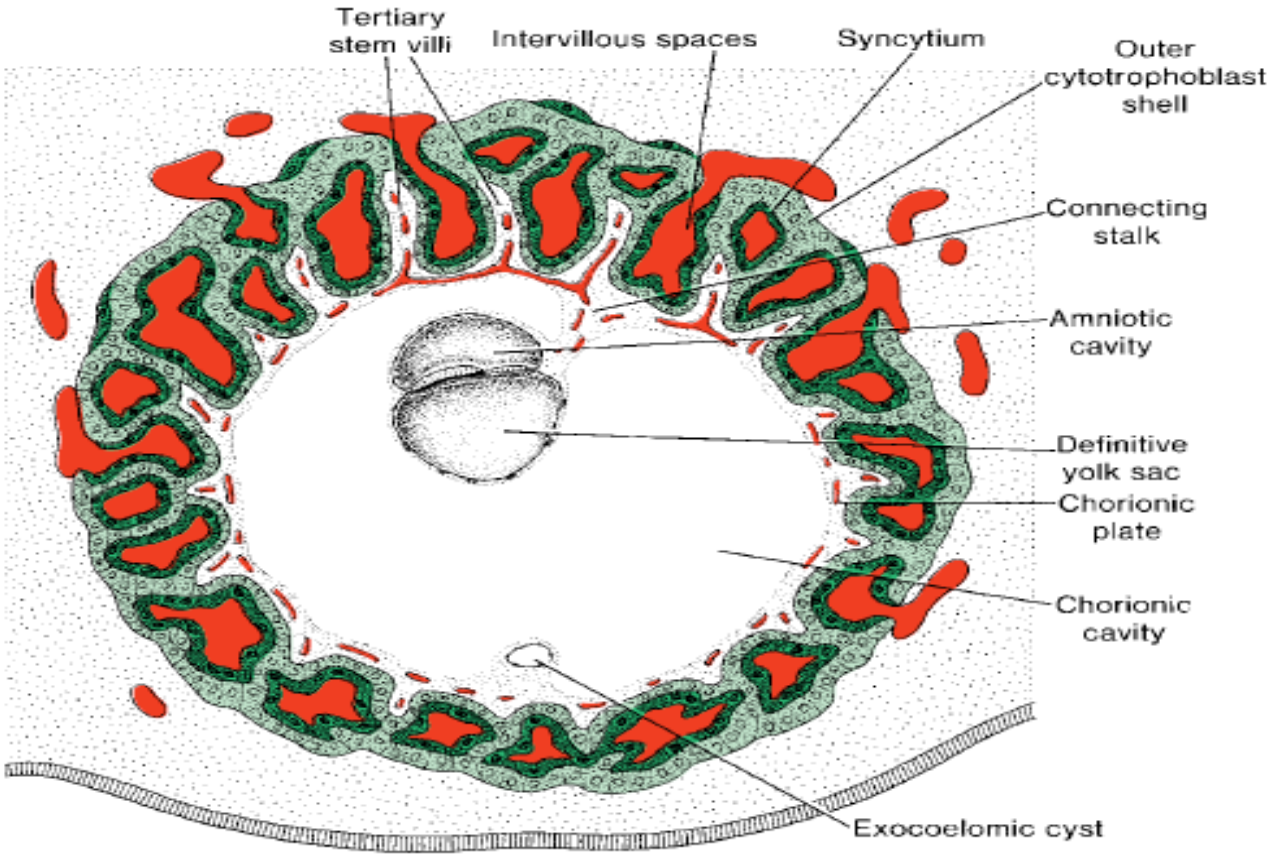
1- **Primary villi (begin of 3rd week):** consist of the 2 layers of trophoblast a **cytotrophoblastic core** covered by a **syncytial layer.** Villi are separated from each other by lacunae filled with maternal blood.

2- **Secondary villi (middle of 3rd week),** It is formed of core extraembryonic mesoderm covered by cytotrophoblast & syncytiotrophoblast.
3- **Tertiary Villi (By the end of 3rd week)**, mesodermal cells in the core of the villus begin to differentiate into blood cells and small blood vessels, forming the villous capillary system. Capillaries in tertiary villi contact capillaries developing in mesoderm of the chorionic plate and in the connecting stalk. These vessels, in turn, establish contact with the intraembryonic circulatory system, connecting the placenta and the embryo.

- **cytotrophoblastic cells** in the villi penetrate progressively into the overlying syncytium until they reach the maternal endometrium.
- Here they establish contact with similar extensions of neighboring villous stems, forming a thin outer **cytotrophoblast shell**.
- This shell gradually surrounds the trophoblast entirely and attaches the chorionic sac firmly to the maternal endometrial tissue.
- Villi that extend from the chorionic plate to the decidual plate are called **stem or anchoring villi.** Those that branch from the sides of stem villi **are free (terminal) villi,** through which exchange of nutrients and other factors will occur.
- The chorionic cavity becomes larger, and by the 19th or 20th day, the embryo is attached to its trophoblastic shell **by a narrow connecting stalk.** The connecting stalk later develops into the umbilical cord, which forms the connection between placenta and embryo.




Endometrium
Maternal vessels
Outer cytotrophoblast shell
Intervillous space
Syncytiotrophoblast
Cytotrophoblast
Mesoderm core with capillaries
Chorionic plate
Connecting stalk
Chorionic cavity


Tertiary stem villi
Intervillous spaces
Syncytium
Outer cytotrophoblast shell
Connecting stalk
Amniotic cavity
Definitive yolk sac
Chorionic plate
Chorionic cavity
Exocoelomic cyst

Third to Eighth Week

(Embryonic Period)

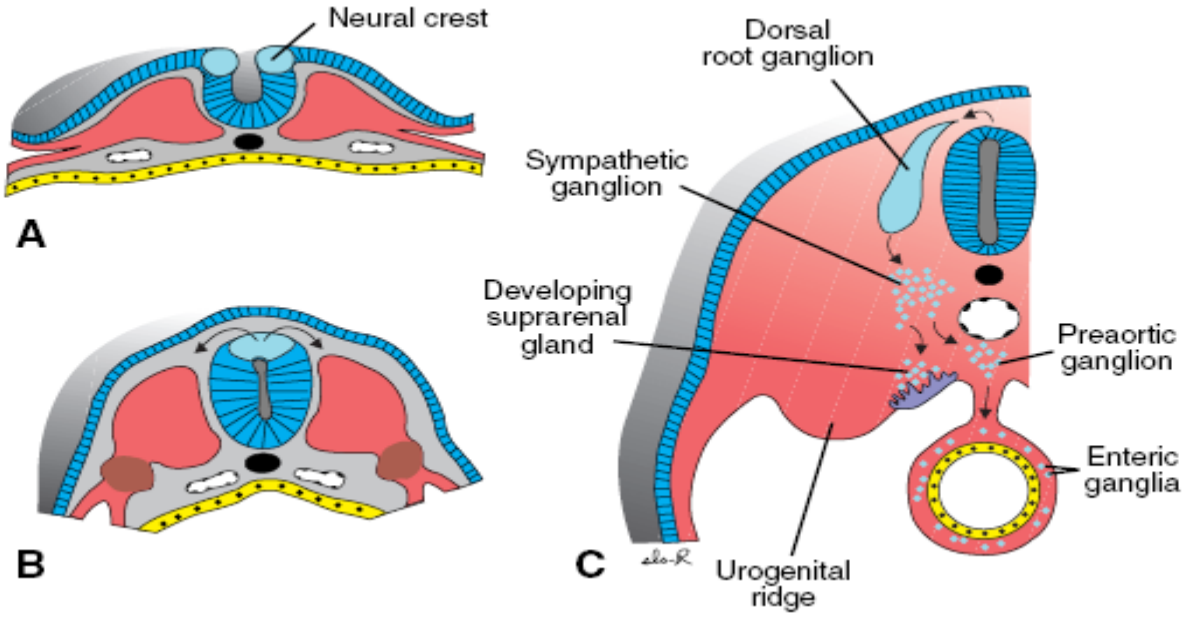
- The embryonic period or period of organogenesis occurs from the third to the eighth weeks of development and is the time when each of the three germ layers, ectoderm, mesoderm, and endoderm, gives rise to several specific tissues and organs.
- By the end of the embryonic period, the main organ systems have been established, rendering the major features of the external body form recognizable by the end of the second month.
- At the beginning of the third week of development, the ectodermal

  germ layer has the shape of a disc that is broader in the cephalic than the caudal region.
- Appearance of the **notochord** and **prechordal mesoderm** induces the overlying ectoderm to thicken and form the neural plate. Cells of the plate make up the **neuroectoderm** and their induction represents the initial event in the process of neurulation.

NEURULATION:

- Once induction has occurred, the elongated, slipper-shaped **neural plate** gradually expands toward the primitive streak.
- By the end of the third week, the lateral edges of the neural plate become more elevated to form **neural folds**, and the depressed mid-region forms **the neural groove.**
- Gradually, the neural folds approach each other in the midline, where they fuse. Fusion begins in the cervical region and proceeds cranially and caudally. As a result, **the neural tube** is formed.

- Until fusion is complete, the cephalic and caudal ends of the neural tube communicate with the amniotic cavity by way of the cranial and caudal neuropores, respectively.
- **Closure of the cranial neuropore** occurs at approximately day 25, whereas the **posterior neuropore closes** at day 27.
- Neurulation is then complete, and the central nervous system is represented by a closed tubular structure with a narrow caudal portion, the **spinal cord**, and a much broader cephalic portion characterized by a few dilations, the **brain vesicles**.
  - As the neural folds elevate and fuse, cells at the lateral border or crest of the neuroectoderm begin to dissociate from their neighbors. This cell population, the **neural crest**. which leaves the neuroectoderm by active migration and displacement to enter the underlying mesoderm.



Derivatives of Ectodermal Germ Layer

- Ectoderm is the outermost layer which gives off all structures that react with the external environment.
- **Surface ectoderm** gives off:
  - Epidermis of the skin & skin appendages (hair, nail. Sweat & sebaceous glands).
  - Lower ½ of anal canal.
  - Mouth vestibule & parotid gland.
  - External & internal ears.
  - Eye: cornea, conjunctiva, eye lens, muscles of iris & (retina from neuroectoderm)
- **Neuro-ectoderm** gives off:
  - Neural tube: brain & spinal cord.
  - Neural crest cells.
- **Neural Crest Derivatives:**
  - Connective tissue and bones of the face and skull.
  - Cranial nerve ganglia.
  - C- cells of the thyroid gland.
  - Cono truncal septum in the heart.
  - Odontoblasts.
  - Dermis in face and neck.
  - Spinal (dorsal root) ganglia.
  - Sympathetic chain and preaortic ganglia.
  - Parasympathetic ganglia of the gastrointestinal tract.
  - Adrenal medulla.
  - Schwann cells.
  - Glial cells.
  - Arachnoid and pia mater (leptomeninges).
  - Melanocytes.

Derivatives of the Mesodermal Germ Layer

(Intraembryonic mesoderm IEM)

- **<u>It is derived from three sources</u>**:

  1- Primitive streak

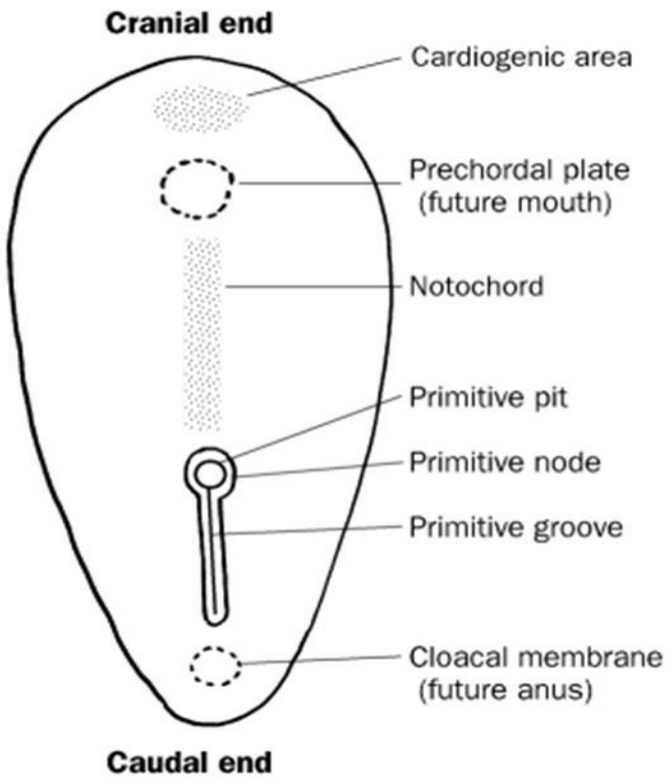
  2- Primitive node

  3- Notochord

- **<u>It is absent from three sites:</u>**

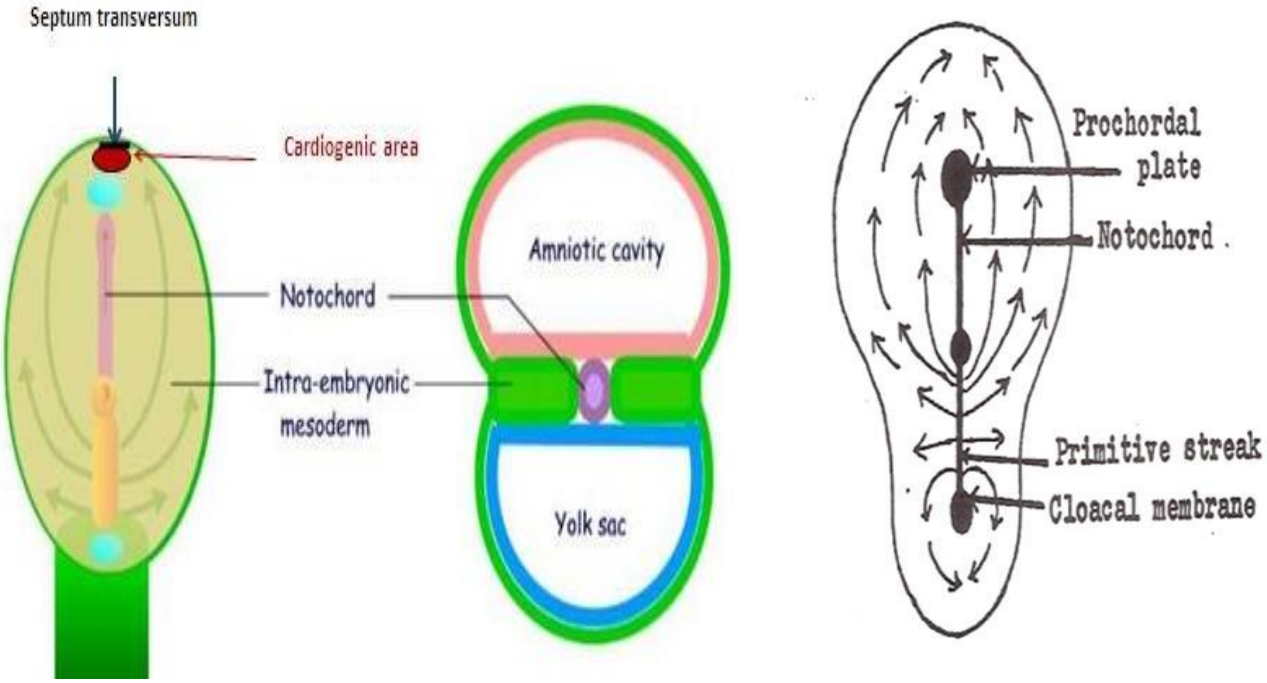
  1. In the region of the **oropharyngeal membrane.**

  2. In the region of the midline of the embryonic disc, occupied by the **notochord**, primitive node and primitive streak.



  3. In the region of the **cloacal membrane.**

- The cells of the I E M migrate sideways between ectoderm and endoderm and are condensed at three sites which form an **inverted U - shaped structure.**
- **On each side of** the notochord, primitive node and primitive streak.
- Some cells migrate cranial to the prechordal plate to form the **cardiogenic area (future heart).**
- Some cells migrate more cranially anterior to the cardiogenic area, forming the **septum transversum (future diaphragm).**

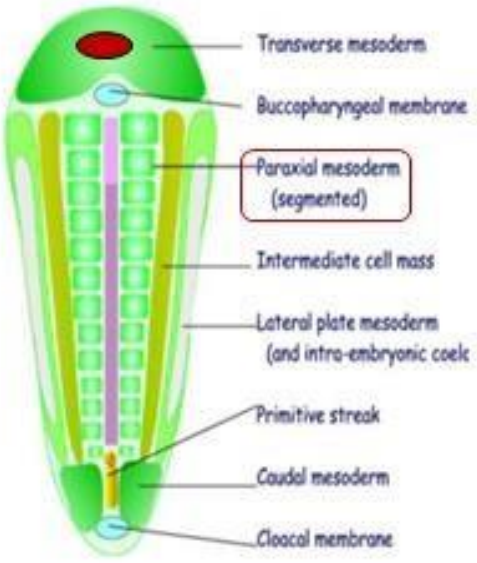


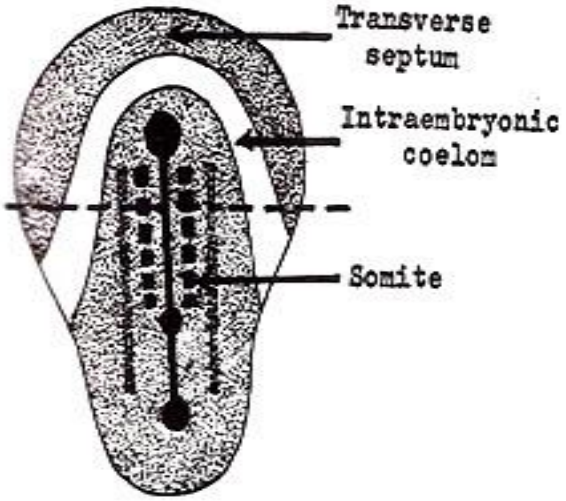
Derivatives of paraxial mesoderm

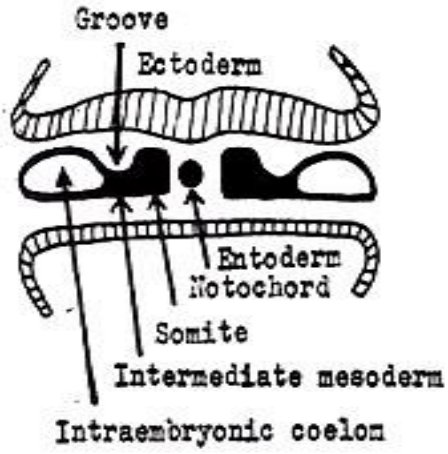
It is divided into paired cubical masses called **somites.**

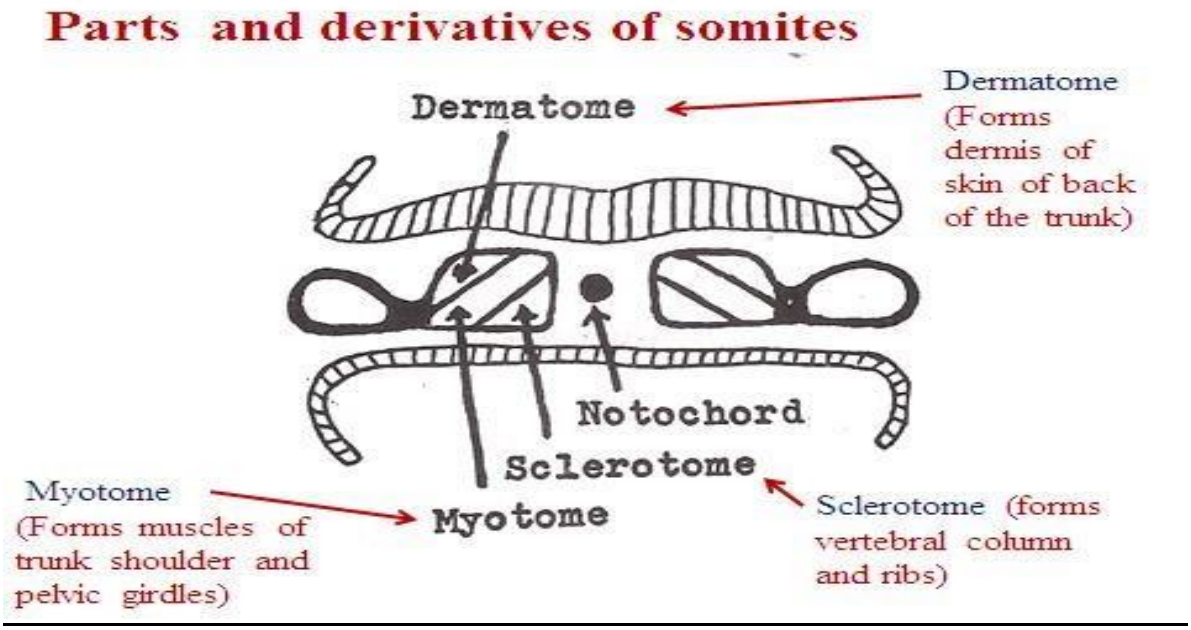
-The first pair of somites appear at 20th day of development and by the end of the 5th week, 42 - 44 pairs could be identified:

4 occipital
8 cervical
12 thoracic
5 lumbar
5 sacral and
8-10 coccygeal somites.









<u>The 4 occipital somites have special fate:</u>

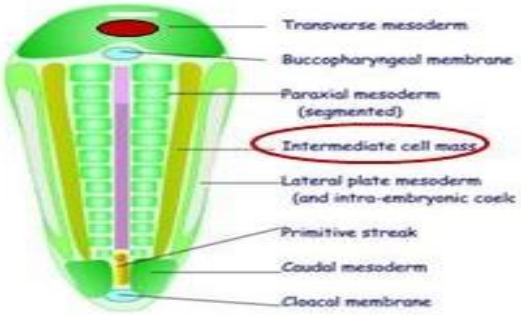
1. The 1st somite disappears.

2. The 2nd , 3rd and 4th scleretomes form most of the occipital bone of the skull.

The 2nd , 3rd and 4th myotomes form muscles of the tongue.

Derivatives of intermediate cell mass

Called nephrogenic cord and gives most of genitourinary system

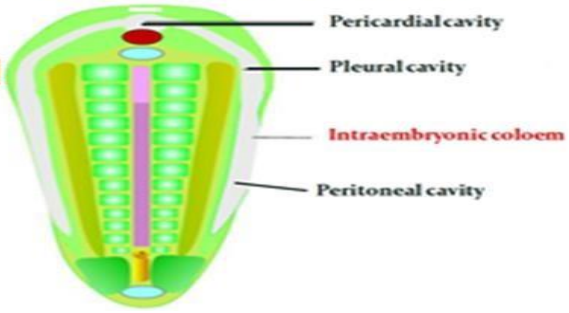


Derivatives of lateral plate mesoderm

- Cavities appear in that plate which fuse together to form an inverted horseshoe — shaped cavity called the intraembryonic coloem (I E C).

The I E C gives rise to three serous cavities:

1. Pericardial cavity.
2. Right and left pleural cavities.
3. Peritoneal cavity.



- **The I E C divides the lateral plate mesoderm into:**

1- **Somatic or parietal layer** which is called **somatopleure**. It forms the dermis of the ventrolateral part of the trunk and forms the whole appendicular skeleton (bones, joints, muscles, vessels and dermis of the limbs).

2. **Splanchnic or visceral layer**, which is called the **splanchnopleure**. It forms connective tissue, smooth muscles and vessels of the gastrointestinal tract, respiratory, and genito -urinary systems.

- **<u>FORMATION OF THE EXTRA-EMBRYONIC MESODERM</u>**

Extra-embryonic (1ry) mesoderm arises from the hypoblast

It surrounds the amnion, and the yolk sac & separates them from the trophoblast

Derivatives of endoderm

Endoderm is the innermost layer which gives off all structures that line viscera (yolk sac).

- **<u>Derivatives, Epithelial lining of:</u>**
  1. GIT, except mouth vestibule & lower ½ of anal canal.
  2. Respiratory epithelium.
  3. Lining of urinary bladder & urethra.
  4. Middle ear & auditory tube.
- **<u>Parenchyma (cells) of:</u>**
  1. Thyroid & Parathyroid glands
  2. Liver & Pancreas.
- **<u>Stroma of:</u>**
  1. Palatine tonsils.
  2. Thymus gland.

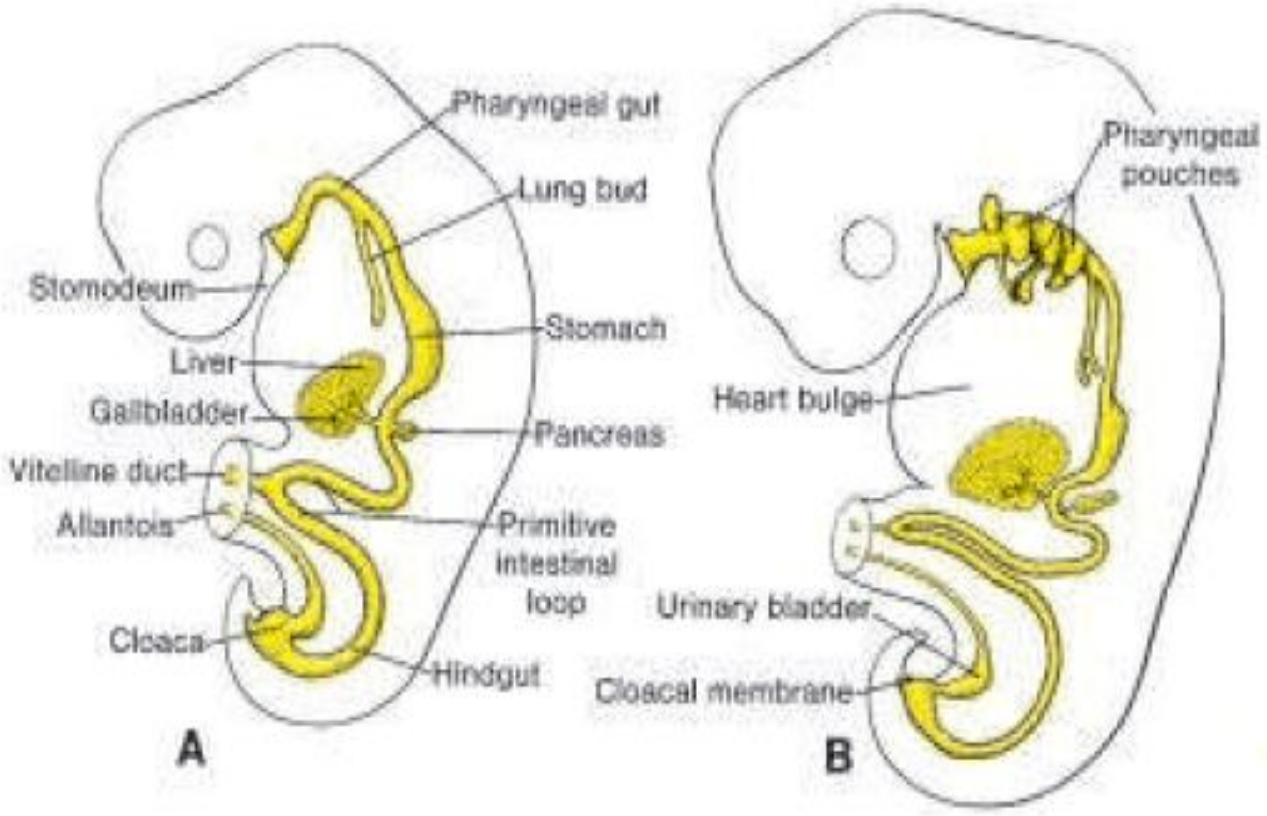
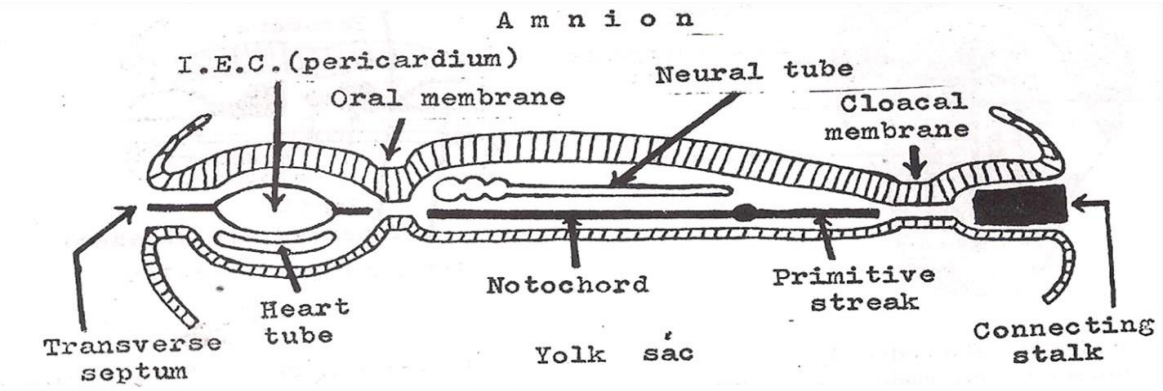


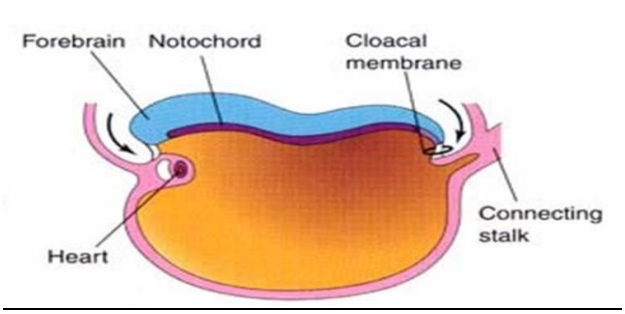
Figure 5.18 Sagittal sections through embryos showing derivatives of the endodermal germ layer. **A.** Pharyngeal pouches, epithelial lining of the lung buds and trachea, liver, gallbladder, and pancreas. **B.** The urinary bladder is derived from the cloaca and, at this stage of development, is in open connection with the allantois.

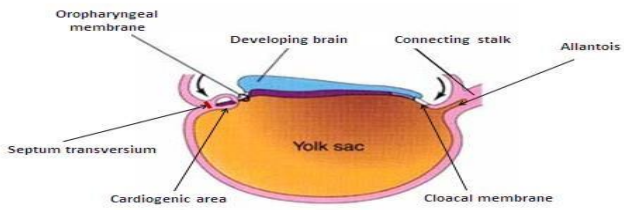
Folding of the embryo

- Occurs in the 4th week of pregnancy. ▪ Features of folding:

1. Cranial, caudal and lateral folding occurs simultaneously.
2. The three layers of the embryonic disc fold simultaneously.
3. At the end of folding, every structure had fused with its opposite similar structure (ectoderm with ectoderm, mesoderm with mesoderm and endoderm with endoderm) all around the connecting stalk (the future umbilical cord).







formation of: I. Head fold:

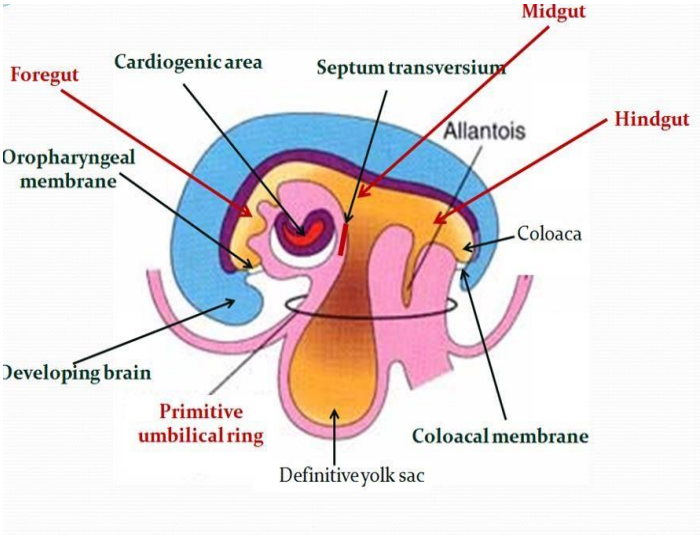
1. The brain becomes the most cranial while the heart is caudal to it into the chest.
2. Buccopharyngeal membrane becomes ventral & cranial to heart.
3. Formation of foregut.

II. Tail fold:

1. The connecting stalk & allantois become ventral in position.
2. Cloacal membrane becomes ventral & caudal to the connecting stalk.
3. Formation of hindgut.

III. Lateral fold: leads to formation of intra embryonic coelom & midgut.

IV. Umbilical ring: contains connecting stalk, umbilical vessels & allantois.



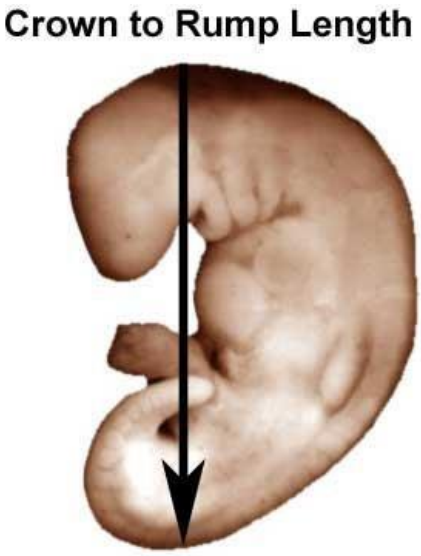
External appearance during second month of pregnancy

At the end of the 4th week:

- The embryo has approximately 30 somites.
- The main external features are the somites and appearance of pharyngeal arches.
- The age of embryo is therefore usually expressed in somites.

During the second month:

- Counting of somites is difficult to express age during the 2nd month.
- Crown-rump length (CRL) is used instead to express the age of the embryo.
- CRL is the measurement from the vertex of the skull to the midpoint between the apices of buttoks.



External appearance by the end of the 2nd month:

- All vital organs are formed by the 8th week.
- The head: is more rounded and large forming about half length of the body.
- Eyes, ears and nose are developing.
- The neck region is established.
- The abdomen: physiological hernia is present in the proximal part of umbilical cord.
- Physiological hernia occurs due to rapid growth of the intestine that bulges through the umbilical ring by the 6th week of pregnancy and reduced by 10th week

• The heart is formed with its septa, valves and is beating rhythmically.

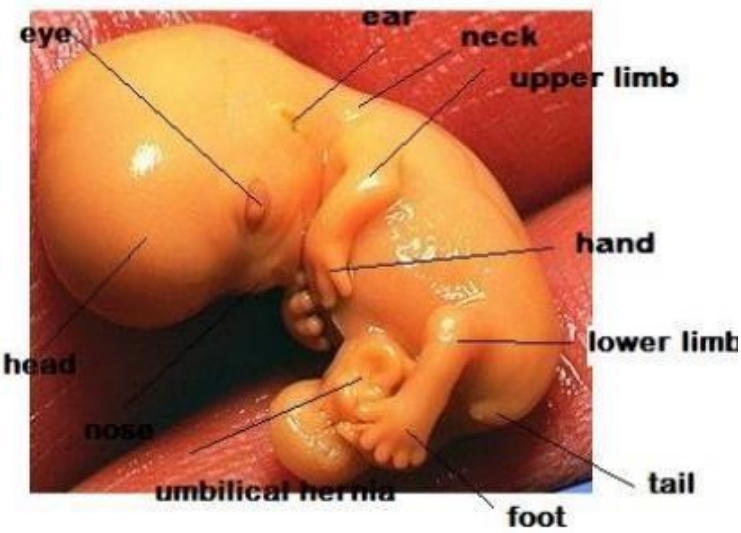
• External genitalia are present, but sex is not distinguishable by ultra sound.

• The primitive tail is regressing.

• Placenta is fully developed.

• Length is 25 mm (1 inch).

• Weight is less than 10 gm



• Limbs: are segmented:

— The upper limb: shoulder, elbow and wrist are formed with five digital rays for fingers.

— The lower limb: hip, knee and ankle are formed.

— Primary ossification centers for limbs appear by the eighth week.

The fetal period: from 3rd month till birth time

- This period is characterized by maturation of organs & rapid growth of the body. Growth in length is more rapid during 3rd, 4th, 5th moths, while increase in fetal weight occurs at last 2 months of pregnancy.

During the third month:

- The face the face becomes more human looking. The eyes, initially directed laterally, move to the ventral aspect of the face, and the ears come to lie close to their definitive position at the side of the Head.
- Primary ossification centers are present in the long bones and skull by the 12th week.
- External genitalia are developed & could be determined by ultrasound.
- By the 12th week the midgut loops withdraw into the abdominal cavity (Physiological hernia is reduced).

During the 4th - 5th months:

- Rapid increase in length (CRL ~ 15cm).
- Movements of the fetus can be felt by the mother.
- Slow increase in weight (less than 500 gm by the end of 5th month).

Crown-rump length during the fetal period of pregnancy:

CRL (cm)	Approximate age (month)	Weight (gm)
~ 5	3	~ 50
~ 10	4	~ 150

~ 15	5	~ 250
~ 20	6	~ 500
~ 25	7	~ 1000
~ 30	8	~ 1500
~ 33	9	~ 2500
~ 36	Full term	3000-3500

External appearance 6th month till birth time:

- **Weight** increased during the **last 2 months** due to deposition of the subcutaneous fat.
- **Lanugo hairs**: fine, soft, unpigmented downy hairs that cover the whole fetal skin between 5- 7 months of pregnancy. Sometimes it persists till the time of birth.
- **Vernix Caseosa**: a fatty secretion formed by sebaceous gland & desquamated layers of epidermis (whitish, like toothpaste) to protect the fetus from the macerating effect of the amniotic fluid.
- **At time of birth:**
    - Weight is about 3- 3 ½ kg.
    - The crown-rump length (CRL) is about 36 cm.
    - The crown-heel length (CHL) is about 50 cm.
    - Sexual characteristics are pronounced, and the testes should be in the scrotum.

Fetal membranes:

Placenta

- The **functional unit** of exchange between fetus and the mother.
- **structure:** By the beginning of the fourth month, the placenta has two components:

  (a) fetal portion, formed by the chorion frondosum.

  (b) maternal portion, formed by the decidua basalis.

- **Chorionic villi:**

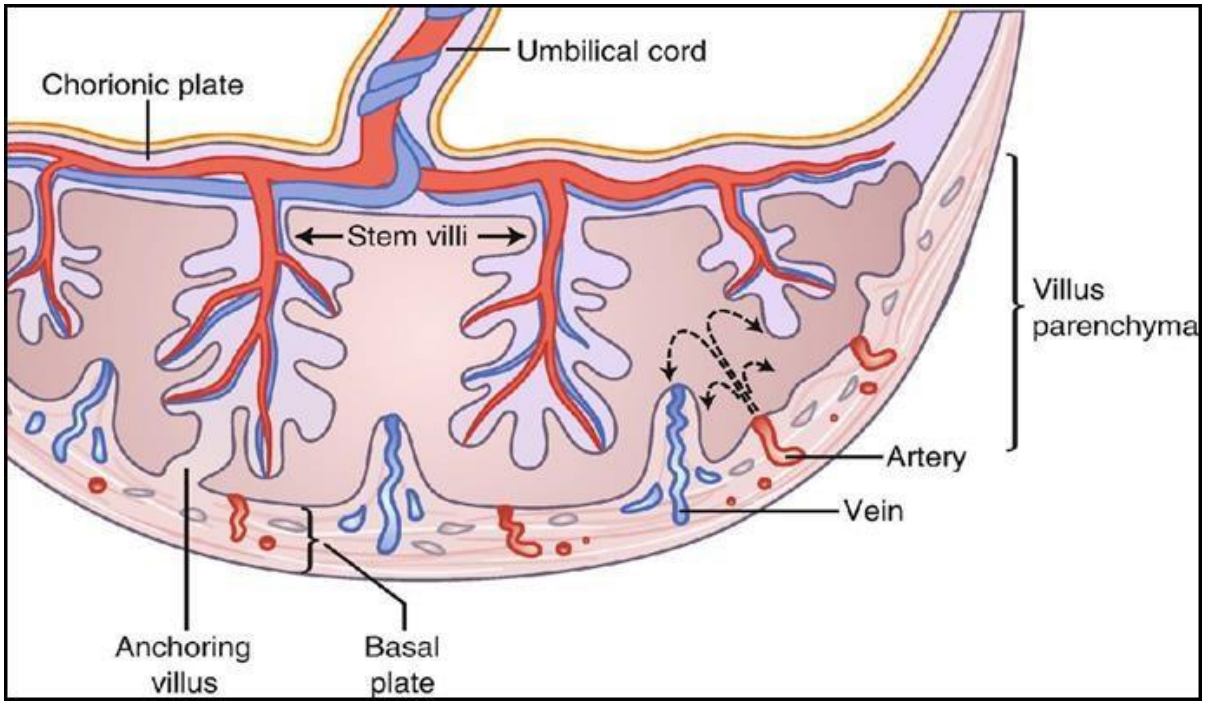
- **Definition: finger like projections from the trophoblast.**
- **Classification:**
  - **Depending on the structure:**
    1. Primary chorionic villi.
    2. Secondary chorionic villi.
    3. Tertiary chorionic villi.
  - **According to distribution: (by the 2nd month of gestation)**

1. **Chorion leave:** the chorionic villi facing the decidua capsularis become degenerated.
2. **Chorion frondosum:** the chorionic villi facing the decidua basalis become branched and more complex

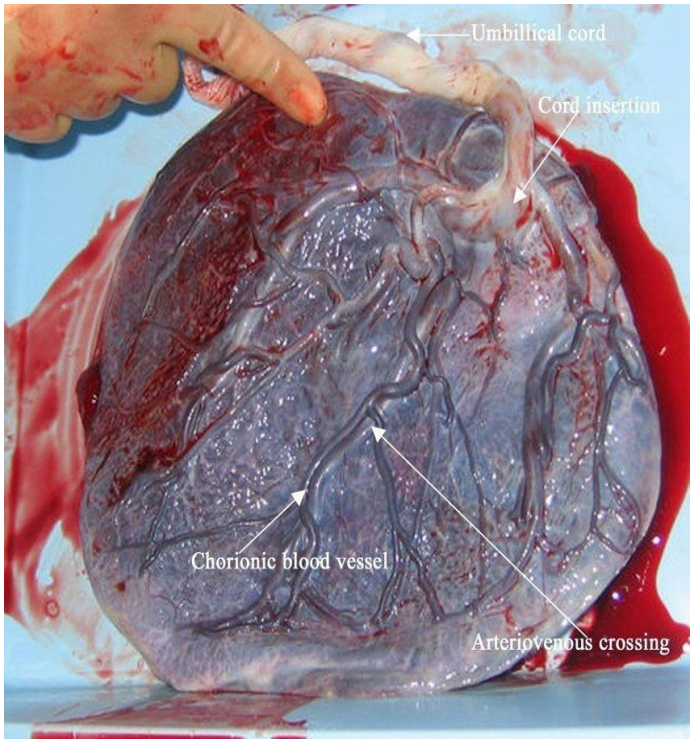
- **According to function: (by the 3 rd month of gestation), only at the site of the chorion frondosum:**

  1.Anchoring (stem) villi: large villi that extends to decidua basalis & become adherent to it by (cytotrophoblast shell) for fixation of the placenta.

  2.Absorbing (free): small villi arise from the stem villus into the intervillous space for exchange process with maternal blood.



Full term placenta:



- Discoid shaped.
- 15- 20 cm in diameter.
- About 500 gm in weight.
- Thickness: 3 cm at the center and thinned at its periphery.
- Maternal surface: covered by decidua basalis & divided by decidual septa into 15-20 lobes (**cotyledons**).
- Fetal surface is smooth and covered by **amnion**. Umbilical cord is attached near to the center (eccentric).

Functions of the placenta:

- **Gas exchange (respiratory):** Exchange of gases, such as oxygen, carbon dioxide, and carbon monoxide, is accomplished by simple diffusion.
- **Exchange of nutrients and electrolytes,** such as glucose, amino acids, fatty acids, vitamins.
- **Transmission of Maternal Antibodies.**

- **Excretion:** urea and creatinine.
- **All hormones are synthesized in the syncytial trophoblast,** such as estrogen, progesterone, human chorionic gonadotropin (hCG), somatomammotropin (formerly placental lactogen).
  - **Placental barrier:**
    - All layers are separating between maternal and fetal blood. It includes: 1- Syncytiotrophoblast 2- Cytotrophoblast 3- Extra-embryonic mesoderm. 4- Endothelium of fetal capillaries.
    - **After 4th month**: it is only of two layers: (syncytiotrophoblast and Endothelium of fetal capillaries).
  - **CIRCULATION OF THE PLACENTA:**
    - About 80 to 100 spiral arteries pierce the decidual plate
    - They enter the intervillous spaces at regular intervals.
    - The blood pressure in the intervillous space is high.
    - This pressure forces the blood deep into the intervillous spaces and bathes the numerous small villi of the villous tree in oxygenated blood.
    - As the pressure decreases, blood flows back from the chorionic plate toward the decidua, where it enters the endometrial veins. Hence, blood from the intervillous lakes drains back into the maternal circulation through the endometrial veins.
  - **Anomalies of the placenta:**
    - **Shape**:
      - **Bi-lobed (bipartite):** placenta is formed of two lobes.
      - **Tri-lobed (tripartite):** placenta is formed of three lobes.
      - **Accessory lobe (placenta succenturiate):** associated with small accessory lobe.
    - **Number**: more than one in multiple pregnancies (twins).
    - **Position**: in the lower uterine segment.

- Placenta previa centralis: overlies the internal os.
- Placenta previa marginalis: related to the margin of the internal os.
- Placenta previa parietalis: beside the internal os.

➢ **<u>Attachment to the umbilical cord:</u>**

- Marginal attachment (battledore placenta).
- Velamentous attachment: the umbilical cord attached to the chorion some distance from the placenta.

➢ **<u>Invasion into the endometrium:</u>** placenta increta.

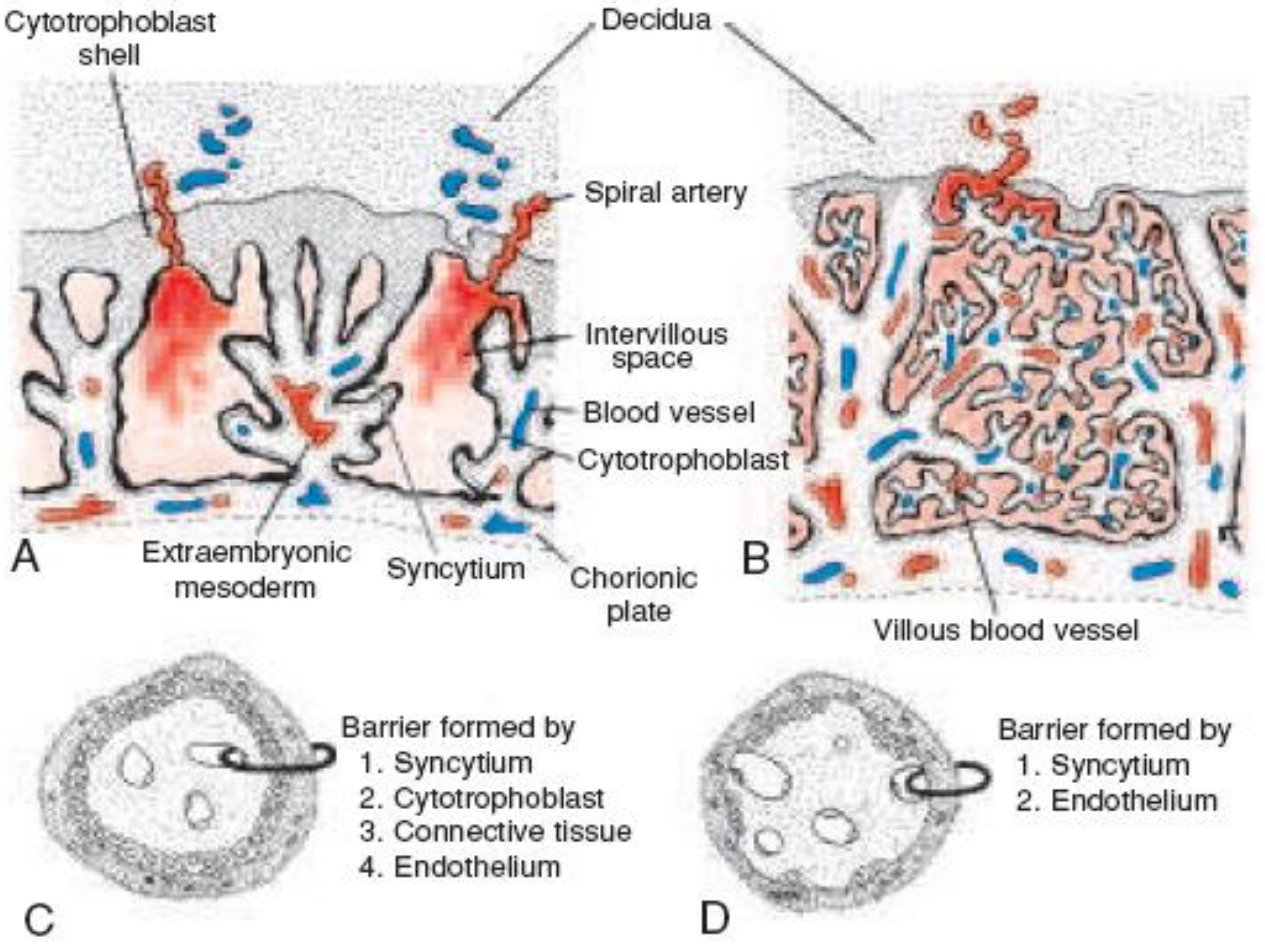


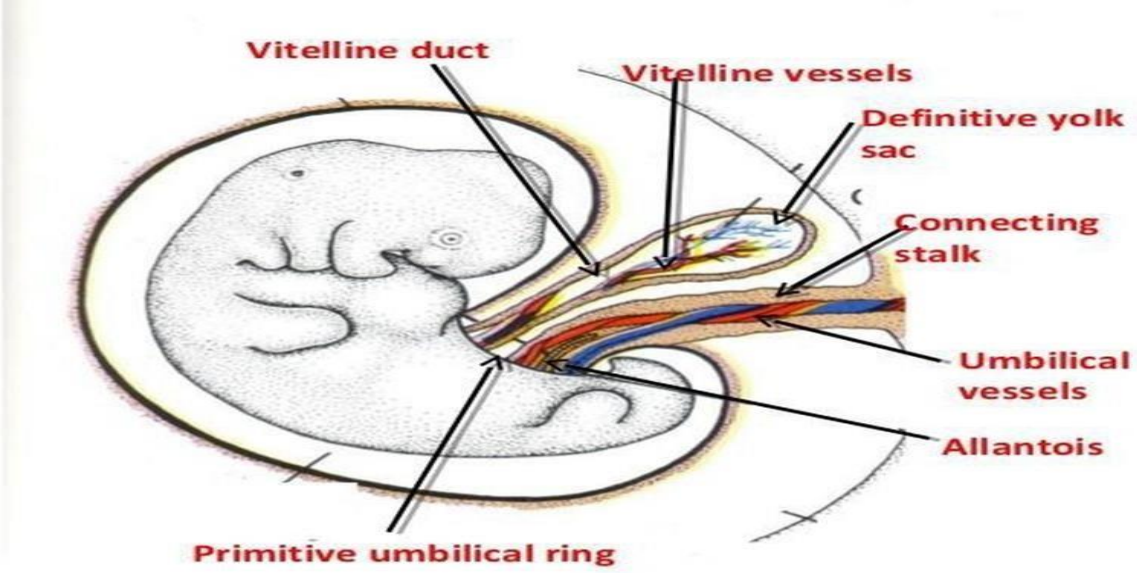
Figure 6.8 Structure of villi at various stages of development. **A.** During the fourth week. The extraembryonic mesoderm penetrates the stem villi in the direction of the decidual plate. **B.** During the fourth month. In many small villi the wall of the capillaries is in direct contact with the syncytium. **C** and **D.** Enlargement of the villus as shown in **A** and **B,** respectively.

Umbilical cord

- **Definition:** It is a soft tortuous cord which connects the fetus to the placenta.
- **Functions:**
  It allows the blood to circulate between the fetus & the placenta.
  It allows free fetal movement.
- **Development of umbilical cord:**
  - **Formation of the connecting stalk:** a mass of extra-embryonic mesoderm connects the germ disc to the trophoblast (~ 13th day).
  - **Formation of the primitive umbilical ring:** because of folding (4th week), the connecting stalk becomes ventral to the embryo & the umbilical ring is formed which contains:

  (The connecting stalk, Allantois, Umbilical vessels, Vitello-intestinal duct and
  Connection between intra-embryonic & extra-embryonic (chorionic) cavities).

N.B. Vitello-intestinal duct; connecting the midgut to the definitive yolk sac.



- **Formation of the definitive umbilical cord:**
  - By the 8th week, the definitive umbilical cord is formed by elongation of the primitive umbilical cord, covered by amnion, with the following changes:
  - Mesoderm of the connecting stalk transformed to mucoid connective tissue (Whorton's jelly).
  - The extra-fetal part of allantois is fibrosed to form the median umbilical ligament.
  - Vitello-intestinal duct degenerated.
  - Umbilical vessels the right umbilical vein is degenerated with persistent of the left umbilical vein & the two umbilical arteries.
  - Herniation of the midgut loop into the remnant of extra-embryonic coelom (physiological hernia; occurs between 6th to 10th weeks of gestation).

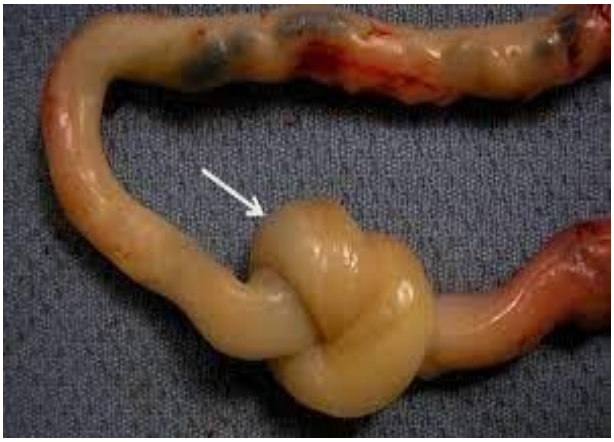
- **Features of the full-term umbilical cord:**

  - Length: ~ 55 cm.
  - Diameter: between 1 -2 cm.
  - Surface: smooth, covered by the amniotic membrane.
  - Contents: one umbilical vein (the left one) & two arteries.
    - It shows bulges of mucoid connective tissue due to highly tortuous umbilical vessels, form False Knots

- **Anomalies of umbilical cord:**

  - Abnormal long cord (> 1 meter): can lead to formation of true knot or wind around fetal neck & result in fetal death.
  - Abnormal short cord (< 40 cm): can lead to premature separation of the placenta & fetal death.

Long cord - around fetal neck

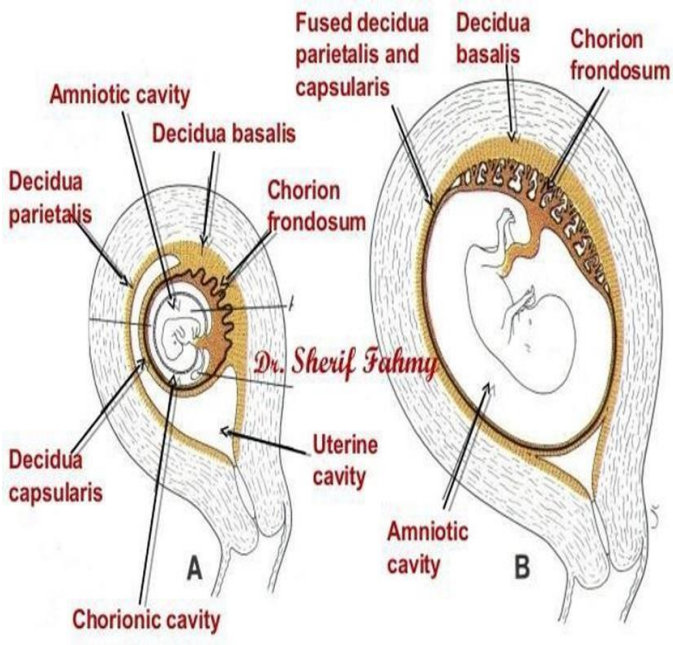


Long cord – true knot

Amnion

Amniotic cavity:

- A cavity lies dorsal to the Epiblast, appears by ~ 9th day of pregnancy.
- **development:**



- At the chorionic vesicle stage (~ 13th day) the cavity enlarges & it is surrounded by extraembryonic mesoderm.
- After folding (~ 4th week), the amniotic cavity surrounds the whole embryo.
- By the 20th week the amniotic cavity enlarges & obliterates the chorionic cavity.

- **Amniotic fluid:**
  - **Definition:** The amniotic cavity is filled with a clear, watery fluid.
  - **Production:**
    - It is produced in part by amniotic cells and is derived primarily from maternal blood (early).
    - After the **5th month of pregnancy**, fetal urine is the main source of amniotic fluid.
  - **Circulation:**
    - The volume of amniotic fluid is replaced **every 3 hours**.
    - From the beginning of the **fifth month**, the fetus swallows its own amniotic fluid, and it is estimated that it drinks about 400 ml a day, about half of the total amount.

- Absorbed by gut epithelium.
- Excess fluid passed through placenta & other amounts is excreted again to the fetal urine.

- **Volume: about 1000 cc**
- **Functions:**

A. It acts as a water cushion for protection of the fetus.
B. It prevents adherence of the fetus to the amniotic membrane.
C. It keeps fetal body temperature constant.
D. It allows free fetal movement for Musculo-skeletal development.
E. It dilates cervix at the time of labor.

- **Anomalies:**
  - **Polyhydramnios:** means **excess fluid > 2000 cc.** Primary causes include idiopathic causes, maternal diabetes, and congenital malformations, including gastrointestinal defects (e.g., esophageal and duodenal atresia) that prevent the infant from swallowing the fluid.
  - **Oligohydramnios**: means **lack of fluid < 400 cc.** It may result from **renal agenesis.**
  - **Amniotic band syndrome:** abnormal bands extend from the amniotic membrane that could be tied around fetal parts cause limb amputation or fetal death.
  - **Premature rupture of the amnion**, the most common cause of preterm labor, occurs in 10% of pregnancies.
- **Amniocentesis**: aspiration of amniotic fluid for chemical & genetic study for prenatal diagnosis of birth defects.

TWINS

- **Definition of twins:** Delivery of more than one baby at the same labor setting.
- **Incidence**:
- Delivery of two babies is about 1/80 of deliveries.
- Delivery of three babies is about 1/800 of deliveries.
  Delivery of four babies is about 1/8000 of deliveries.

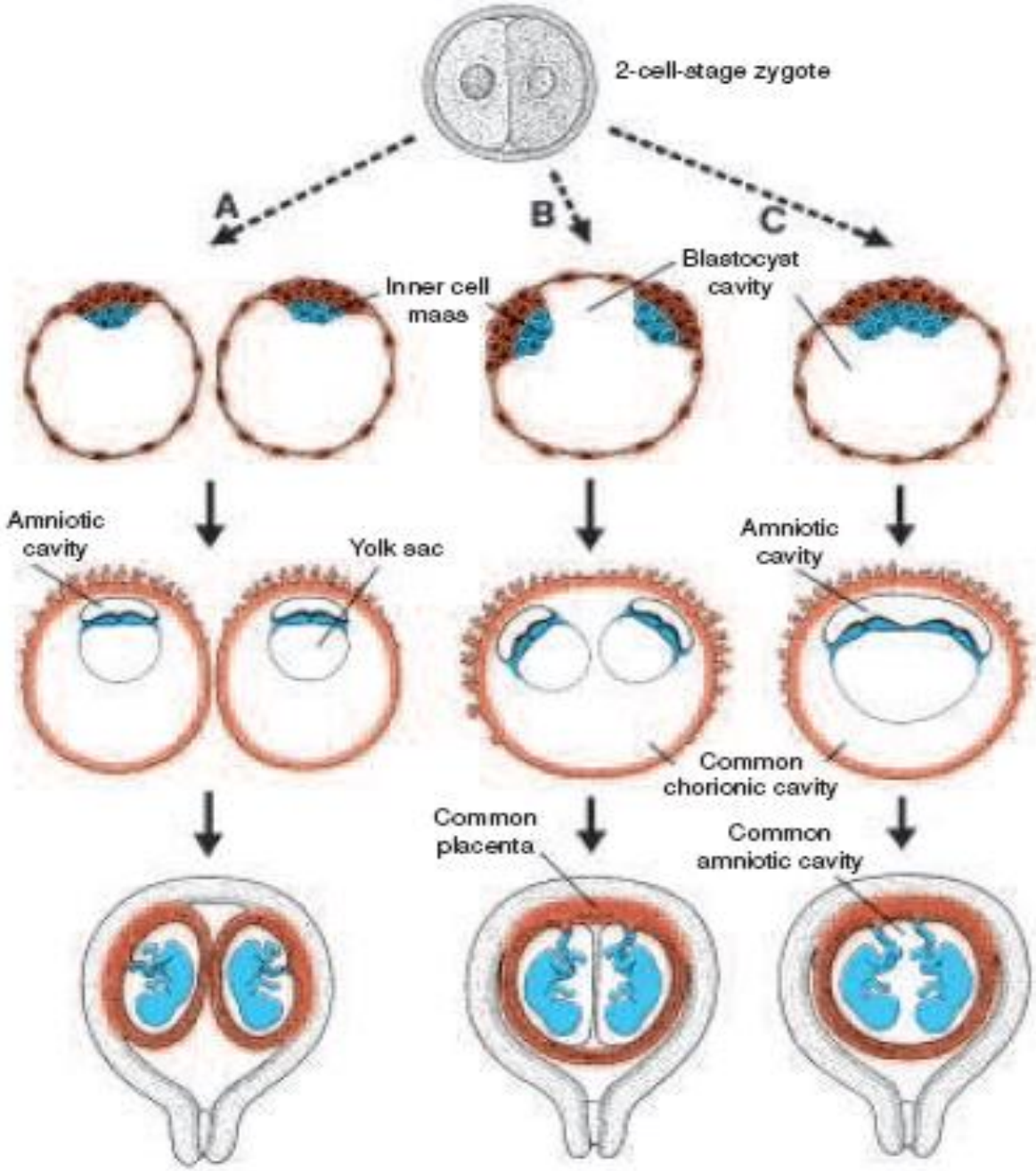
- **Types of twins:**
  - **Dizygotic twins (fraternal):**
    - It is formed when two different ova are fertilized by two different sperms.
    - It accounts about 2/3 of cases.
    - Sex: they are of the same or different sexes.
    - Genetic features: they are different.
    - Fetal membranes: each fetus has its own chorion, placenta and amniotic sac (they have separate membranes).
  - **Monozygotic twins (identical):**
    - It is formed when a single ovum is fertilized by one sperm.
    - It accounts about 1/3 of cases.
    - Sex: they are of the same sex.
    - Genetic features: they are the same (they are different in finger and iris prints).
    - Fetal membranes: according to the stage of division of the Zygote.

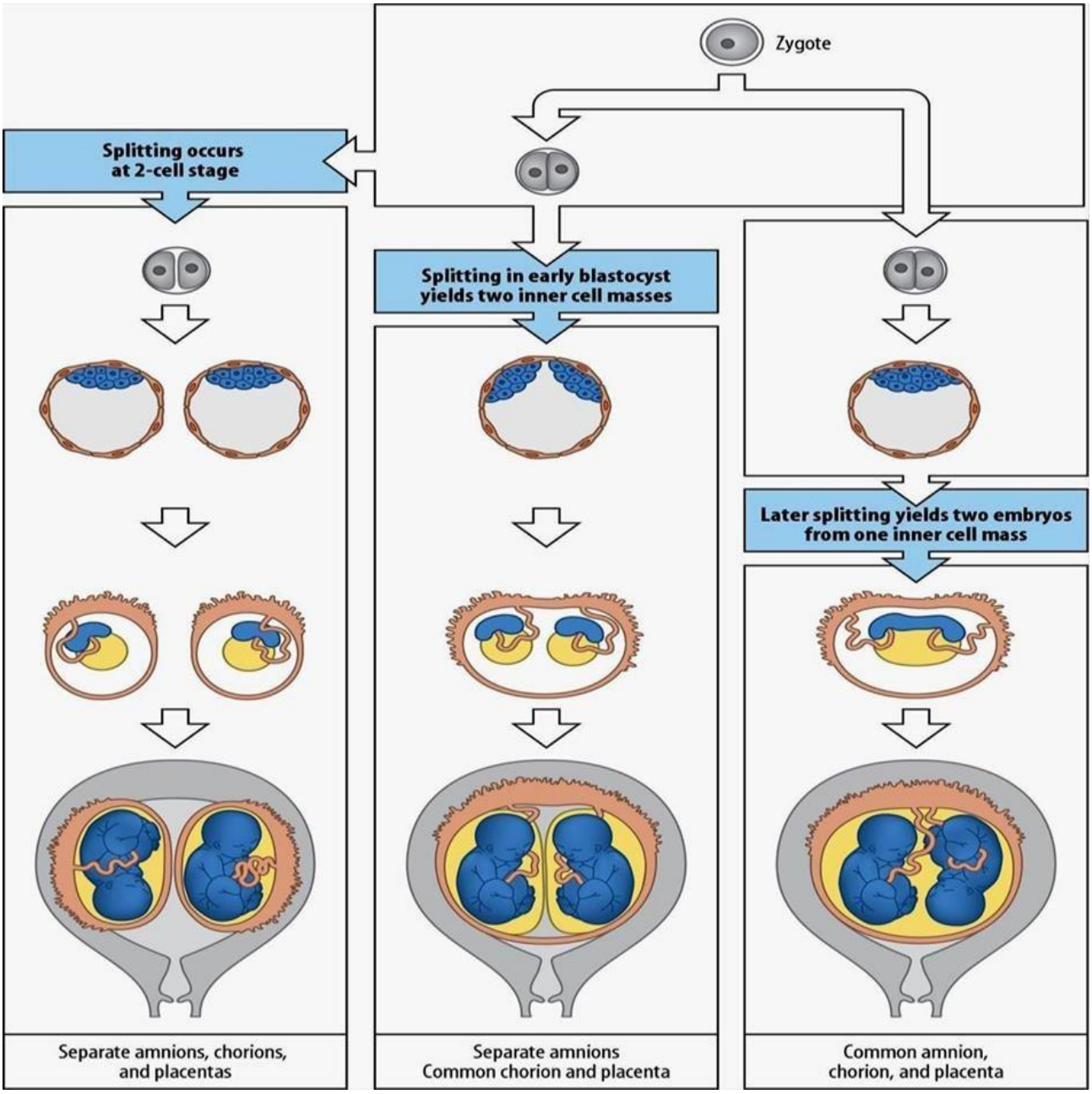
1. **Division at two cell stage:** Each fetus has its own chorion, placenta and amniotic sac (like dizygotic twins).
2. **Division at blastocyst stage**:

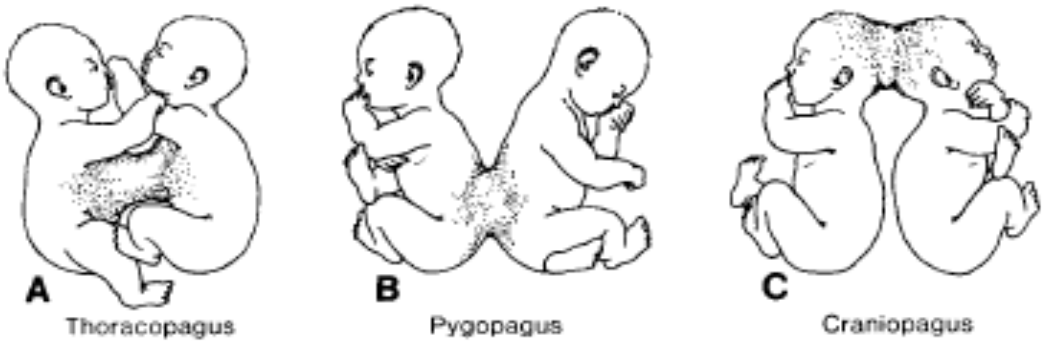
- It occurs after formation of chorion (outer cell mass).
- They have separate amniotic sac but common chorion and placenta.

3. **Division at chorionic vesicle stage:**

- It occurs after formation of embryonic disc.
- They are characterized by common chorion, placenta and amniotic sac.
- If division of the two embryonic discs is incomplete, conjoined (siamese) twins could be the result.
- According to the point of fusion, conjoined twins are classified into: cranio-pagus, thoraco-pagus, pygopagus.




Zygote
Splitting occurs at 2-cell stage
Splitting in early blastocyst yields two inner cell masses
Later splitting yields two embryos from one inner cell mass
Separate amnions, chorions, and placentas
Separate amnions
Common chorion and placenta
Common amnion, chorion, and placenta



Birth defects &prenatal diagnosis Birth defects

- It's a description of **structural**, **functional** & **metabolic** disorders since birth.
- Teratology: is the science that studies these disorders.
- **Major** structural anomalies:
  - 4-6% of live born infants.
  - Considered as a major contributor to disability.
  - Chromosomal anomalies account for 15% of these anomalies.
- **Minor** structural anomalies:
  - 15% of live born infants.
  - Examples: microtia (small ears) & short palpebral fissure.
  - Presence of one minor anomaly increases the chance to 3% to have a major one. Two minor anomalies increase the chance up to 10% to have a major one. Three minor anomalies increase the chance up to 20% to have a major one.
- **Types of anomalies:**
  - **Malformations:**

- The disorder occurs during the organ formation (embryonic period: 3rd to 8th weeks).
- The organ is not formed, partially formed or abnormally formed (examples: renal aplasia & polydactyly).

➢ **Disruptions:**

- Morphological alterations of already formed structures.
- Example: amniotic band syndrome.

➢ **Deformations:**

- Abnormality due to a mechanical force.
- Example: club foot due to compression in the amniotic cavity.

➢ **Syndromes:**

- Groups of anomalies occurring together by a specific cause.
- Example: VACTERL = vertebral, anal, cardiac, tracheoesophageal, renal, limb defects).

Club foot polydactyl

▪ **<u>Teratogens</u>**

- **Definition**: an agent that can produce a congenital anomaly or birth defect.
- **Causes** of birth defects:

1. 50 – 60 % of unknown cause.
2. Genetic (15 %): due to chromosomal abnormalities.

3. Environmental (10 %): due to teratogens.
4. Combined genetic & environmental (25 % of cases).

- **Types** of teratogens (environmental causes):

➢ **Infectious agents**: Exposure to infections like rubella virus & cytomegalovirus produces cardiac & neural tube defects.

➢ **Physical agents**: like X- ray can kill rapidly dividing cells.

➢ **Drugs:**

- Thalidomide (sedative) produces limb defects.
- Valproic acid (anti-epileptic) produces neural tube defects.

➢ **Hormones**: synthetic progesterone (norethistrone) can produce masculinization of female fetus genital organs.

➢ **Maternal diseases**: maternal diabetes increases the risk for cardiac & nervous defects.

Prevention of birth defects

1. Supplementation of salt supplies with iodine eliminates mental retardation & bone deformities resulting from cretinism.
2. Metabolic control of maternal diabetes by using insulin.
3. Folic acid supplementation lowering the incidence of neural tube defects by 70%.
4. Avoidance of teratogenic drugs during childbearing period.

Methods for prenatal diagnosis of birth defects:

1. **Ultrasonography:**

- A technique that uses high-frequency sound waves reflected from tissues to create images.

- Used for detection of placental position, amniotic fluid & fetal growth.

2. **Maternal serum screening:**

- For searching of biochemical markers of fetal growth.
    - Alpha fetoprotein (AFP) is produced by fetal liver & leaks to maternal blood.
    - High levels of AFP are produced in neural tube defects & low levels are produced in Down syndrome.

3. **Amniocentesis:**

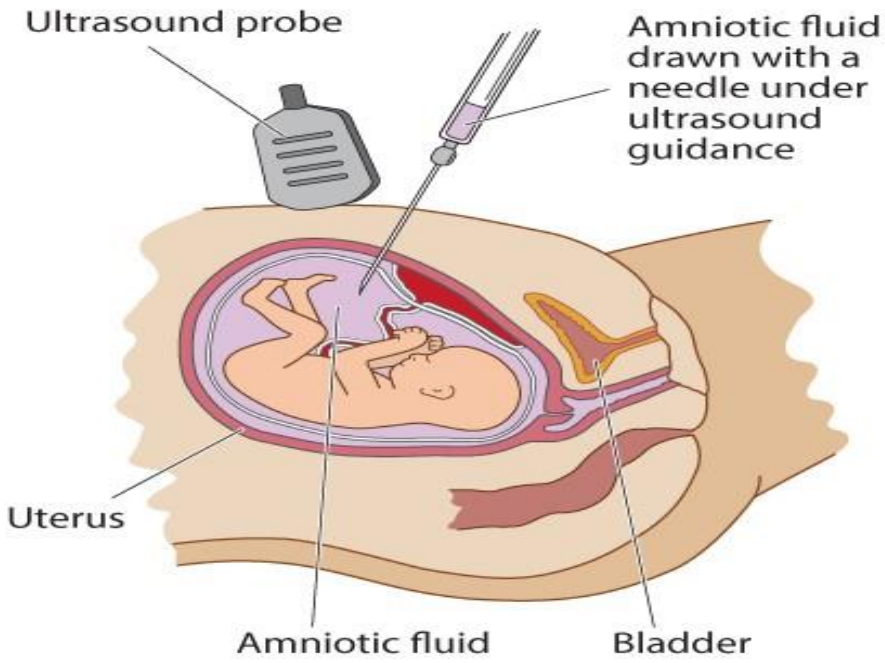
- A needle is inserted trans-abdominally into the amniotic cavity, guided by ultrasound.
- Approximately, 30 ml of fluid are withdrawn for analysis.
- Uses:

➢ Analysis for biochemical markers (AFP).

➢ Karyotype for sloughed fetal cells.

4. **Chorionic villi sampling:**

- A needle is inserted trans-abdominally into the placenta, guided by ultrasound.
- Approximately, 30 mg of chorionic villi are aspirated for analysis.
- Uses: karyotype for fetal cells. It is better than amniocentesis but two-fold higher risk of fetal loss


Ultrasound probe
Amniotic fluid drawn with a needle under ultrasound guidance
Uterus
Amniotic fluid
Bladder