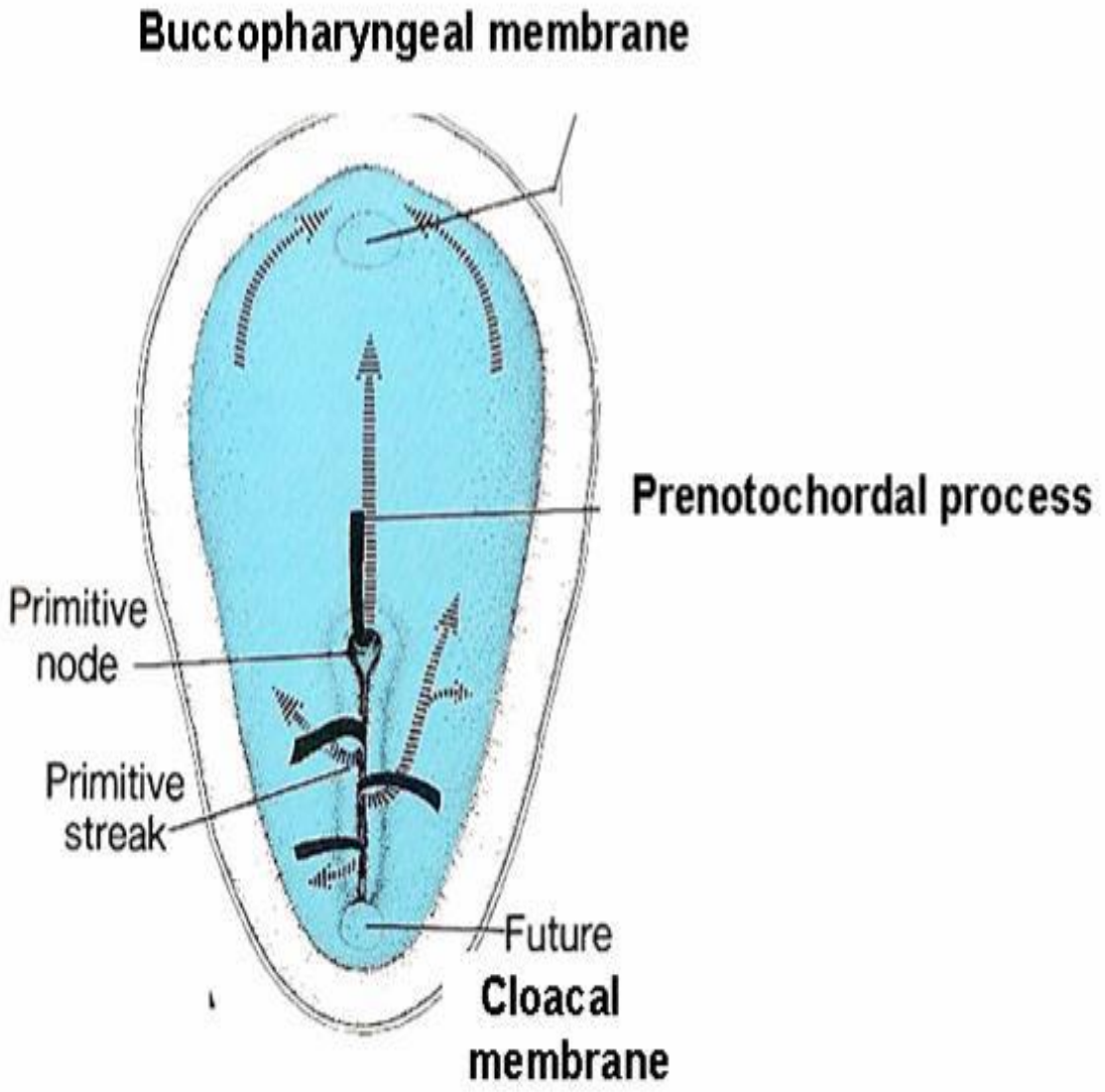
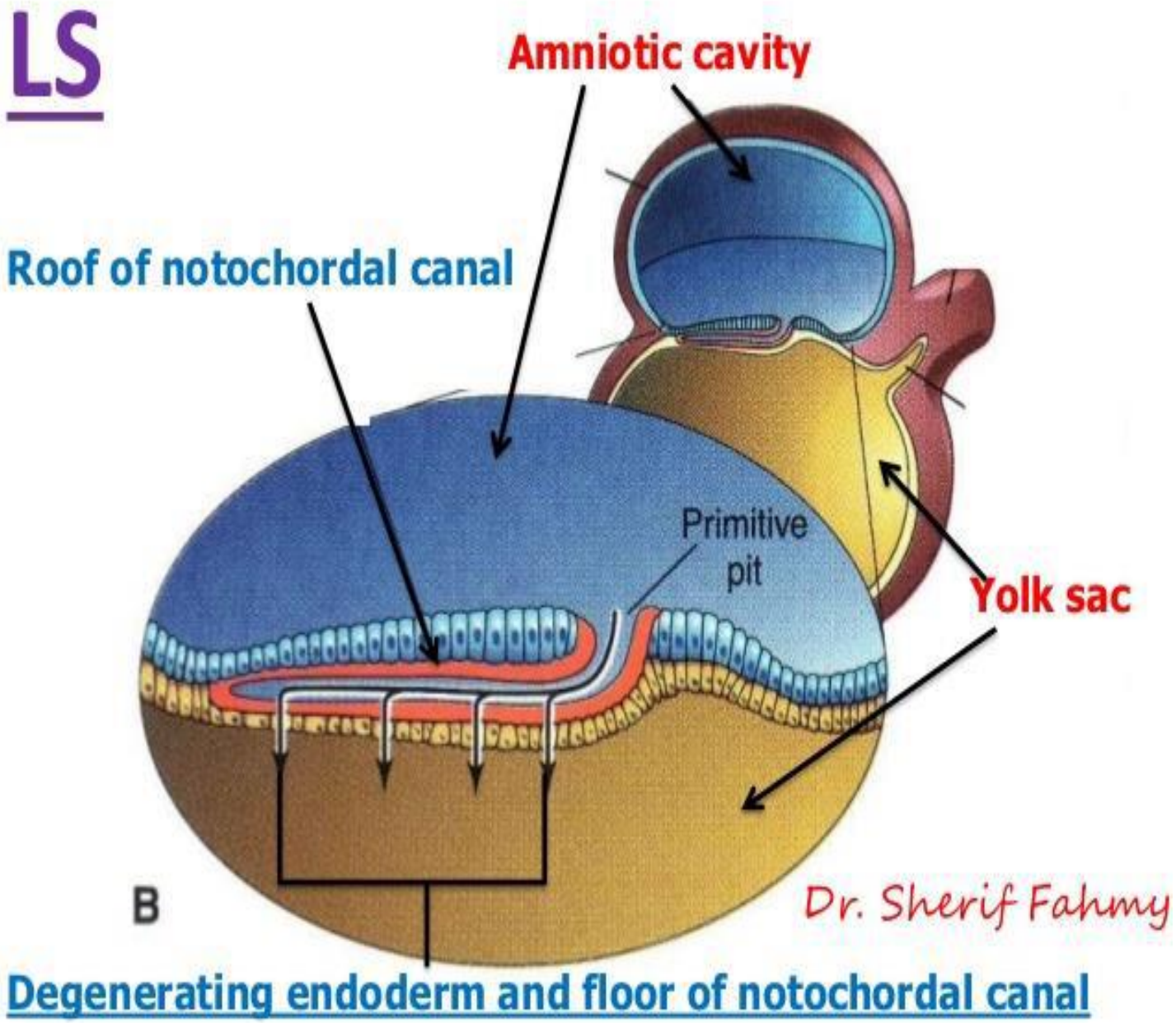
# Formation of the notochord :

-It begins at day 17 .

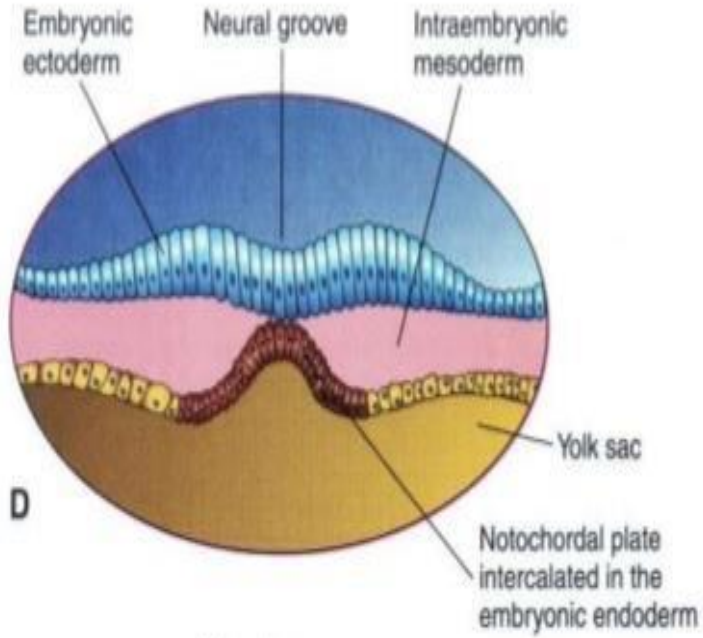
- Formation of the **prenotochordal process** by invagination of cells in the **primitive node** . These cells grow cranially in the median plane between endoderm & ectoderm untill they reach the **buccopharyngeal membrane**.
- A fine canal develops , starts from the **primitive pit** then extends cranially into the prenotochordal process , transforming it to **prenotochordal canal .**

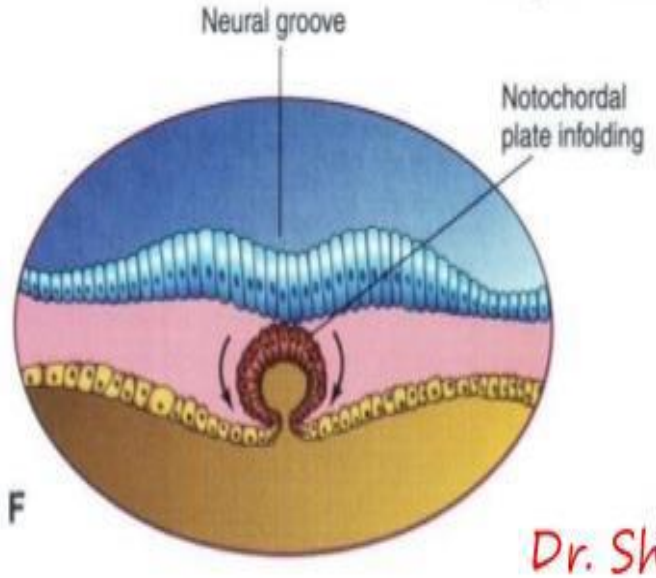


- **Notochordal-endodermal fusion**:
- The **floor** of prenotochordal canal is adherent to the underlying endoderm .
- The floor of the prenotochordal tube **degenerates** together with the underlying endoderm , forming a **Neurenteric canal** that temporarily **connects** the yolk sac with the amniotic cavity.
- **The Notochordal plate** is formed by fusion of the **roof** of the prenotochordal canal with the surrounding endoderm.



- **Definitive notochord is** formed by **folding** of the notochordal **plate** along its longitudinal axis to form a solid cord of cells **extending** from the primitive pit to the buccopharyngeal membrane.
- The **endoderm** on each side of the notochordal plate fuse together to **resume its continuity**.

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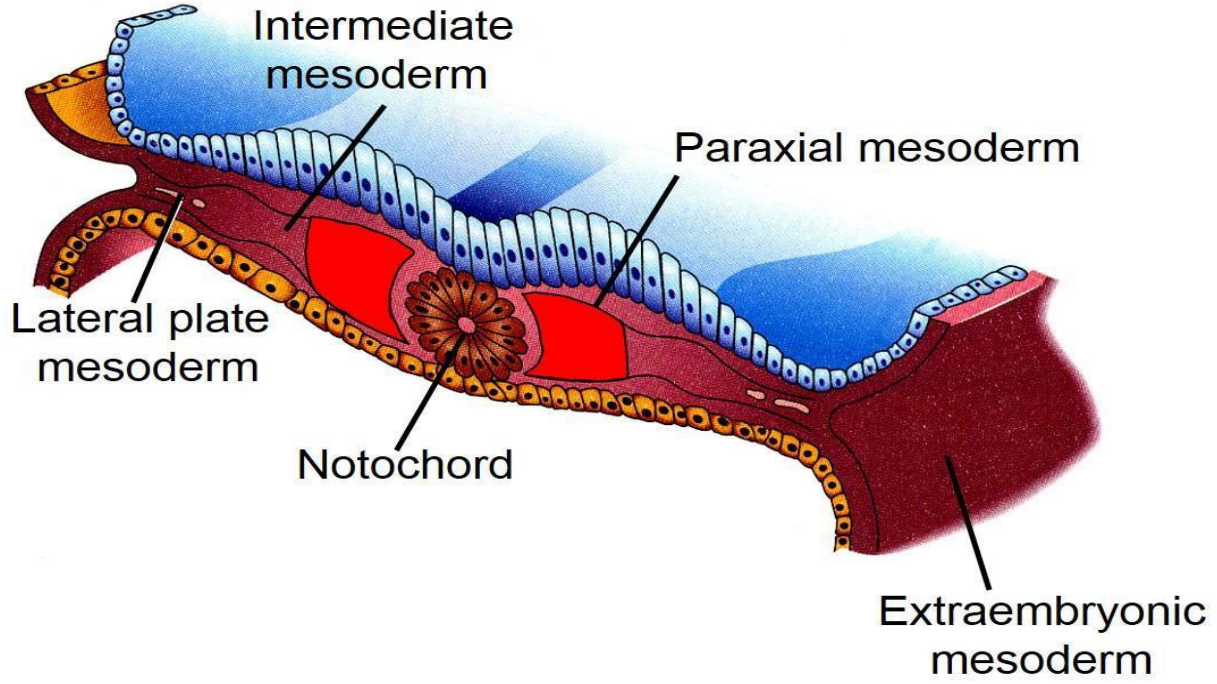
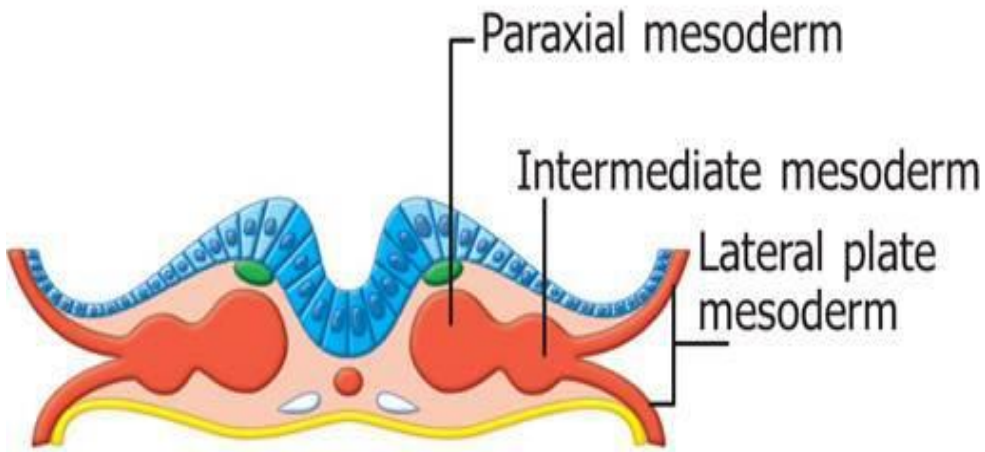
- **Functions of the notochord:**

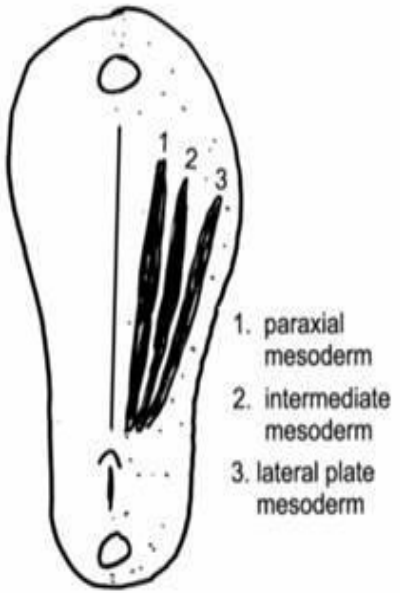
**1. It forms the axis around which the axial skeleton develops (bones of the head and vertebral column).**

**2. It Induces the overlying ectoderm to differentiate to neurectoderm to form the neural plate.**

**3. The notochord degenerates and disappears as the bodies of the vertebrae form. Its remnant is the nucleus pulposus of the intervertebral discs.**



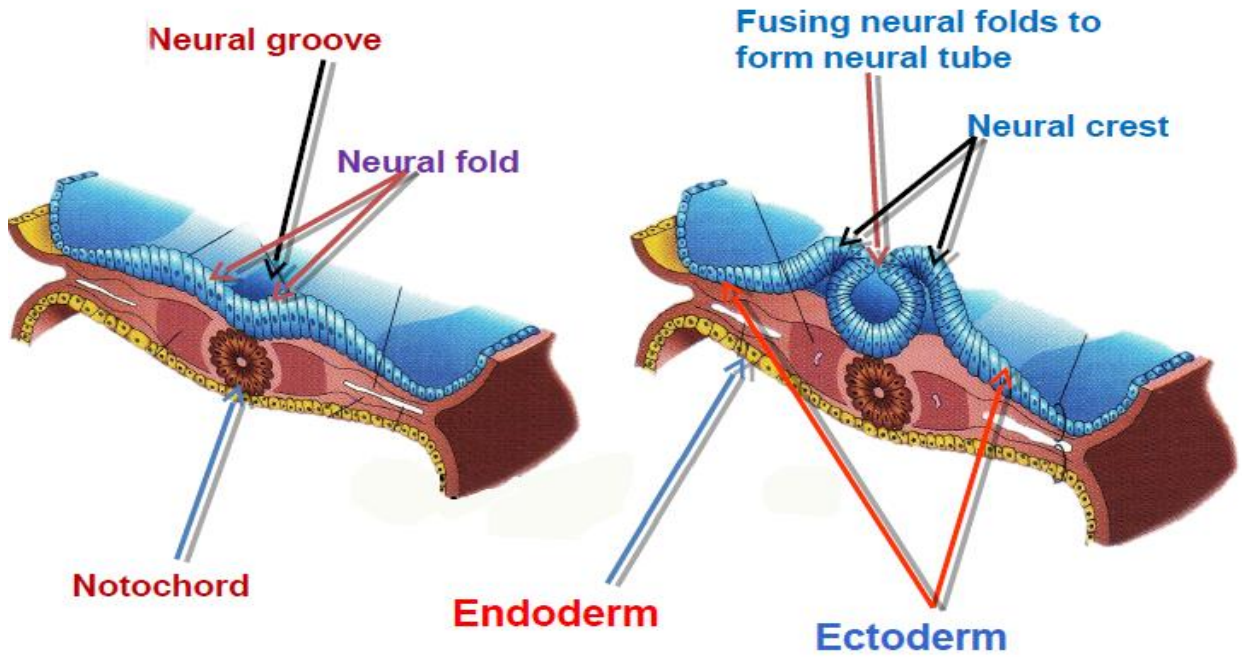



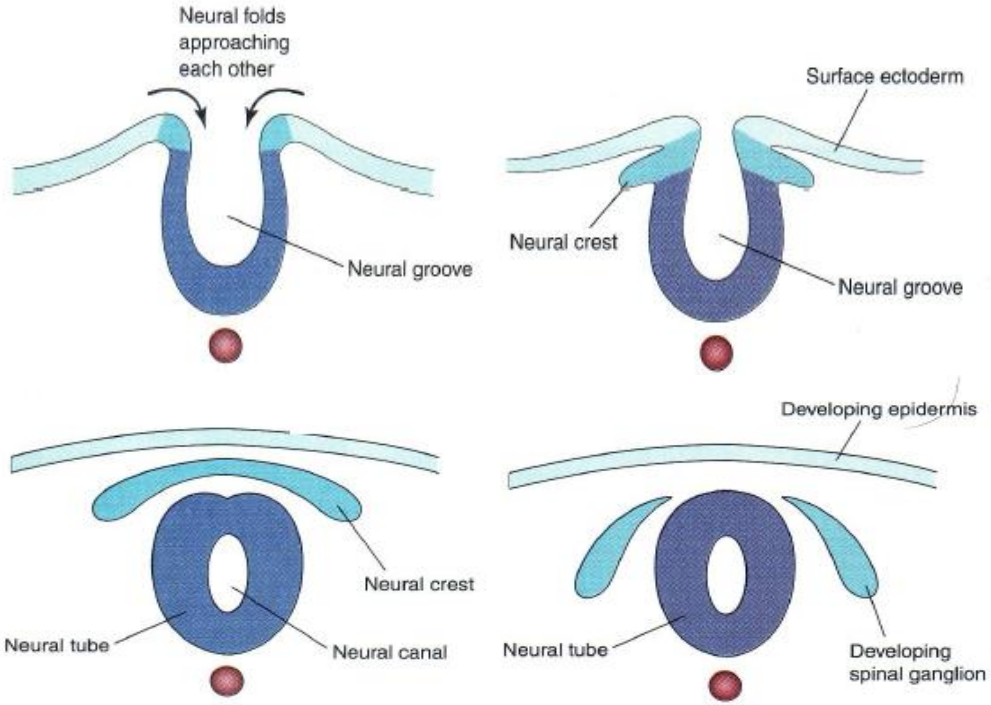
# DEVELOPMENT OF NEURAL TUBE

Begins during the 3rd week (18-20 days)
Ends by the end of 4th week (27 days)
Is induced by the notochord

- Neural plate is median thickened area between primitive node and prechordal membrane. Two strips separate neural plate from the rest of ectoderm which are called neural crest.
- Neural folds are raised margins of neural plate while depressed median region is called neural groove.
- Neural tube is formed by fusion between two neural folds in the middle of the tube and extends craniocaudally.

-The fusion of the folds is absent at the anterior & posterior ends of the tube leaving 2 openings on the surface ectoderm called the anterior & posterior neuropores.

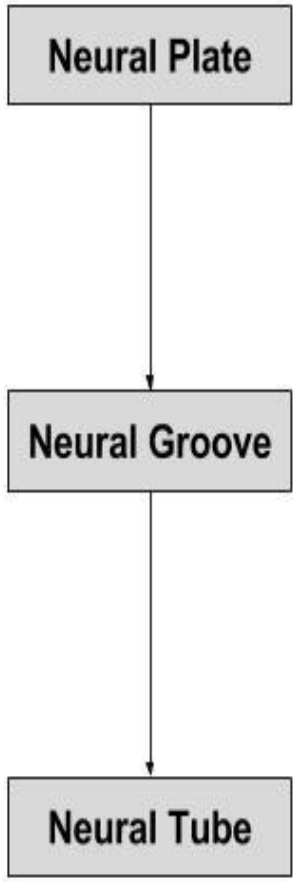


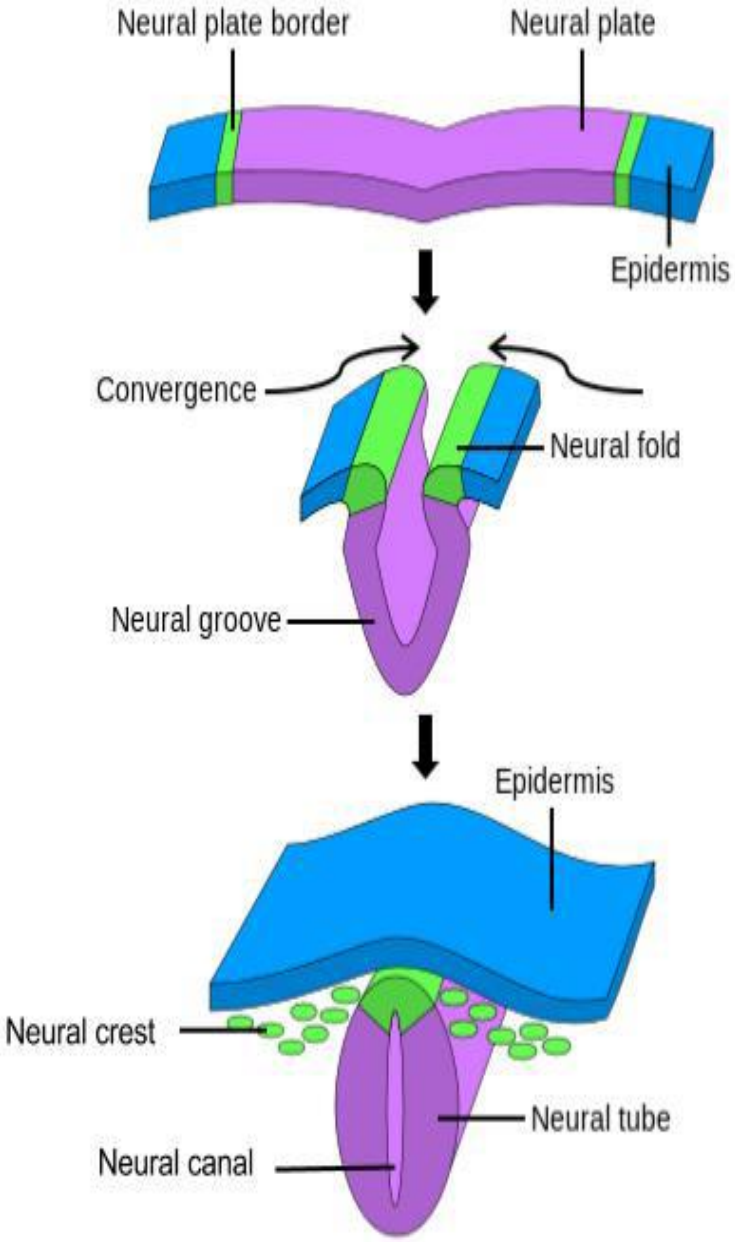



- **Cranial and caudal openings (neuropores) are the last To be closed**
- **-Anterior neuropore closes at 23rd day while posterior neuropore closed at 25th day.**

**- The surface ectoderm regains its continuity again.**

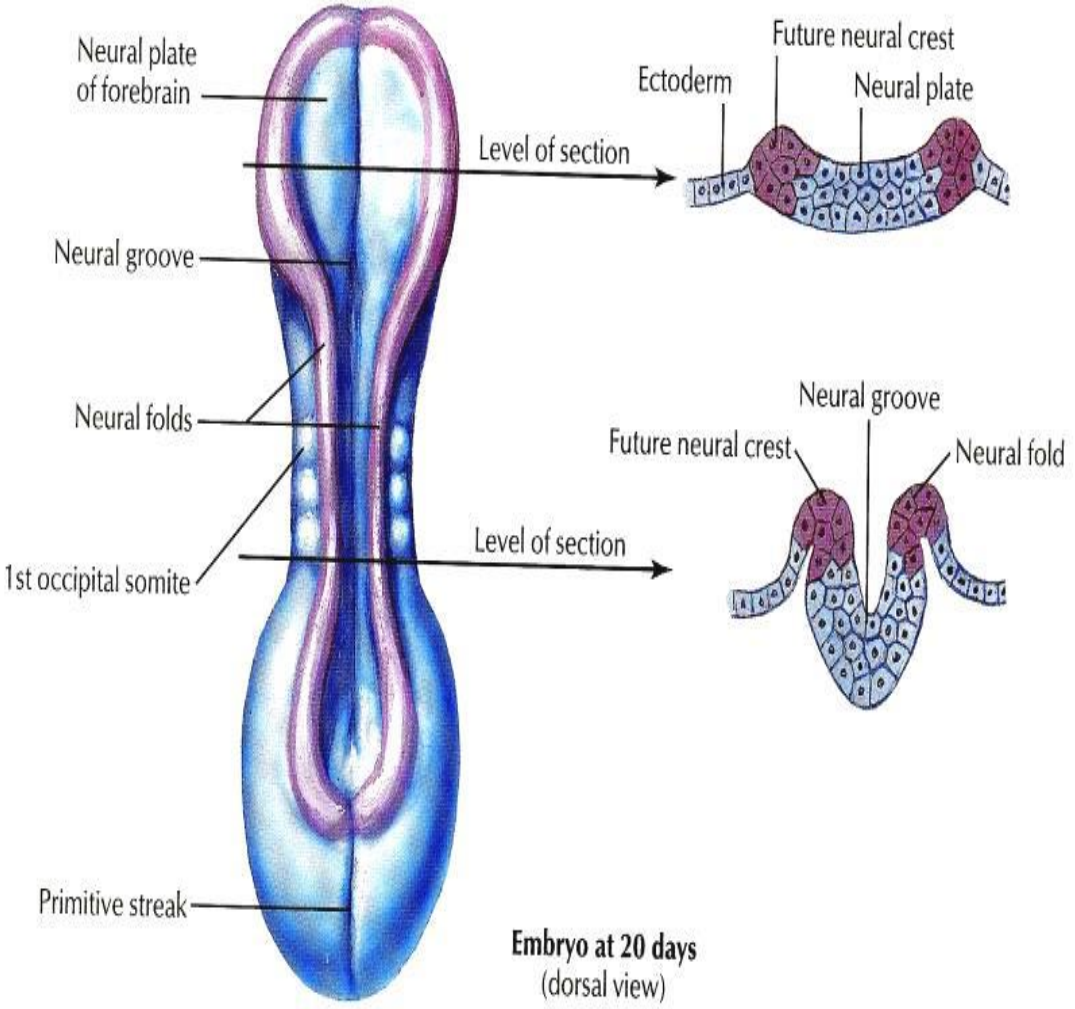
**- The closed neural tube develops into the brain and spinal cord.**

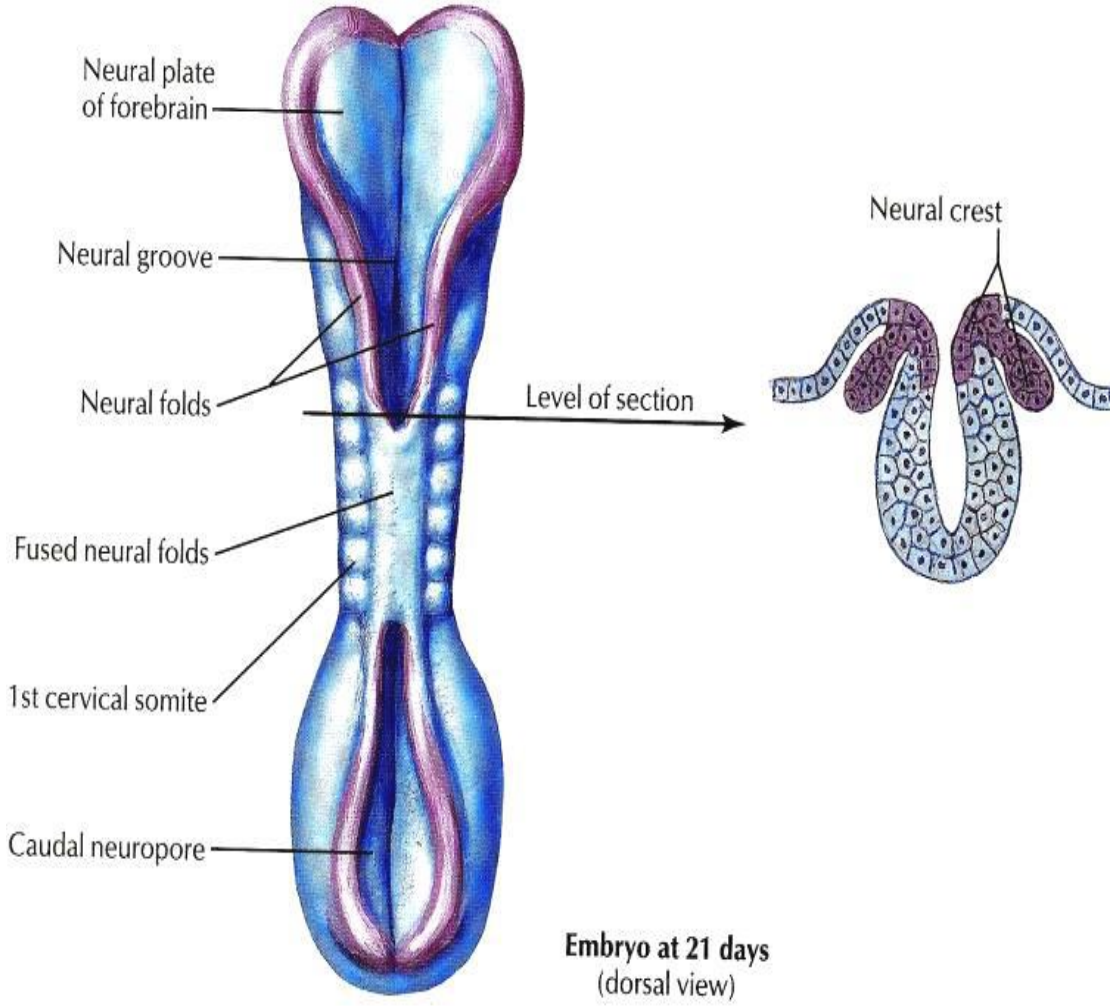


# Dorsal View to the Embryo

**Please see this excellent video for neurulation :**
https://www.youtube.com/watch?v=lGLexQR9xGs



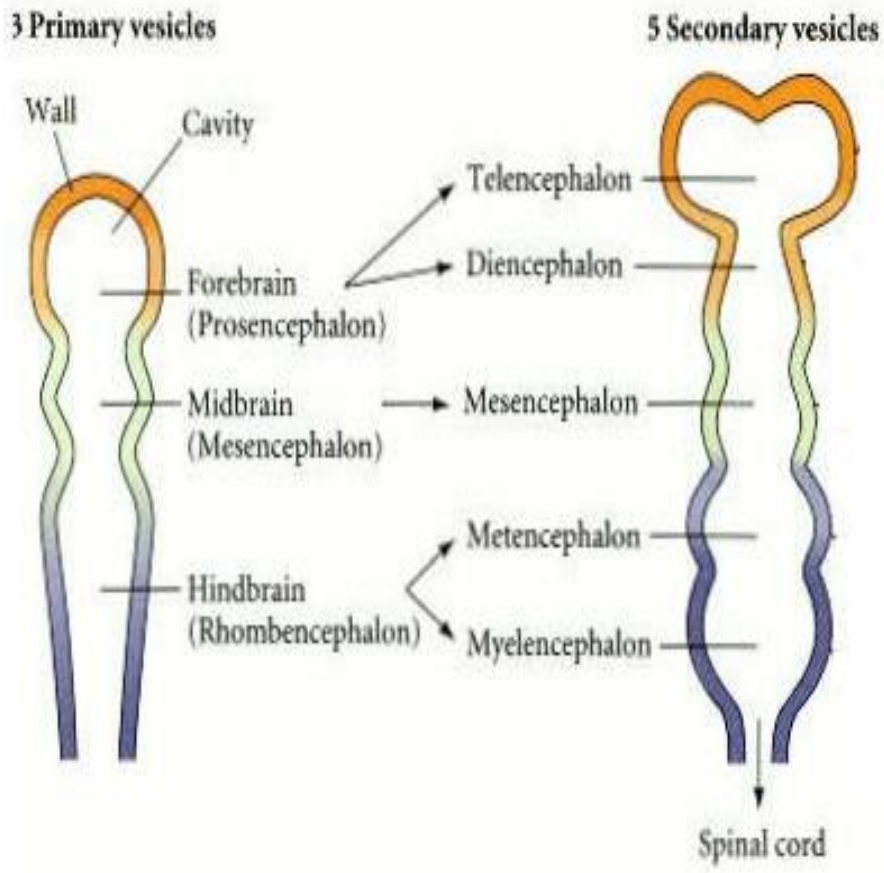
# Fate of the neural tube

- The tube grows in the median region leading to elongation of the embryonic disc in cranio-caudal direction.
- The cranial part of the tube dilates to form the brain vesicle while the caudal part forms the spinal cord.
- The brain vesicle divides by 2 constrictions into:

– Forebrain: forms cerebral hemispheres and diencephalon.

– Midbrain: forms the midbrain (upper part of brain stem).

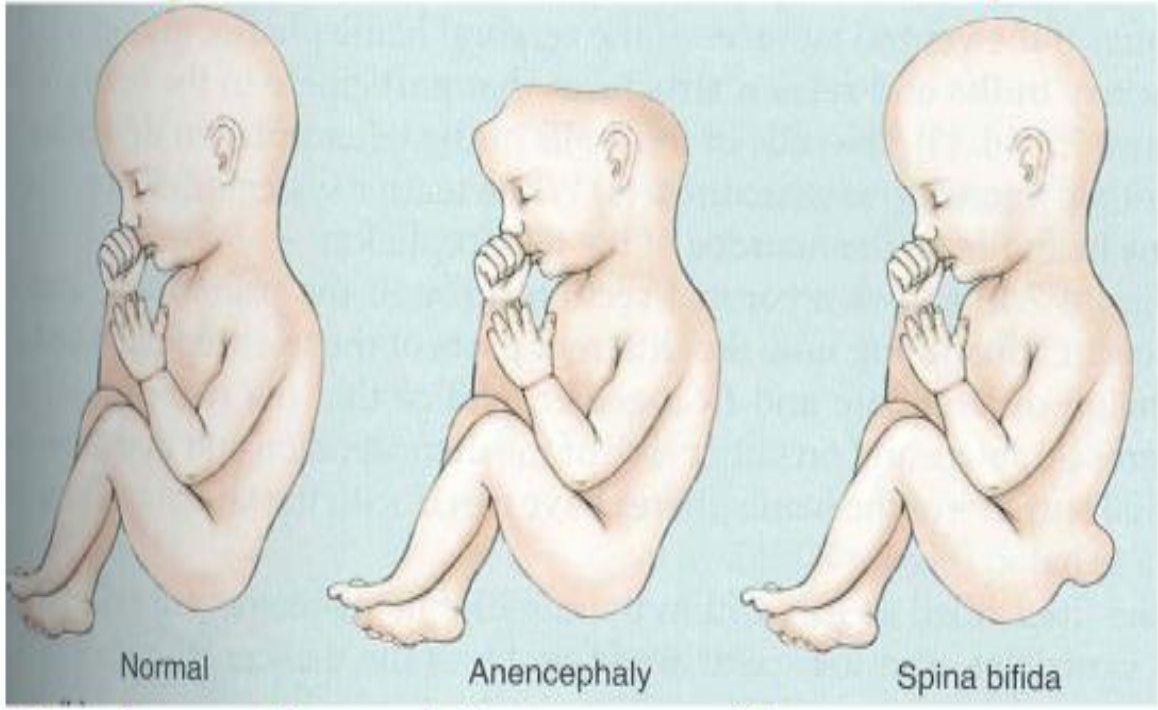
– Hindbrain: forms medulla, pons and cerebellum.



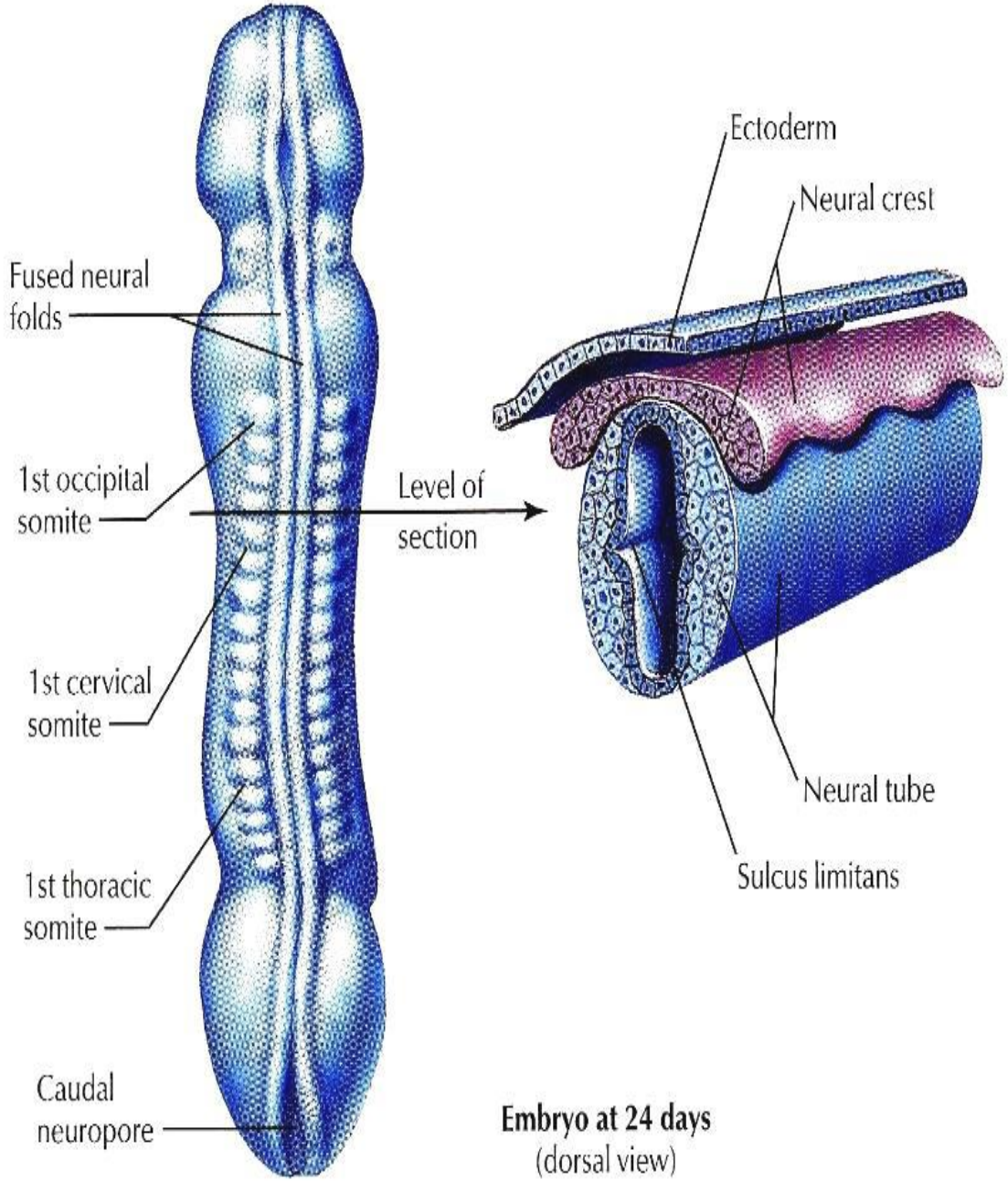

## Neural Tube Derivatives

- Central nervous system
- Peripheral nervous system
- Retina
- Sensory epithelia of nose & ear
- Pineal gland
- Posterior lobe of the pituitary gland

# Congenital Anomalies of the Nervous System

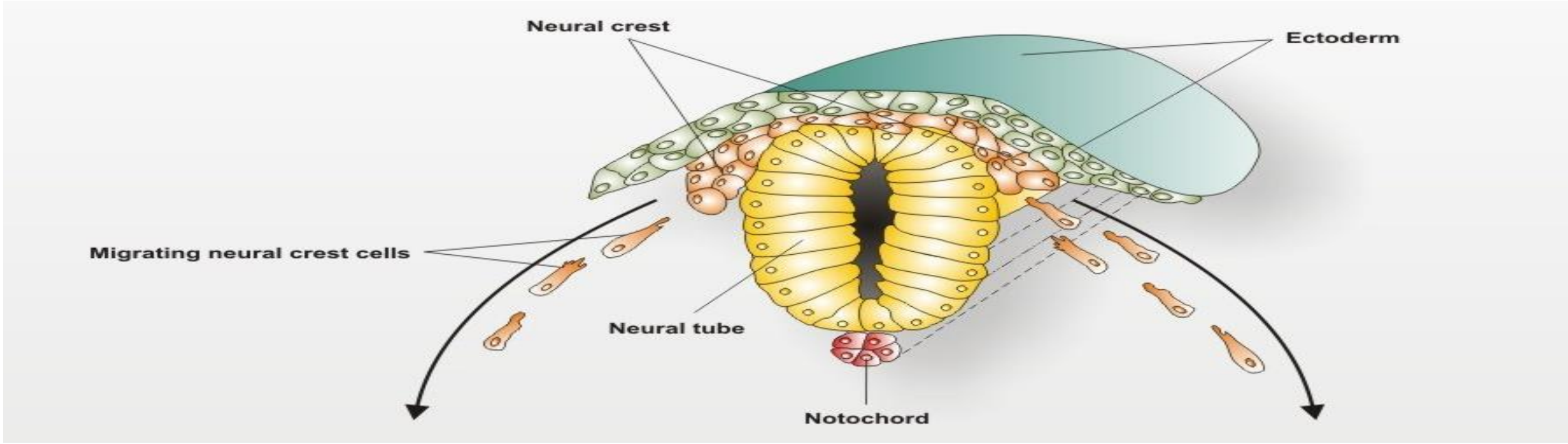



- Disturbance of neurulation may result in severe abnormalities of the brain and the spinal cord
- Most defects are the result of non-closure or defective closure of the neural tube:
  - In the brain region (e.g. anencephaly)
  - In the spinal cord regions (e.g. spina bifida)
- High level of alpha-fetoprotein (AFP) in the amniotic fluid is a strong sign of neural tube defects



## *The neural crests*

**These are the ectodermal cells which are found on the lateral margins of the neural folds. They are separated from the fused edges of the neural tube. They form an intermediate zone between the ectoderm and the formed neural tube. Later they become segmented, and their cells migrate in different directions to give many derivatives.**

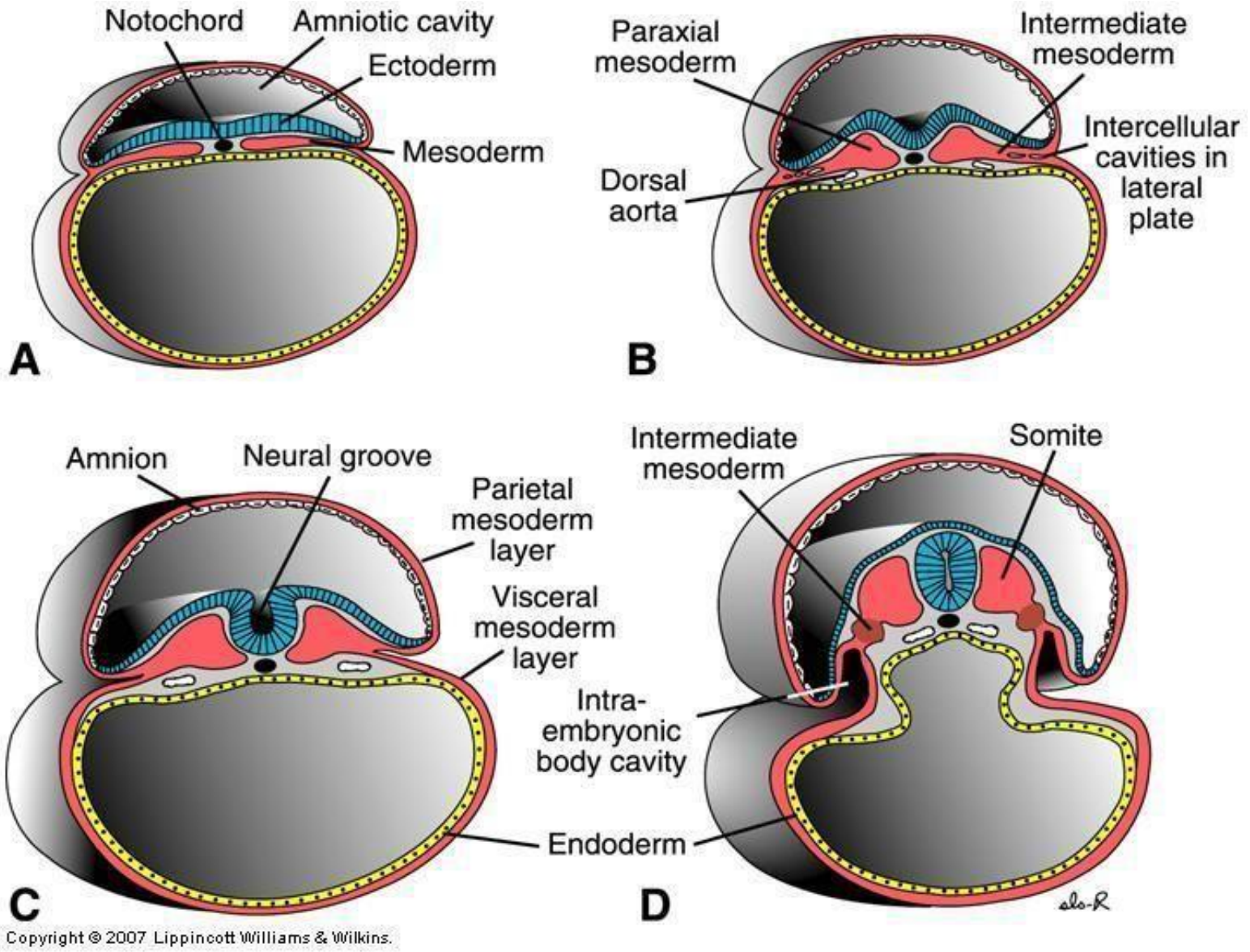



## Fate of neural crest(derivatives)

- **Ganglia:** Sensory (of cranial and spinal nerves), sympathetic and parasympathetic.
- **Cells:** Chromaffin cells of supra-renal medulla, Schwann cells and melanocytes.
- **Others:** Pia mater, arachnoid mater, enamel of teeth, septa of the heart and some bones of the skull.

# 4th – 8th Weeks - EMBRYONIC PERIOD (Period of organogenesis)

- This part of embryonic period is characterized by 2 events :
- I. Organogenesis : is formation of all organs from the 3 germ layers .
- II. Morphogenesis : formation of the shape of the embryo by folding and appearance of its external features .



## I- Organogenesis by development of the three germ layers :

### a) Development of the ectoderm :

- **Early , the ectoderm forms the dorsal layer of the germ disc and forms the floor of the amniotic cavity .**
- **After folding , the ectoderm becomes the outer layer of the embryo.**

**The ectoderm germ layer differentiates into the following structures :**

**1- The epidermis of the skin including skin glands ,hair & nails**

**2- Nervous system :neura tube and neural crest derivatives**

- **The neural tube gives brain , spinal cord , retina and posterior lobe of pituitary gland .**
- **Peripheral nerves.**
- **Pia & arachnoid mater .**
- **Sensory epithelium of sensory organs eg. Olfactory epithelium and taste buds .**

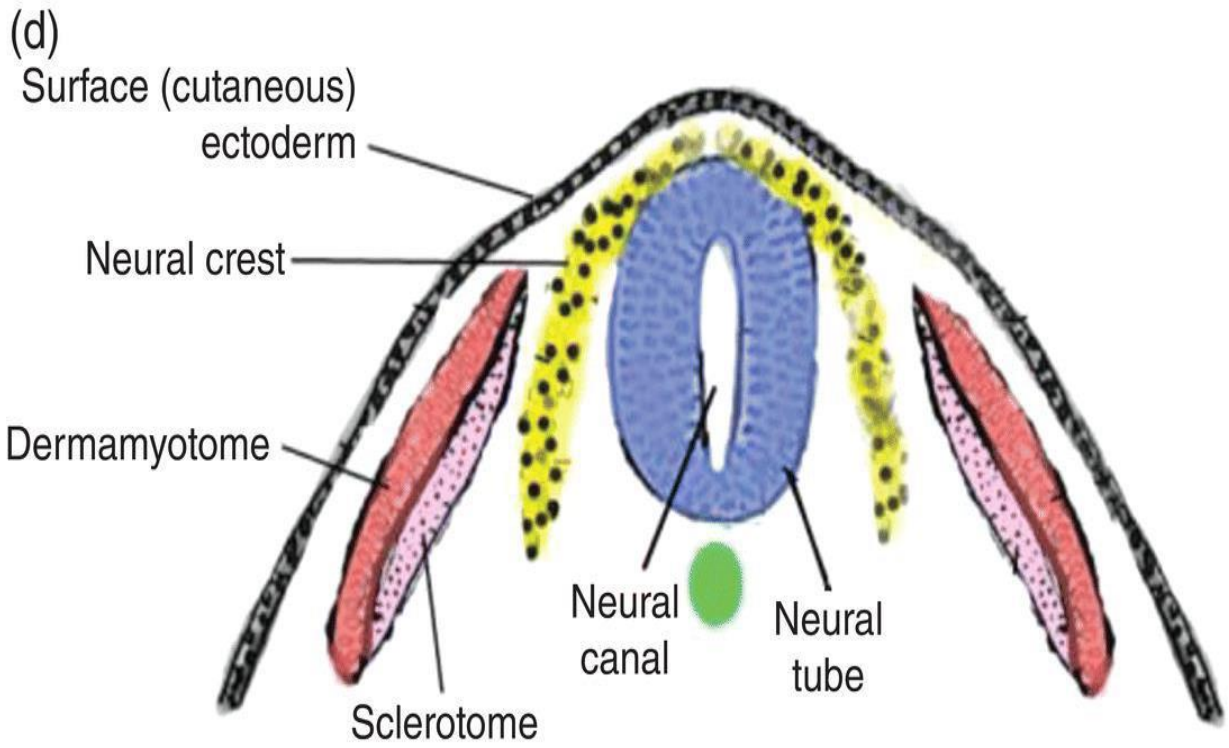
3- **Ear :** external auditory meatus & outer layer of ear drum .

4- **Respiratory system** : nasal epithelium.

5- **GIT** : anterior part of oral cavity and lower ½ of anal canal .

6- **Glands** : suprarenal medulla and pituitary glands .

7- **Urinary tract** : terminal part of male urethra.



## b) Development of the endoderm :

- **Early ,** the endoderm forms the **ventral** layer of the germ disc and forms the **roof** of the yolk sac .
- **After folding ,** the upper part of yolk sac becomes incorporated into the embryo , forming the **primitive gut** which differentiates into the following structures :

### 1- Epithelium lining of:

**Digestive system** except anterior part of oral cavity and lower ½ of anal canal .

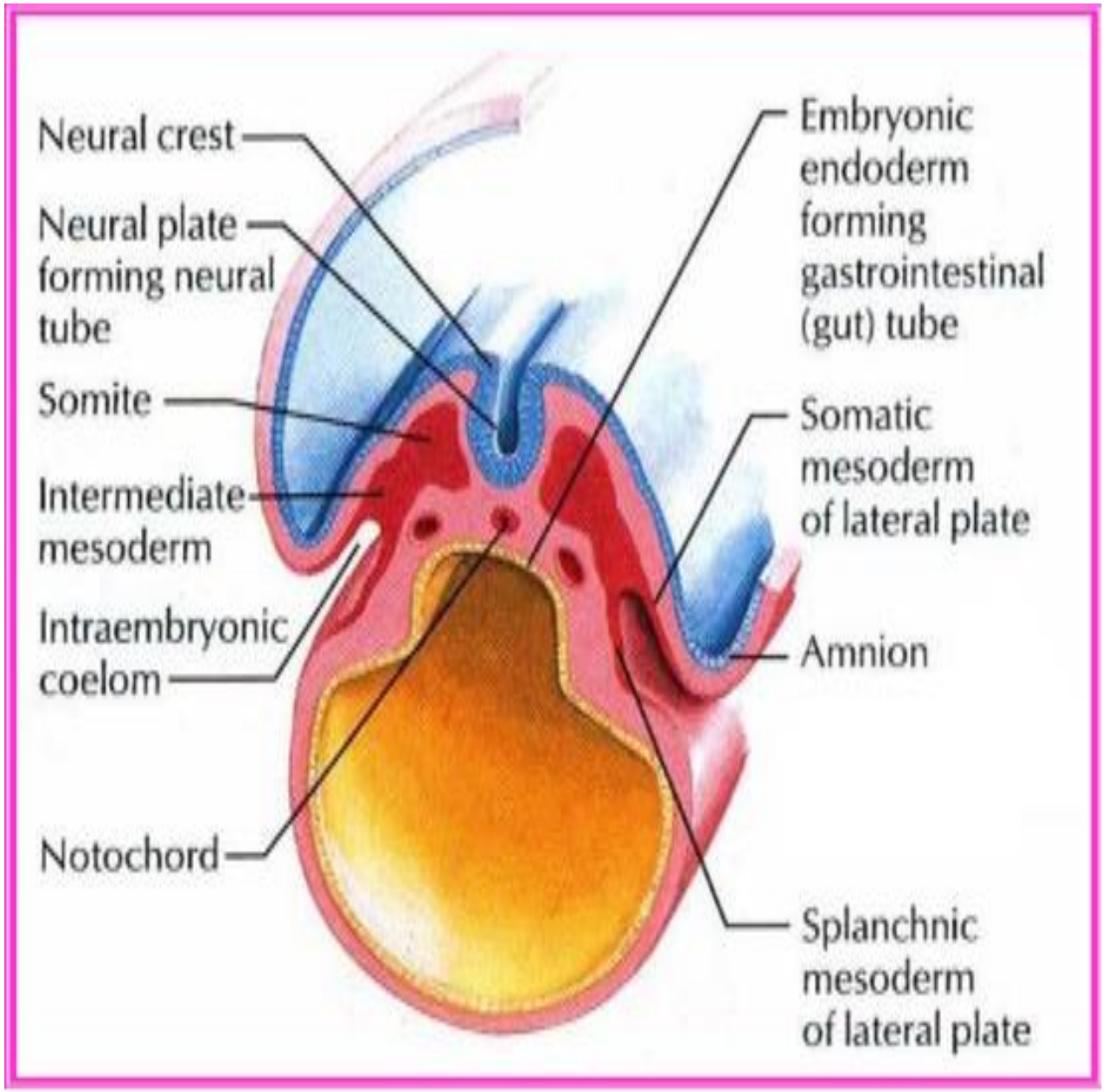
**Respiratory tract** except nasal mucosa .

**Urinary bladder** except trigone

**urethra** except its terminal part .

- The **middle ear** cavity and the **Eustachian tube**.

**2- Parenchyma of** Palatine tonsils , thyroid , parathyroid glands ,thymus , Liver & pancreas .



- **c) Development of the intraembryonic mesoderm :**

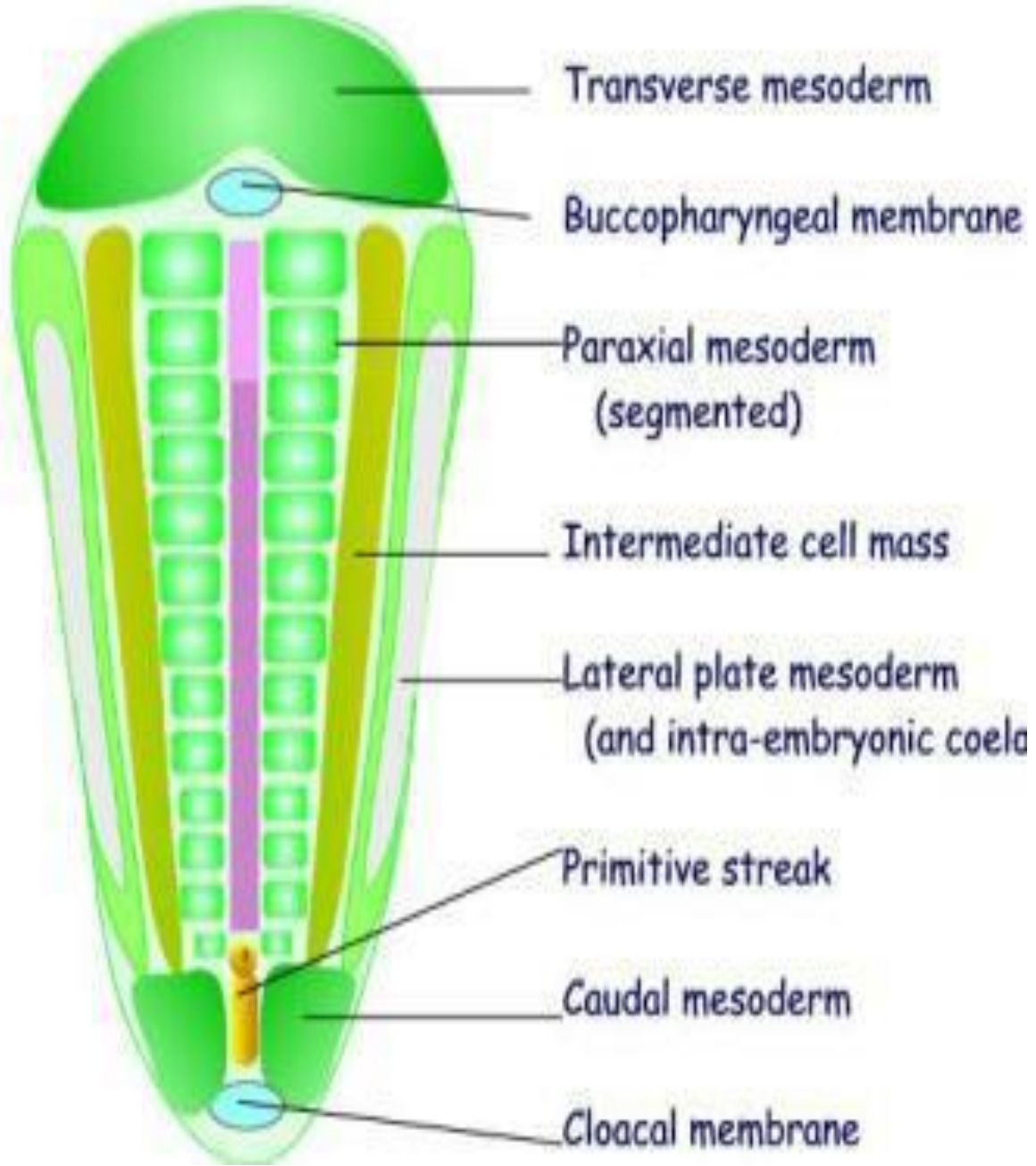
## 1- Paraxial mesoderm:

- It is the medial part that lies on either side of the notochord.

- It is divided by transverse grooves into body blocks called somites (4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 8-10 coccygeal).

-The first pair appears in the occipital region at the 20th day.

- The somites give the axial skeleton (bones & cartilage), vertebral muscles and covering skin.

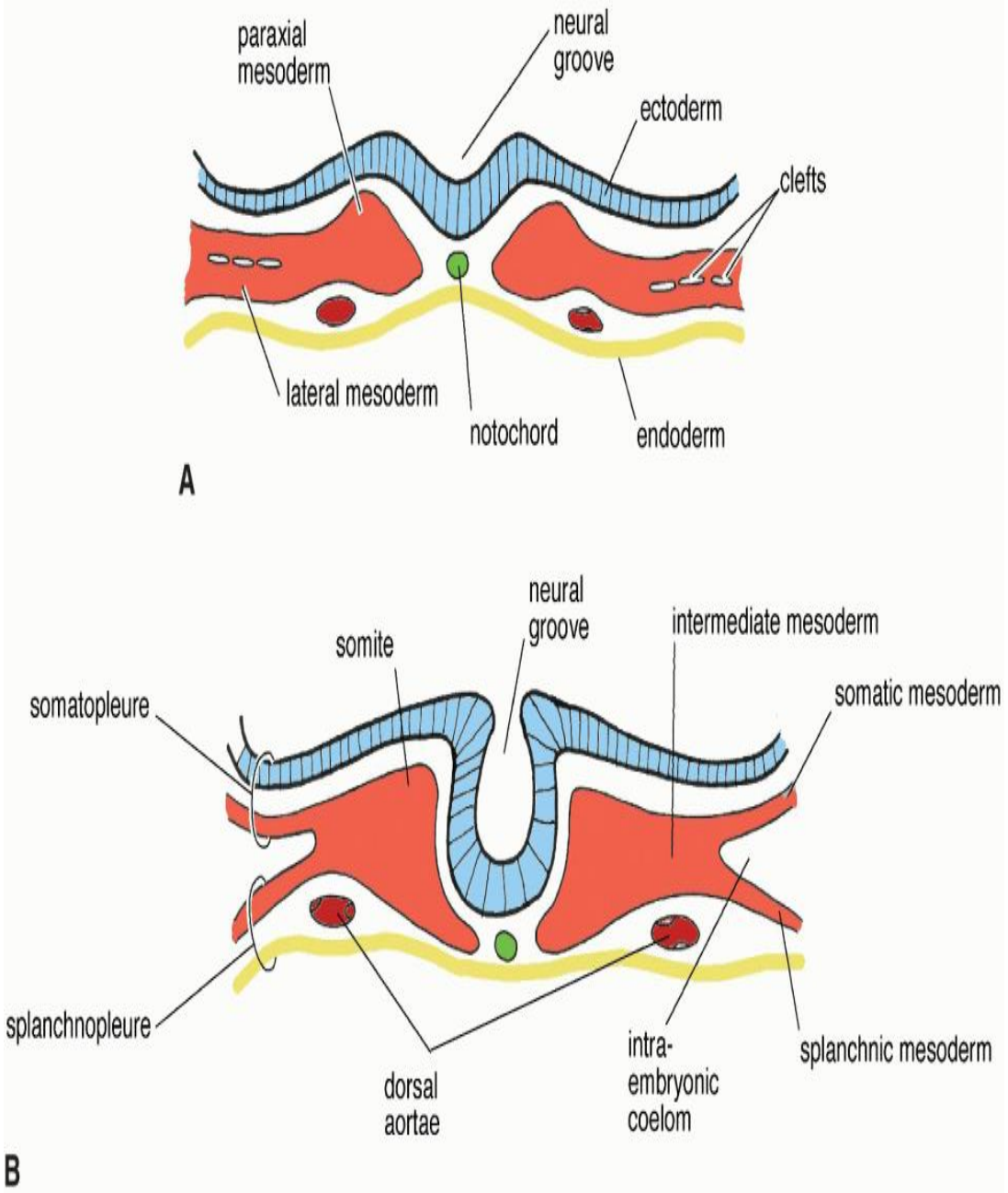


- **2- Development of the intermediate mesoderm :**

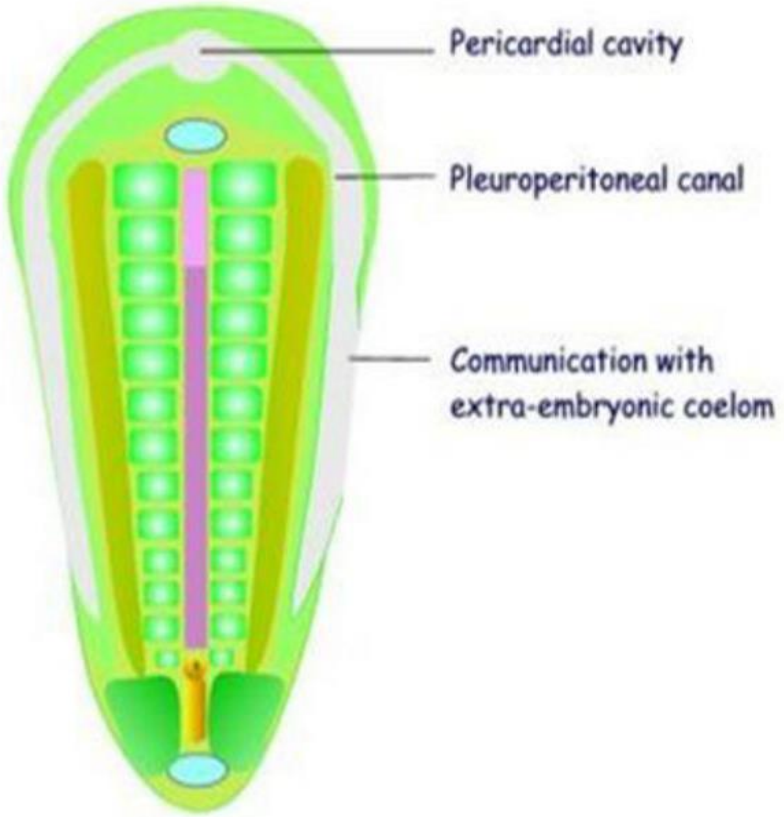
- It forms the cortex of suprarenal gland , nephrons of the kidneys, ureter and parts of genital system.

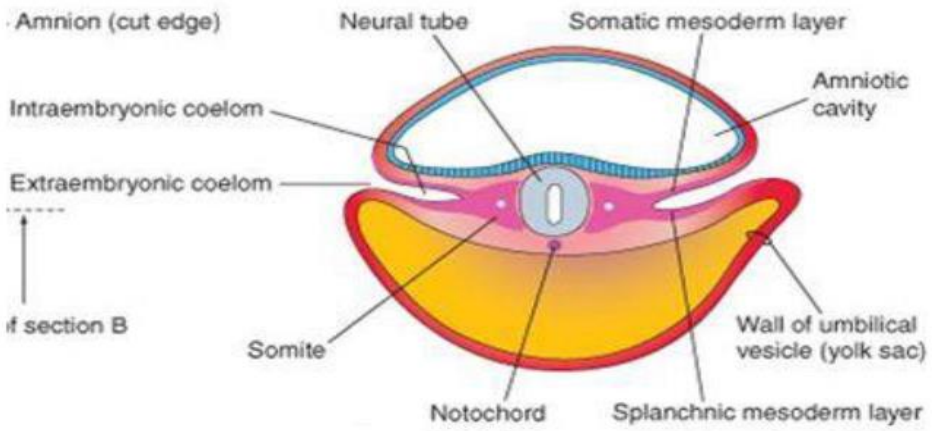
- **3- Development of the lateral plate mesoderm :**

- Small spaces , appear in the lateral plate of mesoderm , which coalesce to form a cavity in this plate called the intraembryonic coelomic cavity



- It **is in the form of an inverted U with a central part cranial to the buccopharyngeal membrane and 2 limbs on the sides of embryo.**
- **The central part will form the pericardial cavity.**
- **The cranial part of the 2 limbs will form the 2 pleural cavity.**
- **The caudal part of the 2 limbs will form the peritoneal cavity .**
- **The mass of mesoderm cephalic to the pericardial cavity is called the septum transversum which will form the diaphragm.**
- **The limbs of the intraembryonic coelomic cavity are open at the periphery of the embryonic disc and are connected to the extraembryonic coelom but this connection is closed at the 10 week .**



**The intraembryonic coelomic cavity divides the lateral plate mesoderm into:**

➢ **The somatic mesoderm:**

- **It becomes adherent to ectoderm to forms**
- **1-the striated muscles and connective tissue of the lateral & ventral aspect of body wall .**
- **2- Parietal layers of serous membranes.**

➢ **The splanchnic mesoderm:**

- **It becomes adherent to endoderm to forms**
- **1-the smooth muscles and connective tissue of the gut & respiratory system .**
- **2- Cardiac muscles .**
- **3- visceral layer of serous membranes.**