



**CNS**  
**Doctor 2021**



# **Embryology**

## **Modified ( 1 )**

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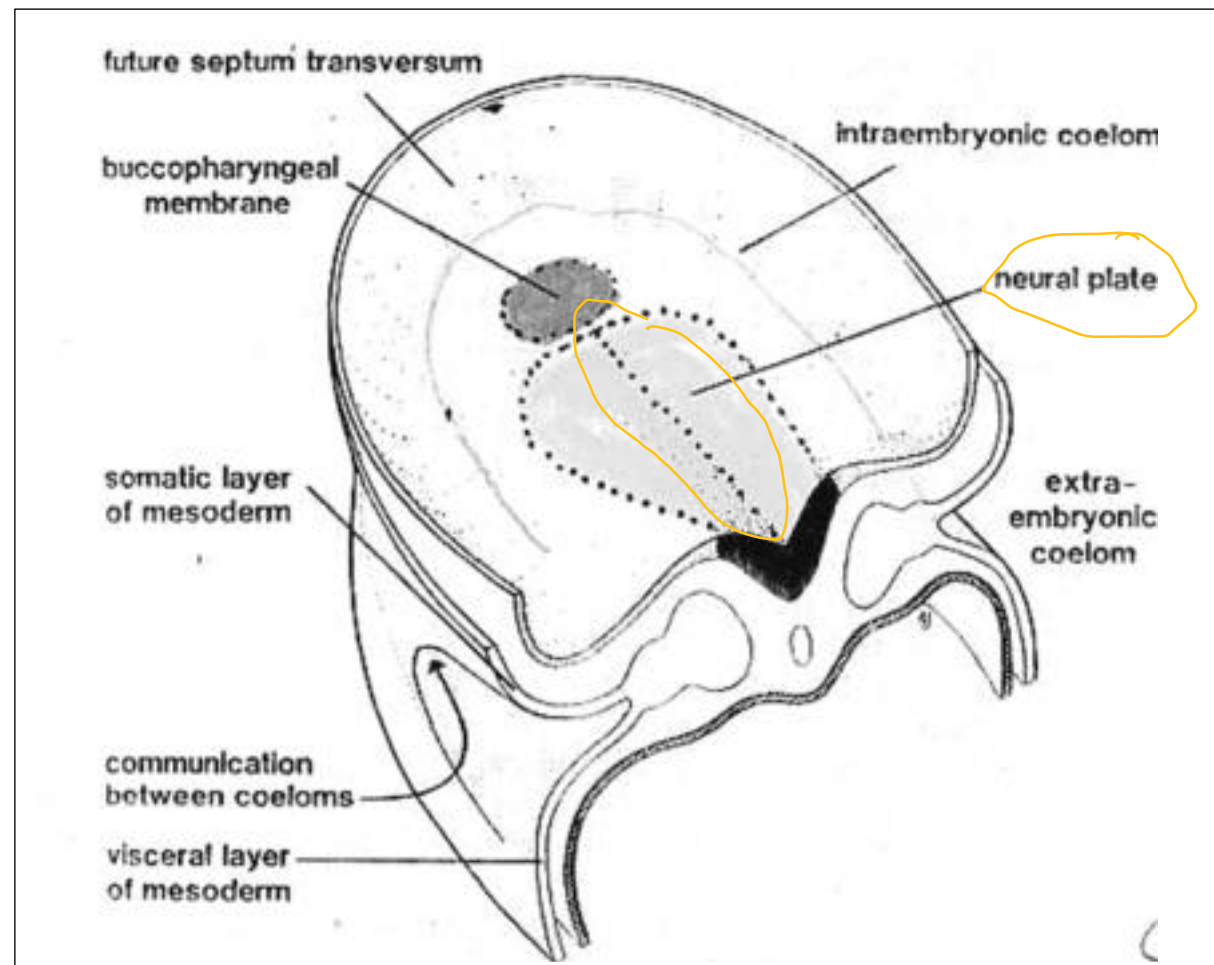
**Daoud**

**Doctor:**

**Mohammad**

## Development of the nervous system

- **Development of the neural tube**
- **Beginning of the 3rd week an ectodermal thickening appears in the middle of the trilaminar germ disc known as the neural plate**
- **The neural plate invaginates to form a neural groove.**
- **The lips of the neural groove approach each other & fuse transforming the groove into a neural tube with anterior & posterior neuropores which are obliterated on days 25 & 27 respectively transforming the neural tube into a closed tube.**



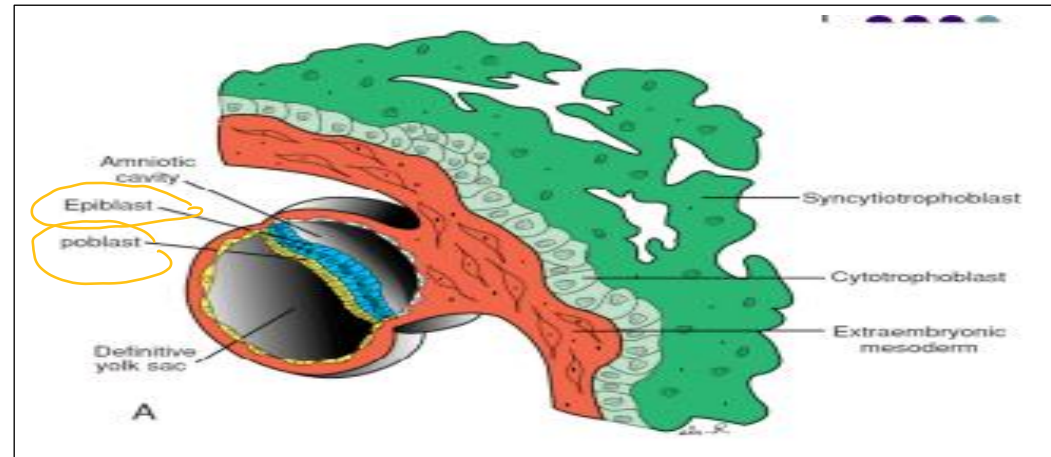
**Cranial ends form primary vesicles and caudal ends form spinal cord.**

**is formed in week 3 of development, during which time the neural plate develops. The neural plate consists of neuroectoderm and becomes the neural tube, which gives rise to the brain and spinal cord.**

**In second week of development, we have only two layers**

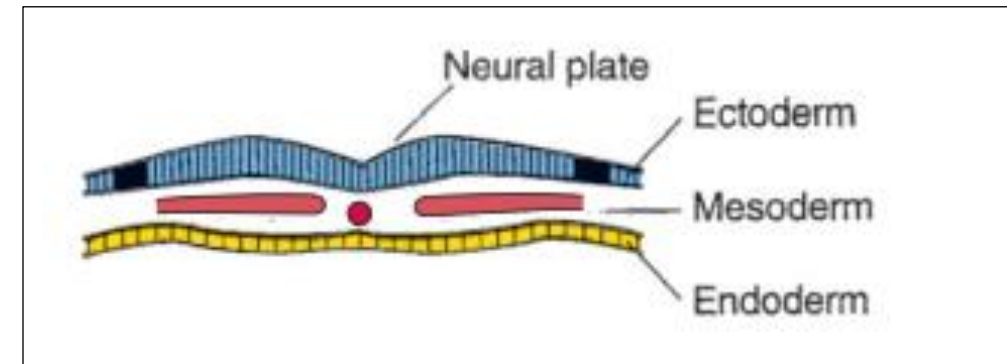
**Epiblast and above it we have an ammonitic cavity**

**Hypoplastic layer and below it we have the Yolk sac**



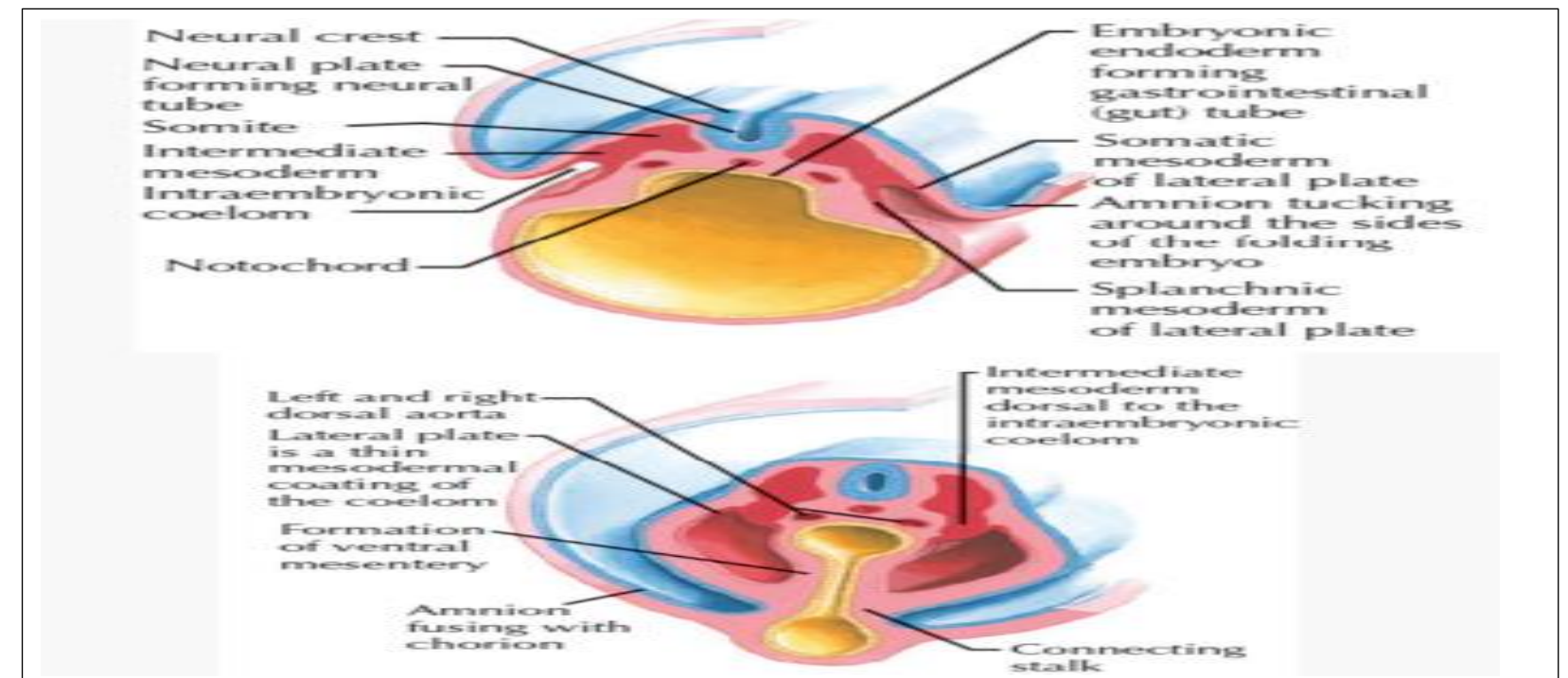
### **trilaminar embryo (Gastrula)**

- **3 major germ layers form the initial developing embryo:**
- **Ectoderm**
- **Mesoderm**
- **Endoderm**



## Neurulation

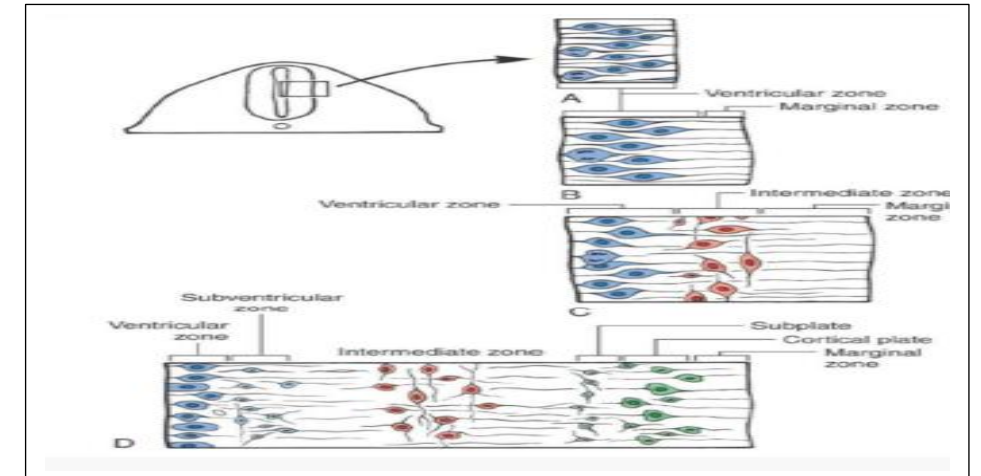
- **Neural plate: thickened mass forms in the overlying ectoderm.**
- **Neural groove :**
- **A crease or fold soon appears in this plate**
- **Rapidly deepens - the precursor of the embryo's CNS**
- **Neural folds: arch over and fuse at several points along the length of the neural tube**
- **Neural tube: “zippered closed ” as by the neural folds, concomitant with the budding somites**
- **Cranial and caudal neuropores which are obliterated on days 25 & 27 respectively transforming the neural tube into a closed tube**



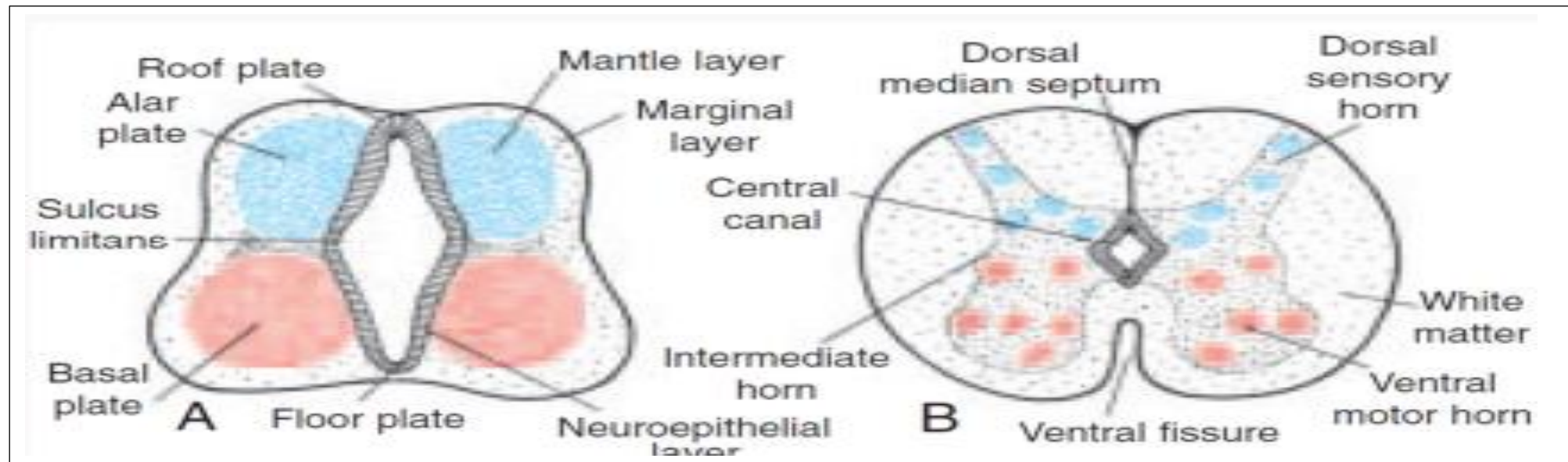


## Development of the spinal cord

- The neural tube is lined by one cell layer called a matrix.
- This epithelium, which extends from the cavity of the tube to the exterior, is referred to as the ventricular zone.
- Repeated division of the matrix cells increases the length and diameter of the neural tube.
- cells migrate peripherally to form the intermediate zone (grey matter)



- Once the neural tube closes, neuroepithelial cells begin to give rise to neuroblasts
- Neuroblasts from the mantle layer, a zone around the neuroepithelial layer (later forms the gray matter of the spinal cord).
- The outermost layer of the spinal cord, the marginal layer, contains nerve fibers emerging from neuroblasts in the mantle layer. As a result of the myelination of nerve fibers, this layer takes on a white appearance and therefore is called the white matter of the spinal cord.

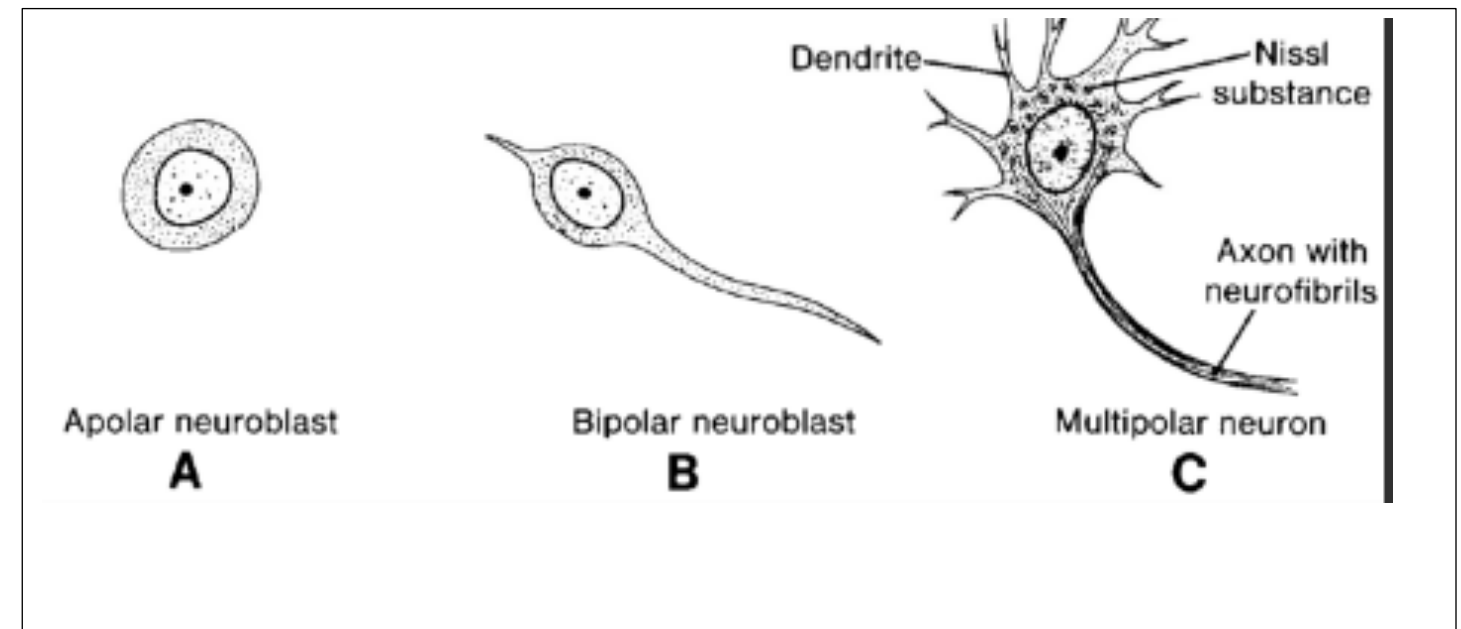


## Cells in the lateral wall of the neural tube are differentiated into 3 layers :

- **Inner ependymal layer:** the ependymal lining of the central canal & ventricles.
- **Middle Mantle Layer:** Cellular layer which forms the grey matter of the spinal cord
- **Outer Marginal Layer:** forms the white matter of the spinal cord
- **The thick lateral walls are connected together by thin roof plate (dorsal) & floor plate (ventral)**
- **A groove (sulcus limitans) appears in the lateral wall dividing it into:**
- **Dorsal part (Alar Plate) which expands to form the dorsal (sensory) horn.**
- **Ventral part (basal plate) which expands to form the ventral (motor) horn.**
- **The cavity of the tube remains narrow & forms the central canal of the spinal cord.**

### **Neuroblasts: arise exclusively by division of the neuroepithelial cells**

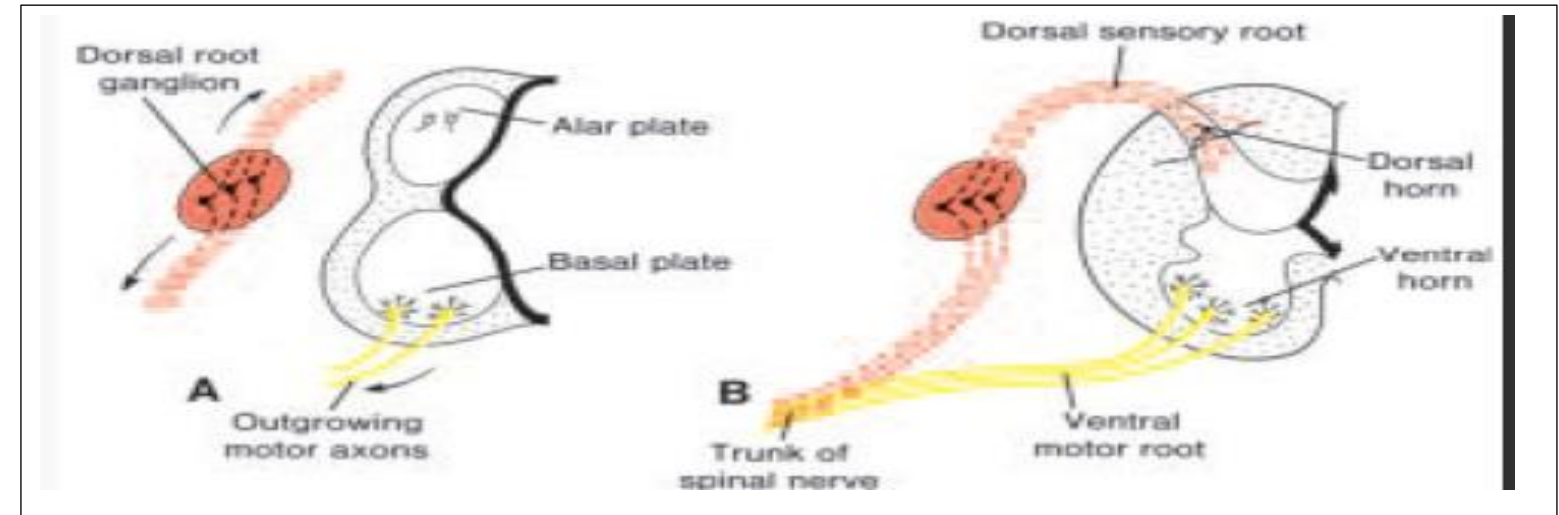
- **Initially they have a central process extending to the lumen (transient dendrite), but when they migrate into the mantle layer, this process disappears, and neuroblasts are temporarily round :**
- **Apolar**
- **Bipolar neuroblast**
- **Multipolar neuroblast**



**Once neuroblasts form, they lose their ability to divide.**

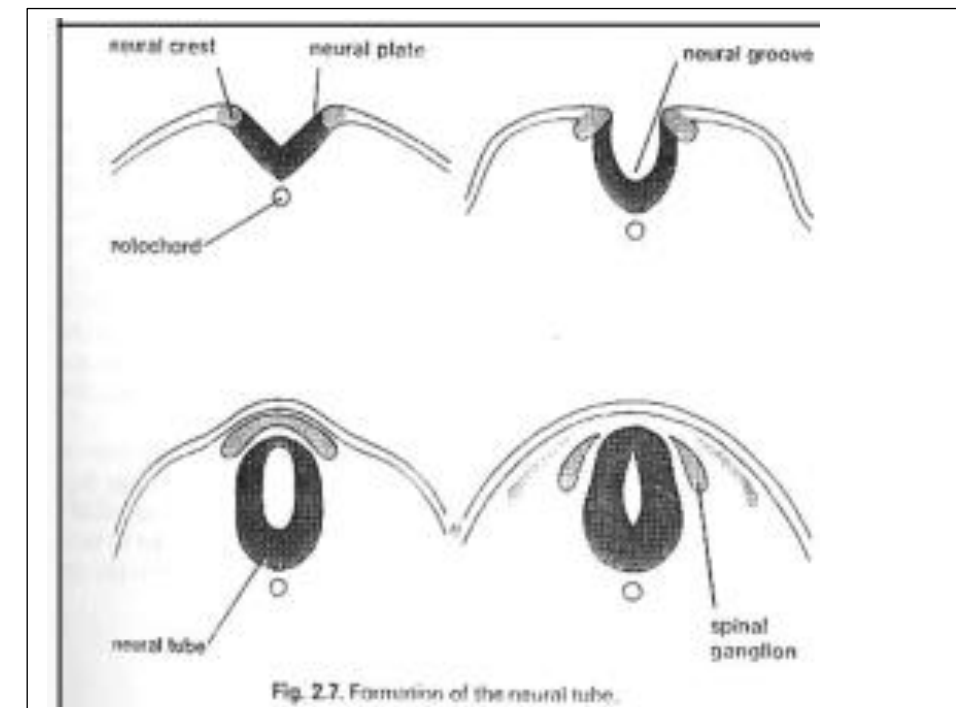
**Ventral motor root of the spinal nerve: Axons of neurons in the basal plate break through the marginal zone and become visible on the ventral aspect of the cord.**

**Dorsal root ganglia: Neural crest cells**



### **Neural crest**

- **Junction of the neural plate with ectoderm**
- **Unite then pinched off as neural tube separates from ectoderm**
- **Neural crest cells migrate within the mesoderm**

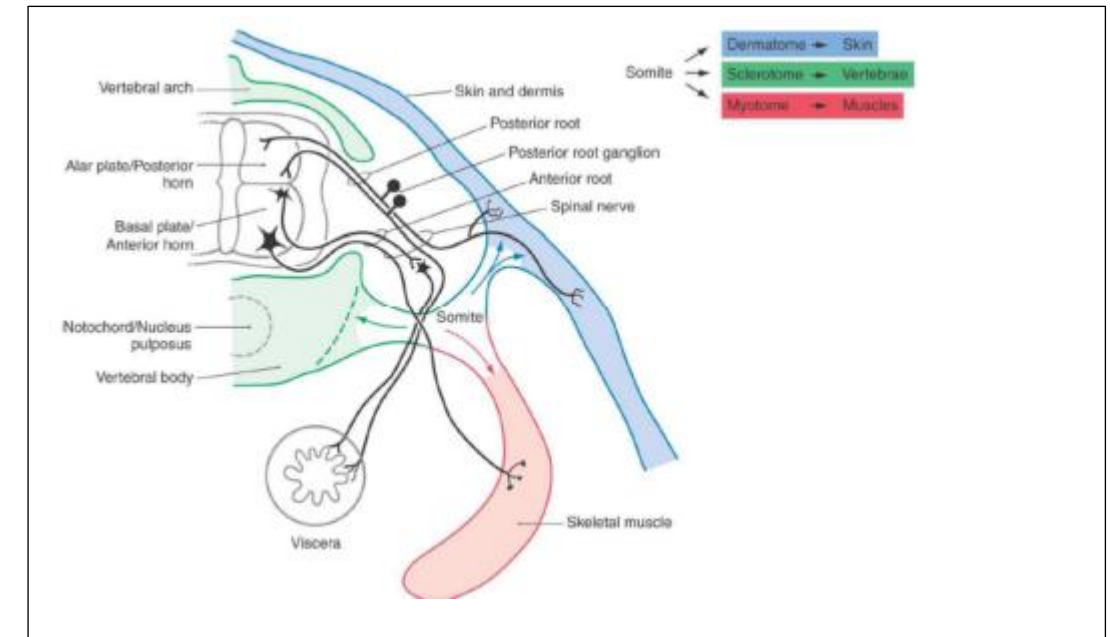


## Neuroblasts of the sensory ganglia form two processes:

- **Central:** either end in the dorsal horn or ascend through the marginal layer to one of the higher brain centers
- **Peripheral:** growing processes join fibers of the ventral motor roots and thus participate in the formation of the trunk of the spinal nerve.

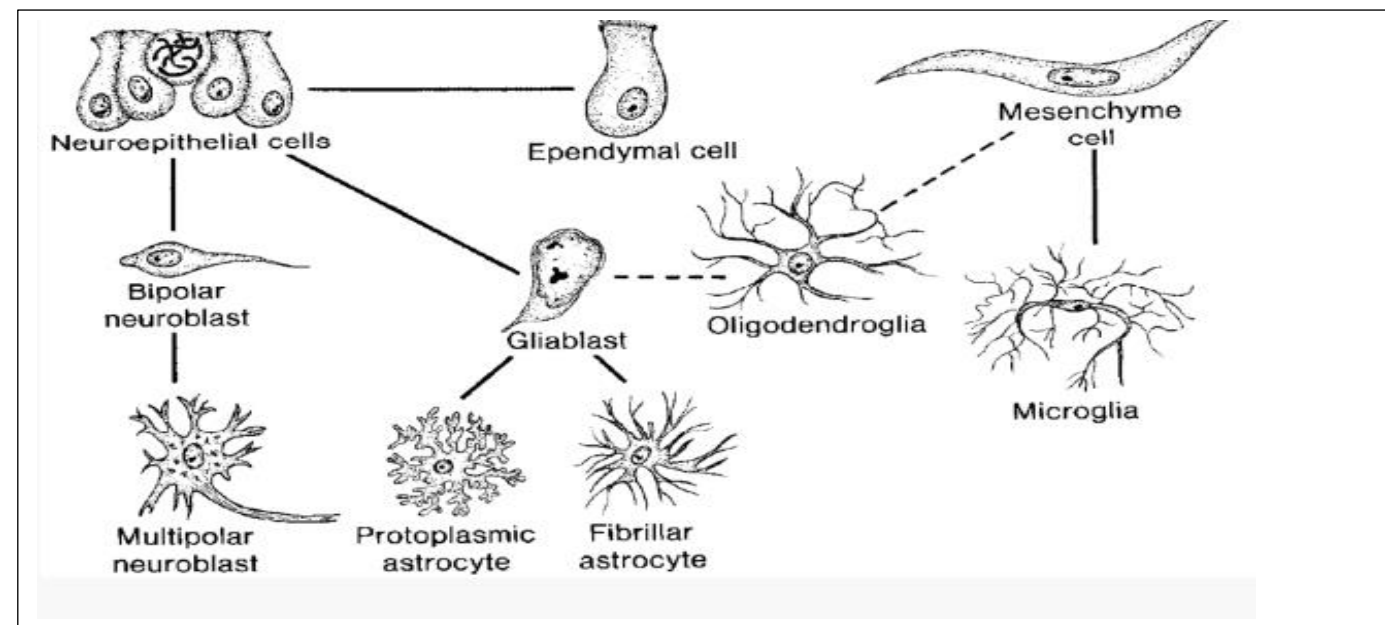
## Ectomesenchyme tissue in the head region

- **Dermis of the head region**
- **All dental tissue except enamel**
- **Branchial arches**
- **Skeleton**
- **Part of musculature**
- **Pigment cells**
- **Melanocytes**
- **Meninges**
- **Spinal & cranial nerve ganglia**
- **Sympathetic & parasympathetic systems**
- **Adrenal medulla**
- **Schwann cells**





**Gliablasts that give neuroglial cells  
Expect microglial cells come from  
monocyte**



## **DEVELOPMENT OF THE MENINGES**

- **Neural crest and mesodermal cells form the primitive meninges (meninx primitiva). no obvious spaces**
- **Between 34 and 48 days the primitive meninges differentiate**
- **Outer: ectomeninx, will become the dura mater**
- **Inner: endo meninx, will form the arachnoid mater and pia mater**
- **By the end of the first trimester: the meninges is established.**

**Meninges arises around neural tube**

## POSITIONAL CHANGES OF THE CORD

**Third month: The spinal cord extends the entire length of the embryo**

**Fifth month: S1**

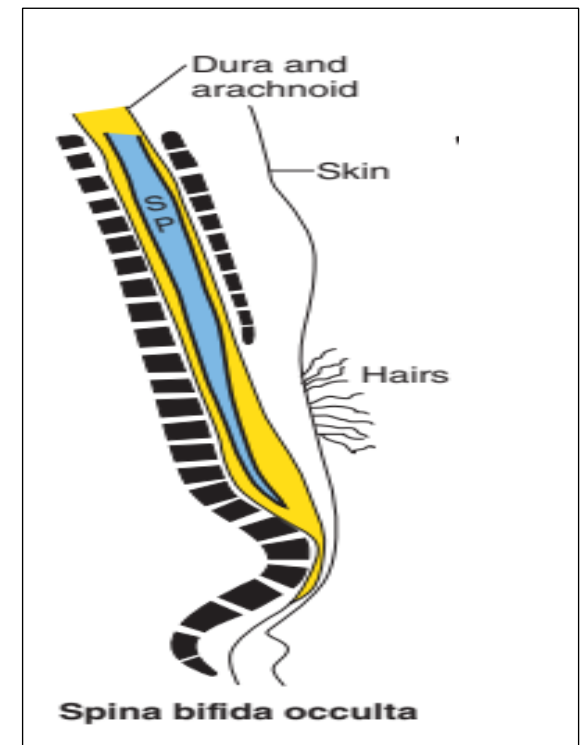
**Newborn: L3-L4**

**Adult: L1-L2**

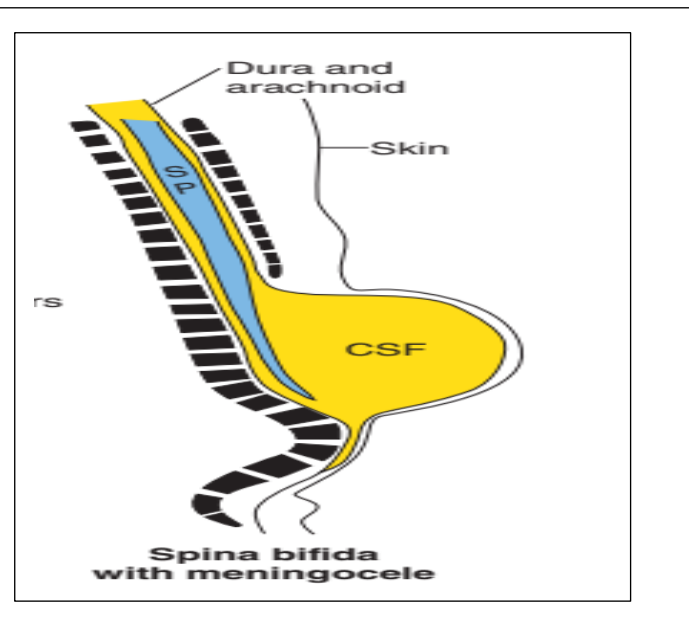
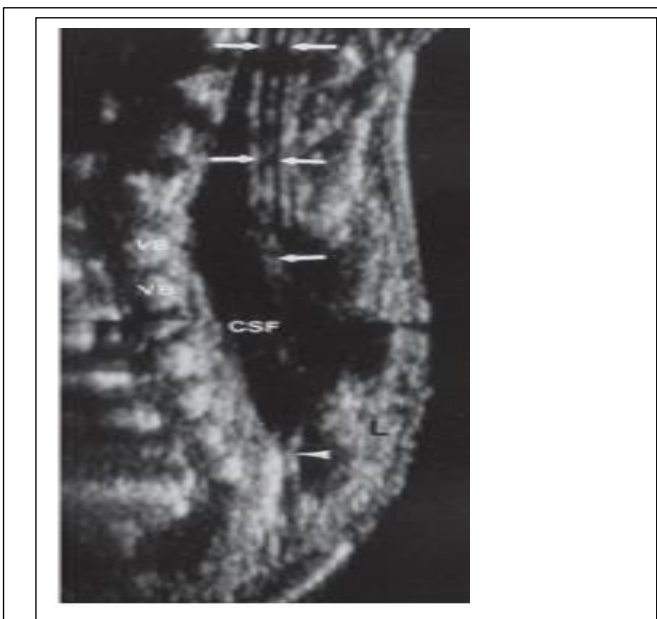
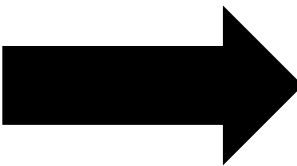
## Congenital Malformations of spinal cord development

- **Spina bifida occulta: Absent vertebral arch with normal spinal cord. It affects the lumbosacral area & is usually covered with hairy skin**
- **Spina bifida cystica:**
- **Meningocele: The meninges herniate through the spina bifida to form subcutaneous sac filled with CSF.**
- **Meningomyelocele: The spinal cord herniates through the meningocele.**
- **Myelocele (Rachischisis): Failure of obliteration of the neural tube**

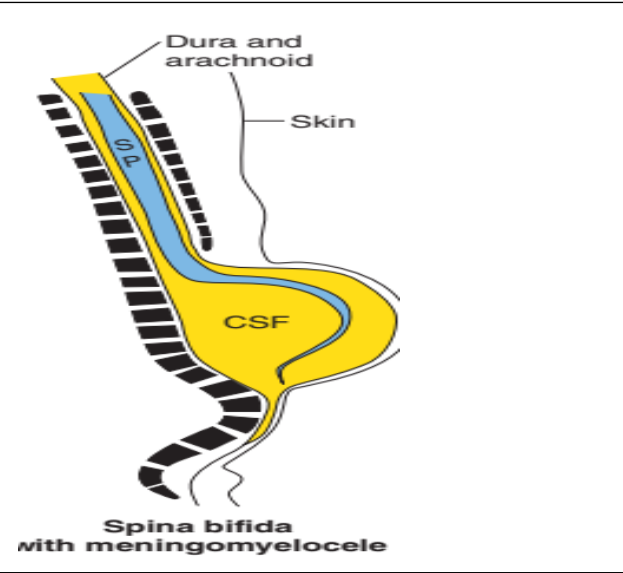
**Spina bifida occulta is evidenced by a tuft of hair in the lumbosacral region. It is the least severe variation and occurs in 10% of the population. The MRI of spina bifida occulta shows the presence of bony vertebral bodies (VB) along the entire length of the vertebral column. However, the bony spinous processes terminate much higher (asterisk) because the vertebral arches fail to form properly. This creates a bony vertebral defect. The spinal cord is intact.**



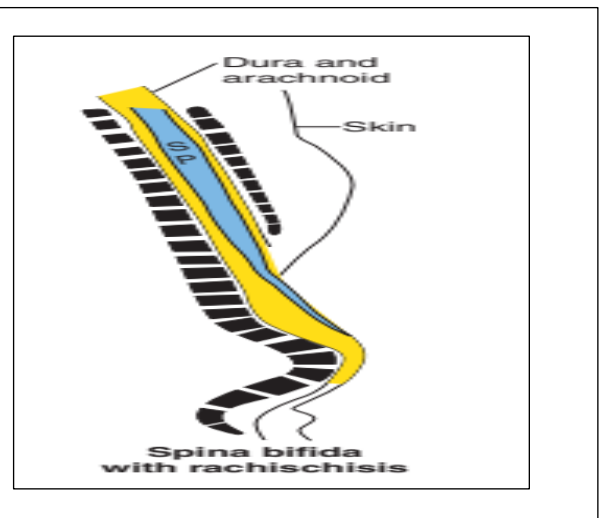
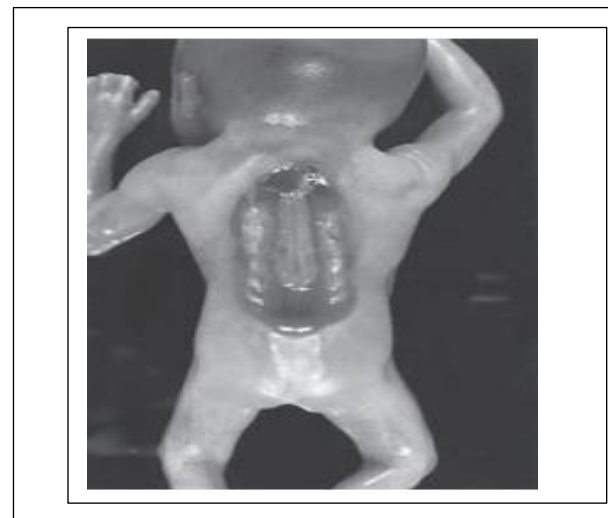
**Spina bifida with meningocele occurs when the meninges protrude through a vertebral defect and form a sac filled with CSF. The spinal cord remains in its normal position. The sonogram of spina bifida with meningocele shows the spinal cord (arrows), CSF-filled sac, a small subcutaneous lipoma (L), and the filum terminale (arrowhead).**



**Spina bifida with meningocele occurs when the meninges and spinal cord protrude through a vertebral defect and form a sac filled with CSF**



**Spina bifida with rachischisis occurs when the posterior neuropore of the neural tube fails to close during week 4 of development. This condition is the most severe type of spina bifida, causing paralysis from the level of the defect caudally. This variation presents clinically as an open neural tube that lies on the surface of the back. This condition also falls into a classification called NTDs.**



## Development of the brain

The cephalic end of the neural tube shows three primary brain vesicles:

**Prosencephalon: forebrain**   **Telencephalon: two lateral out pocketing, primitive cerebral hemispheres**

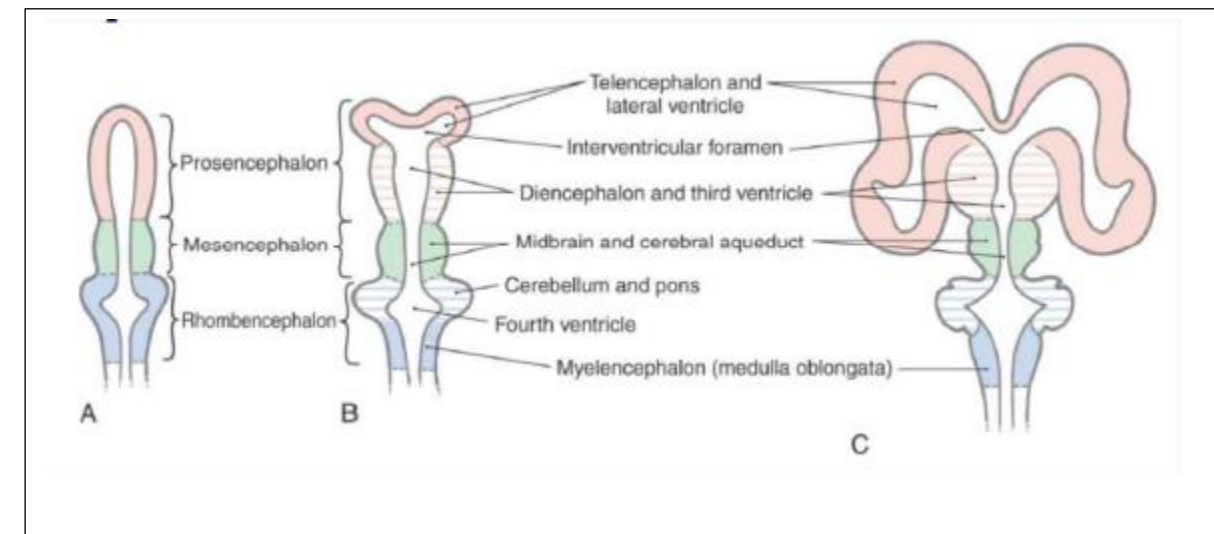
**Diencephalon**

**Mesencephalon: midbrain**

**Rhombencephalon: hindbrain**

**Metencephalon: which later forms the pons and cerebellum**

**Myelencephalon: which later forms medulla oblongata**

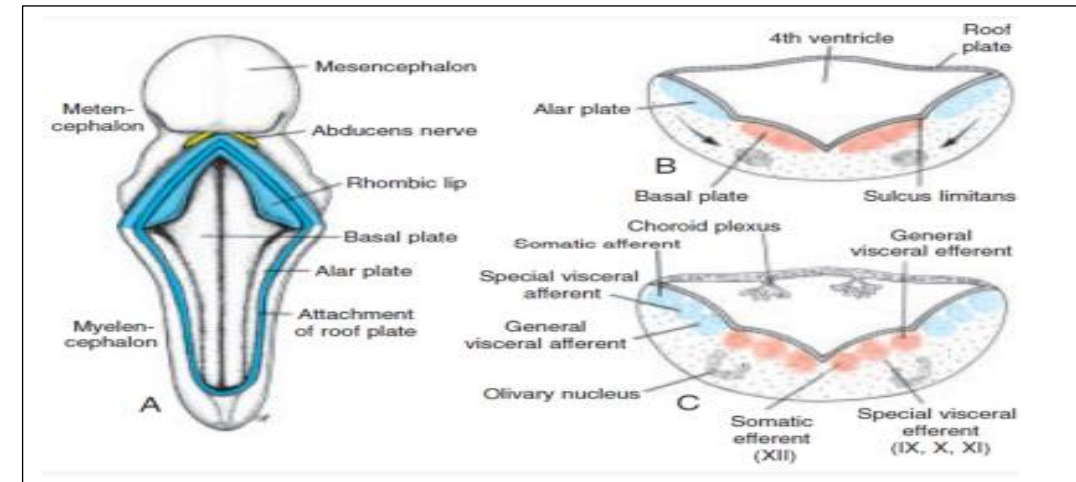


# DEVELOPMENT OF THE MEDULLA OBLONGATA

**Myelencephalon:** which later forms medulla oblongata As in the development of the spinal cord the medulla will have an alar plate & a basal plate separated by a sulcus limitans & connected by a thin roof plate & a floor plate.

- The lateral walls move away from each other stretching the roof plate & enlarging its cavity which forms the 4th ventricle.
- The alar plate forms the sensory nuclei of the medulla & the basal plate forms the motor nuclei.
- Between the fourth and fifth months, local resorptions of the roof plate occur, forming lateral foramina of Luschka, and a median foramen of Magendie.

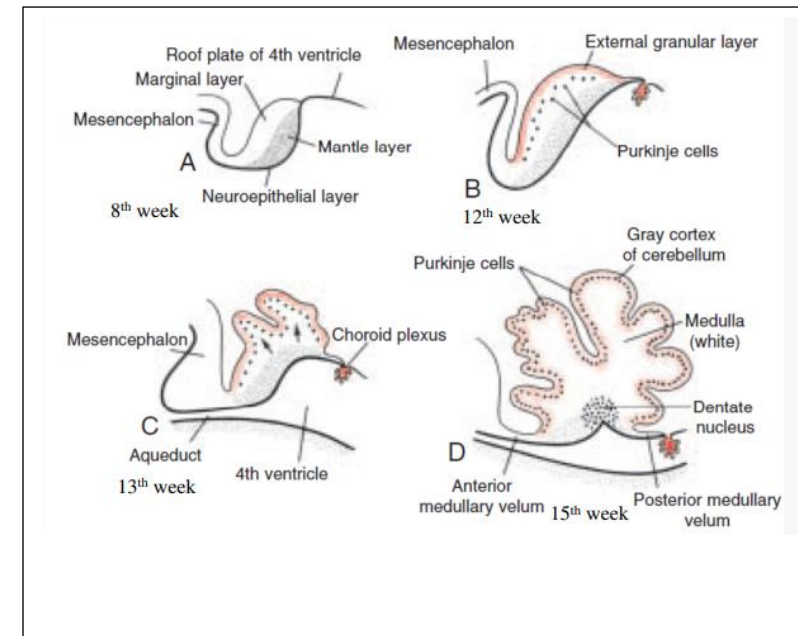
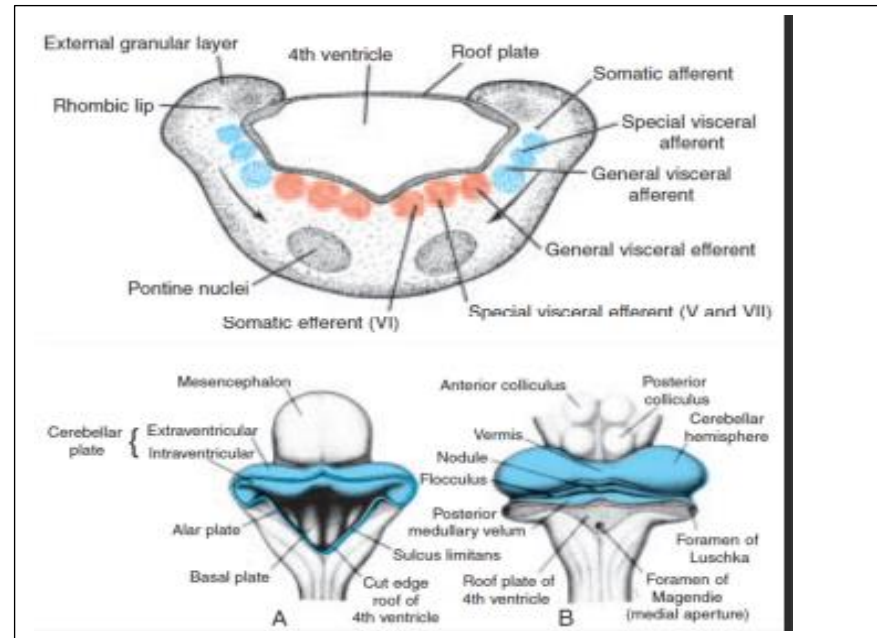
## Development of the pons & cerebellum



**Metencephalon:** which later forms the pons and cerebellum

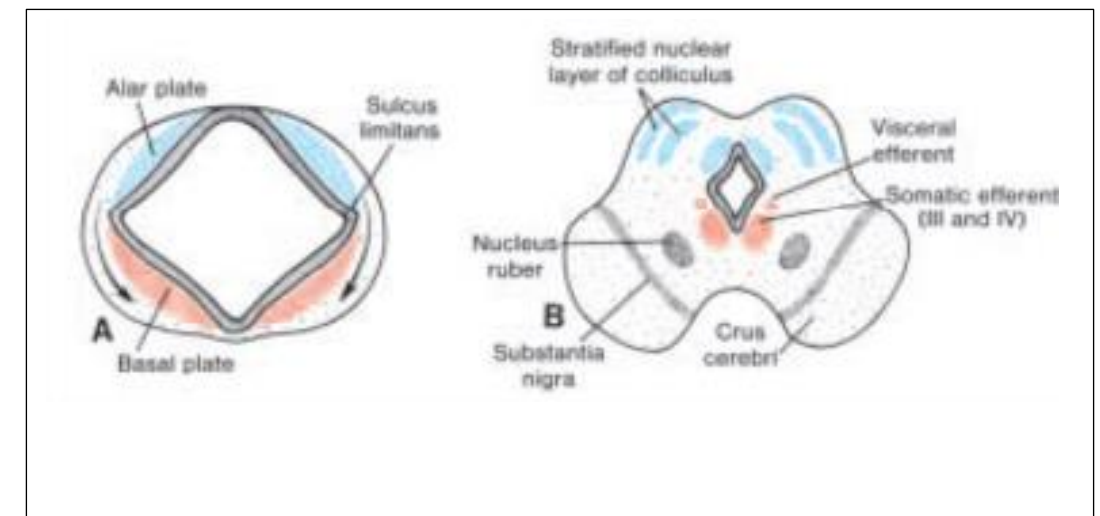
- The same steps in the development of the medulla occur but the alar plates bend medially to form 2 rhombic lips.
- The rhombic lips approach each other & fuse together forming a cerebellar plate.
- The cerebellar plate differentiates into a median part which forms the vermis & 2 lateral masses which form the cerebellar hemispheres.
- The cavity forms part of the 4th ventricle
- **Basal plate:** 1) Medial somatic efferent 2) Special visceral efferent 3) General visceral efferent
- **Alar plates:** 1) Lateral somatic afferent 2) Special visceral afferent 3) General visceral afferent





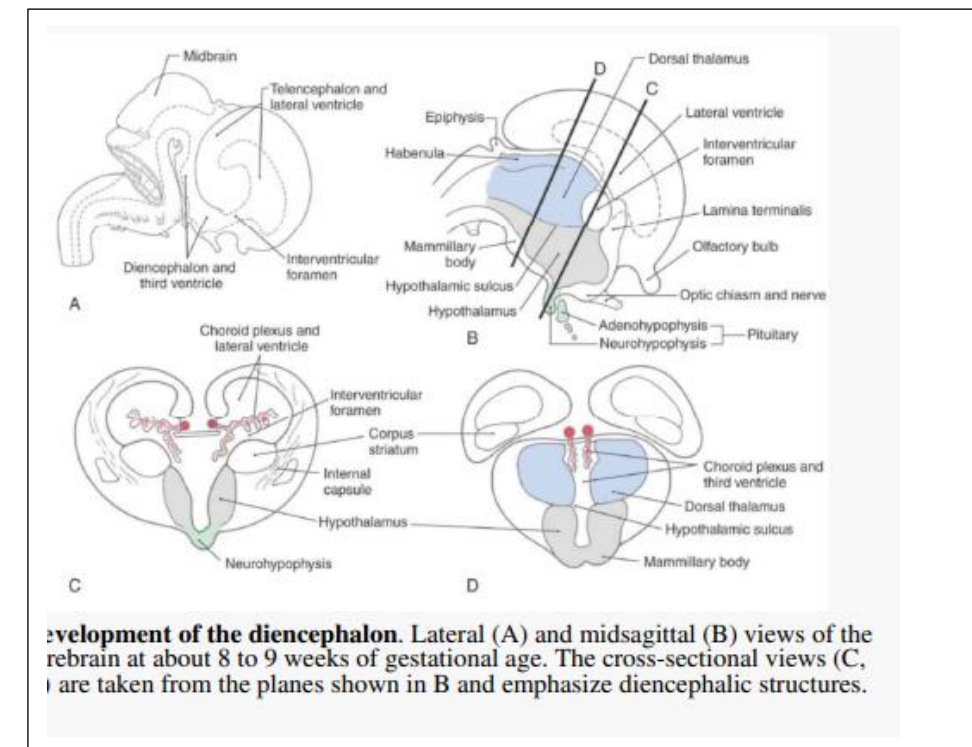
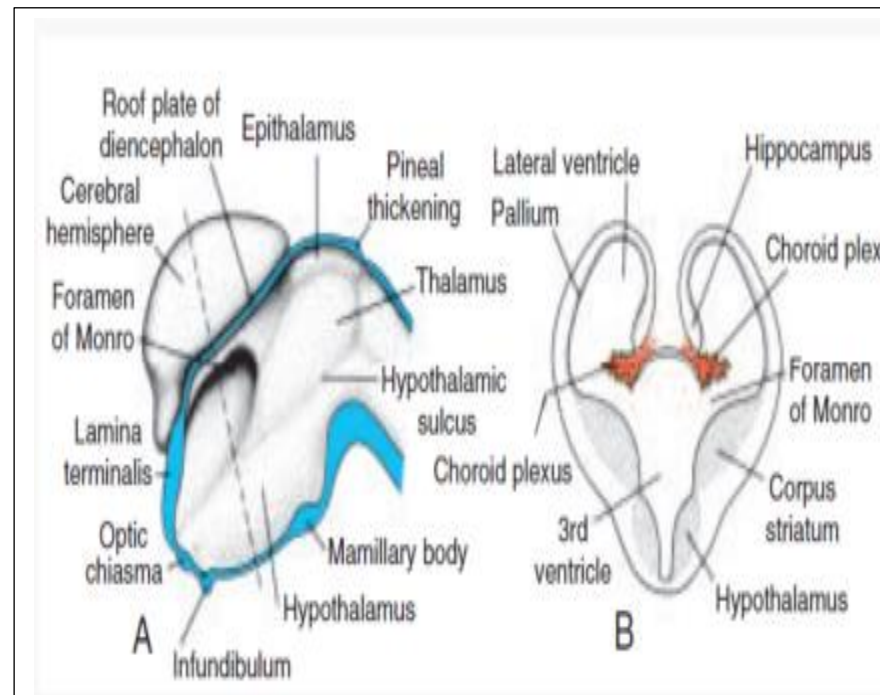
## Development of Midbrain

- **As in the development of the spinal cord & the medulla the midbrain will have an alar plate & a basal plate separated by a sulcus limitans & connected by a thin roof plate & a floor plate.**
- **The alar plates develop to form the tectum which is divided by a vertical & transverse groove into 4 colliculi.**
- **The basal plate forms the motor nuclei in the tegmentum of the midbrain**
- **The marginal layer of the basal plate enlarges greatly to form the crus cerebri.**
- **Its cavity remains narrow & forms the cerebral aqueduct.**



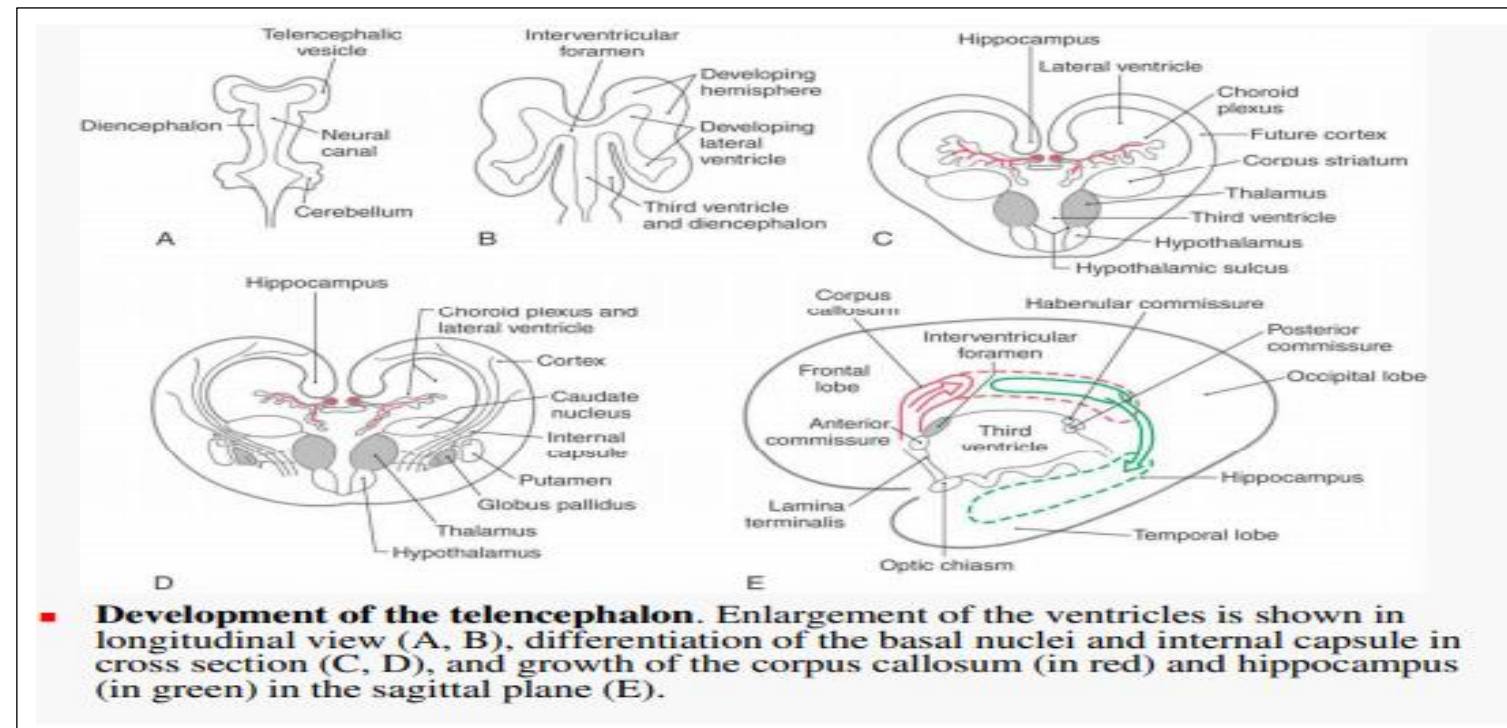
## Development of the Diencephalon

- It develops from the median part of the forebrain. It consists of 2 lateral walls connected by a roof plate & a floor plate, its cavity is called the 3rd ventricle. ✓
- The roof plate:
  - Anterior part forms the choroid plexus of the 3rd ventricle.
  - Posterior part forms the pineal body.
- A hypothalamic sulcus appears in the lateral wall which separates the thalamus above from the hypothalamus below.
- The floor plate forms the posterior lobe of the pituitary gland



## Development of the telencephalon

- The 2 cerebral hemispheres arise as 2 evaginations from the lateral wall of the forebrain.
- The cavity of each of them expands to form the lateral ventricle.
- The wall of the hemisphere consists of 3 layers: ependymal, mantle & marginal.
- The mantle layer at the base of the hemisphere forms the basal ganglia.
- The hemispheres enlarge & overlaps the brain stem & cerebellum.



## **Congenital Malformations of brain development**

### **Hydrocephalus:**

**Internal hydrocephalus: Excessive accumulation of CSF within the ventricles of the brain.**

**External hydrocephalus: Excessive accumulation of the CSF between the brain & arachnoid mater.**

**Exencephaly: It is due to failure of closure of anterior neuropore. The vault of the skull is absent & the brain is exposed. When the brain is degenerated the anomaly is known as Anencephaly.**

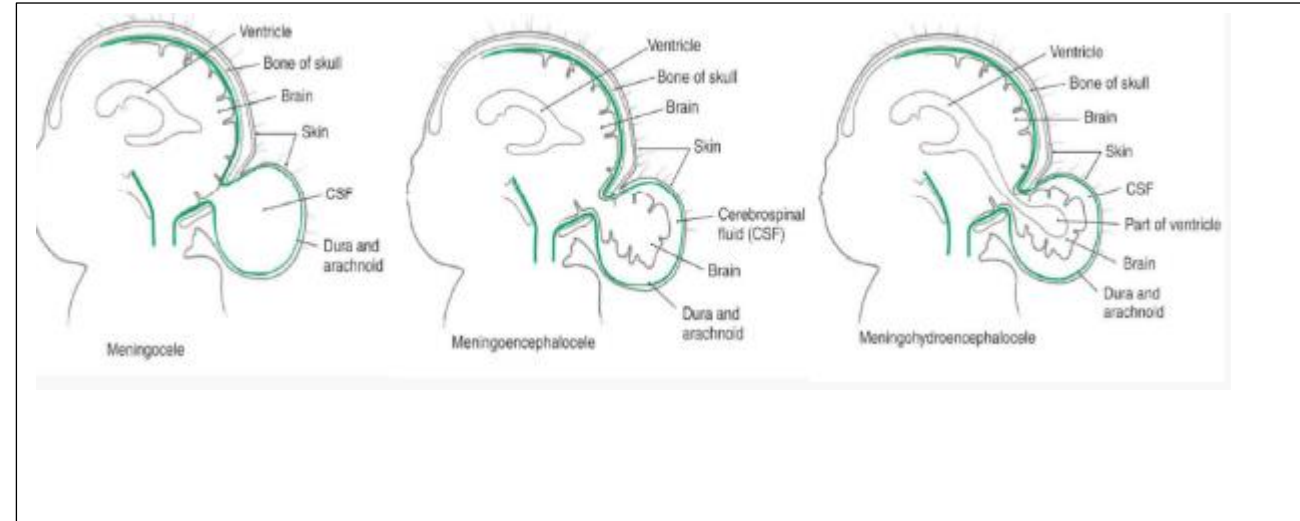




**Meningocele: the meninges herniated through a deficient part of the skull.**

**Meningoencephalocele: part of the brain herniated through the meningocele.**

**Meningo-hydro-encephalocele: part of the ventricle is found within the brain tissue which herniated through the meningocele**



**Holoprosencephaly: Results from degeneration of midline structures leading to fusion of lateral ventricles, orbital & nasal cavities.**

**Microcephaly: due to poor growth of the brain, is frequently associated with mental retardation**

