

Embryology

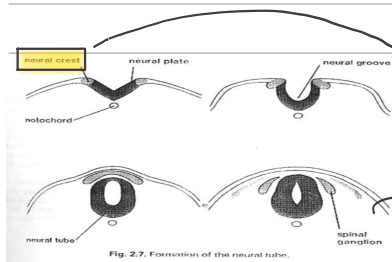
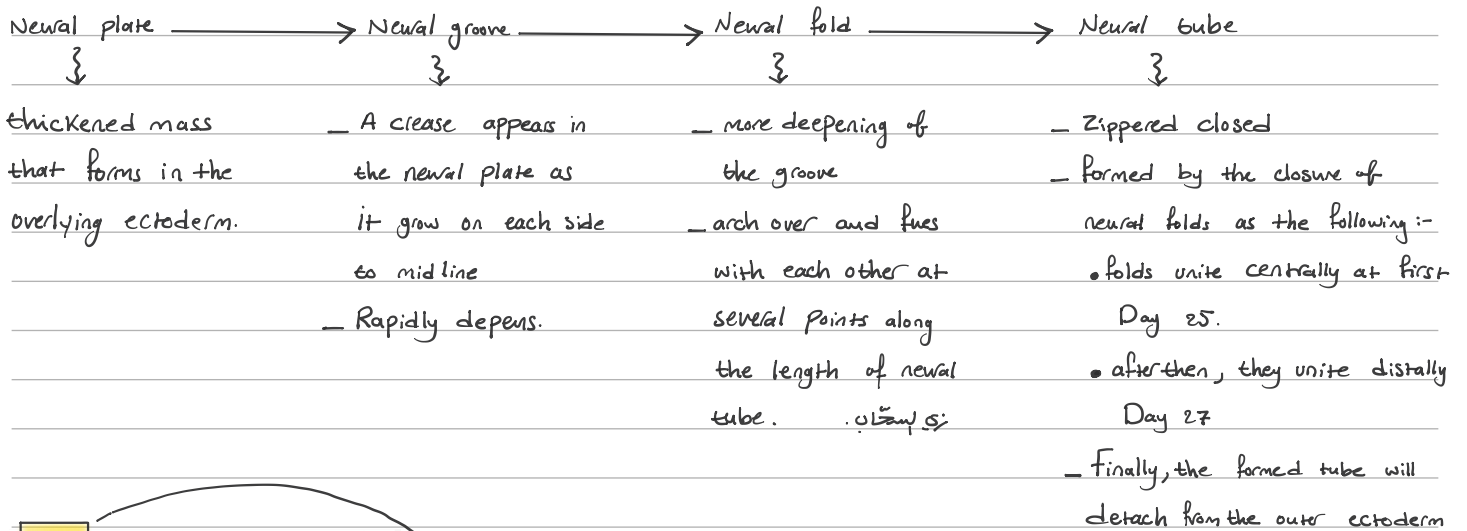
CNS development begins in the 3rd week by the formation of **neural tube**. It will be formed by a process called **Neurulation**.
 3 major germ layers form the initial developing embryo :- It will be formed by the 3rd week as epiblast proliferates.

① Ectoderm
 ↓
 dorsally

② Mesoderm

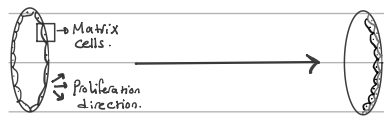
③ Endoderm.
 ↓
 ventrally.

* **Neurulation**



notice the neural crest cells that emerges from each lateral side of neural plate // junction of neural plate with surface ectoderm.
 - these neural crest cells unite initially, then pinched off as neural plate separates from ectoderm.

1) **Development of the spinal cord**



At first neural tube is lined by one cell layer called **Matrix**. Matrix cells will proliferate externally to give a rise to other cell layers.

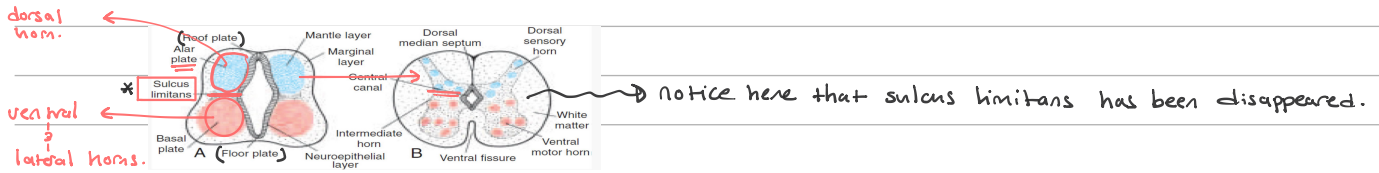
ventricular zone is formed by the epithelium which extends from the cavity of the tube to exterior.

Repeated division of matrix cells results in increase in length and diameter of neural tube. the neuroepithelial cells formed will give rise to Neuroblast differentiate into **Neuronal cells**. Neuronal cells will form intermediate zone called **Mantel layer** → gray matter. another layer is formed outermostly called **Marginal layer** → white matter.

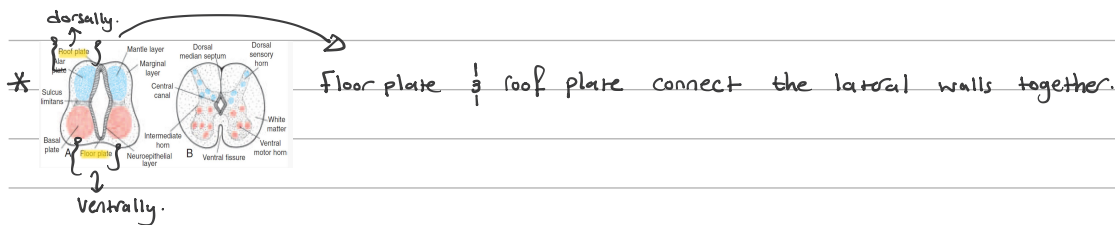
To sum up

- * neuronal tube starts with a single layer of matrix cells
- * the proliferation of matrix cells will end up with three layers :- (from innermost to outermost)
 - ① **Ventricular or ependymal layer** formed from neuroepithelial cells → lining central canal & ventricles.

- 2 **Mantle layer** from intermediate zone → will give rise to gray matter.
- cell bodies — this layer will further divide by Sulcus limitans into :- ① Alar plate ② basal plate.
- Sulcus limitans :- a groove in the lateral wall of the central canal, by the time this groove will disappear because the canal will be narrower.
 - Alar plate → dorsal horn "sensory function"
 - Basal plate → Ventral horn "somatic motor function",
Lateral horn "autonomic motor function"



- 3 **Marginal layer** from outermost zone → will give rise to white matter.
- Fibers

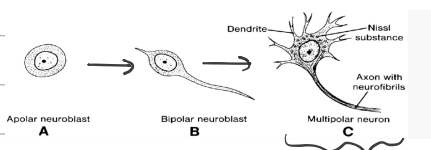


* Neuronal cells formation

- Neuroblasts are formed by the division of neuroepithelial cells.
- once neuroblasts form, they lose their ability to divide.

— Neuroblasts :-

- initially they have a central process extending to the lumen "transient dendrite"
- when they migrate to mantle layer the transient dendrite disappears.
- several changes occur before reaching mantle layer :-



↳ This cell will be found in mantle layer.

- Neuroblasts "cell bodies" of the sensory ganglia form two processes :-

- ① Central → end in the dorsal horn "spinal cord"
→ ascend thro. marginal layer to one of the higher centers in the brain.
- ② peripheral → join fibers of the ventral motor roots to form the trunk of spinal nerve.

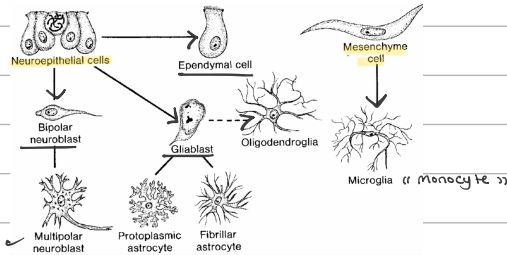
* Neural crest cells

- migrate within mesoderm.
- will give rise to ① dorsal root ganglia. ② Autonomic ganglia. ③ Cranial nerve ganglia.

structures of neural crest cells:-

- Ectomesenchyme tissue in head region
 - Dermis of head region
 - All dental tissue except enamel } From ectoderm.
 - Branchial arches
 - Skeleton
 - Part of musculature
 - Pigment cells
 - Melanocytes
- Meninges
- Spinal & cranial nerve ganglia
- Sympathetic & parasympathetic systems
- Adrenal medulla
- Schwann cells

* Histological differentiation of nervous system cells :-

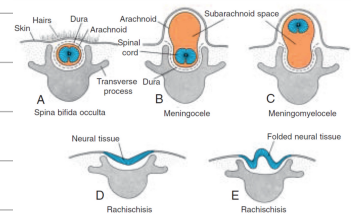


* Development of meninges :-

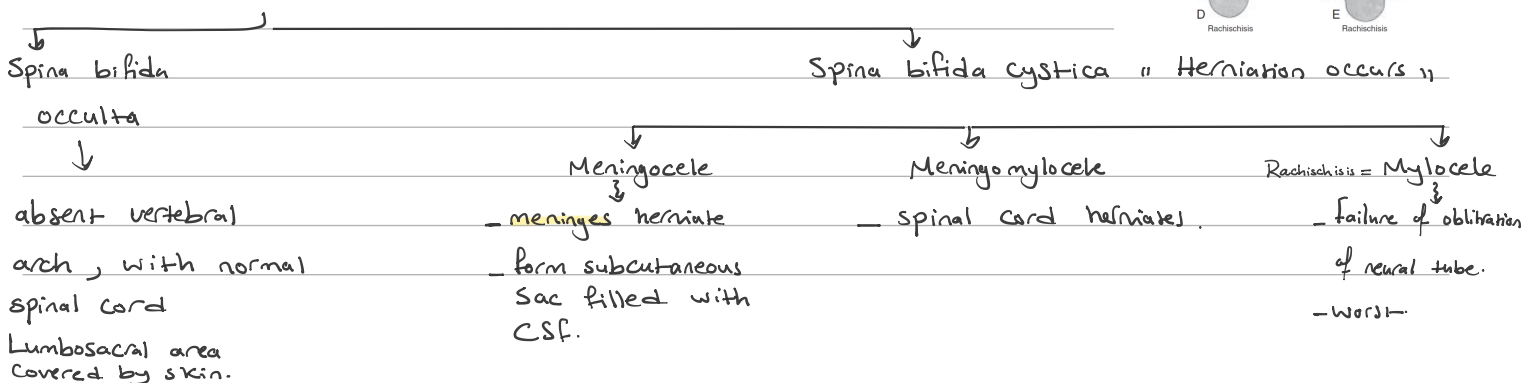
- neural crest (+) mesodermal cells $\xrightarrow{\text{forms}}$ Primitive meninges "meninx primitiva" around neural tube without any obvious space like epidural space.
- between 34 & 48 days, the primitive meninges differentiate into
 - Outer :- ectomeninx \rightarrow dura mater
 - Inner :- endomeninx \rightarrow arachnoid & Pia mater.
- By the end of first trimester "3 months" the meninges is established.

* Positional changes of spinal cord :-

3rd month.	5th month	Newborn	Adult.
spinal cord extends the entire length of embryo "vertebral canal".	spinal cord extends till S1 "bone outgrowth"	L3-L4	L1-L2



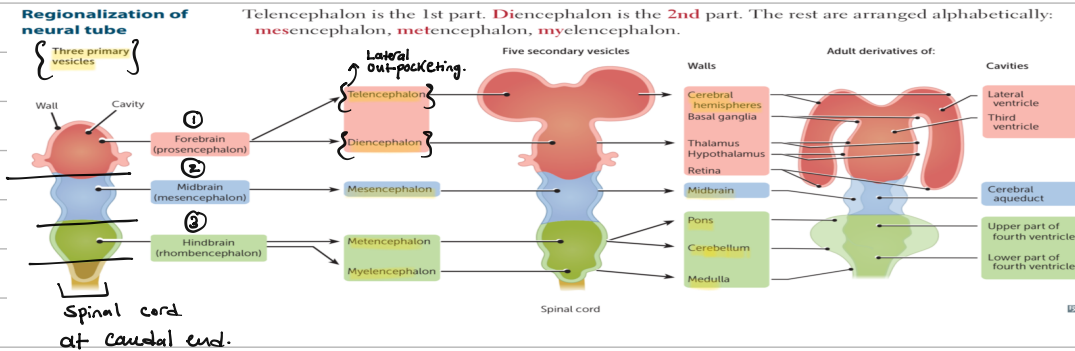
* Congenital Malformation of spinal cord development "Caudal neuropore".



Spinal cord development ✓

② Development of the brain

- the cephalic part of neural tube shows three primary brain vesicle.



* Medulla oblongata :-

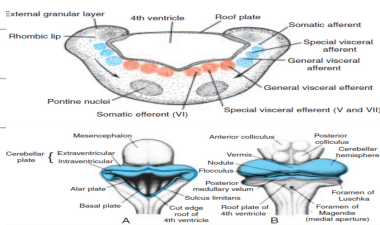
- Myelencephalon

- Medulla will have Alar plate $\frac{1}{3}$ Basal plate separated by sulcus limitans and connected to a thin roof plate and thin plate $\frac{1}{3}$ just like spinal cord.
- The lateral walls move away from each other stretching the roof plate $\frac{1}{3}$ enlarging its cavity \Rightarrow forming the 4th ventricle
- Between 4th $\frac{1}{3}$ 5th months \rightarrow local resorptions of roof plate occur, forming :-
 - ① lateral foramina of Luschka
 - ② Median foramen of Magendie.
- The alar plate will form sensory nuclei of medulla.
- The basal plate will form Motor nuclei

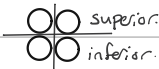
* Pons $\frac{1}{3}$ Cerebellum :-

- Metencephalon

- Same steps in the development of medulla occur **But** alar plate will bend medially forming 2 rhombic lips.
- the 2 rhombic lips fuses with each other forming cerebellar plate.
- cerebellar plate differentiate into :-
 - ① Median part \Rightarrow vermis
 - ② 2 lateral masses \Rightarrow cerebellar hemisphere.
- Basal plate :-
 - ① Medial somatic efferent
 - ② Special sensory efferent
 - ③ General visceral efferent.
- Lateral plate :-
 - ① lateral somatic afferent
 - ② special visceral afferent
 - ③ General visceral afferent.



* Midbrain :-

- as previous structures \rightarrow midbrain will have alar plate $\frac{1}{2}$ basal plate separated by sulcus limitans and connected by roof plate and floor plate.
- **Alar plate** :- forms the tectum which is divided by vertical $\frac{1}{2}$ transverse grooves into 4 colliculi 
- **Basal plate** :-
forms the motor nuclei in the tegmentum of midbrain.
- Marginal layer of basal plate enlarges to form the crus cerebri.
- Its cavity forms the cerebral aqueduct.

* Diencephalon :-

- formed from median part of prosencephalon "forebrain"
- two lateral walls connected by roof and floor plates.
- its cavity \Rightarrow 3rd ventricle
- **Roof plate** :-
 - Anterior part forms the choroid plexus of 3rd ventricle [Mesodermal in Origin]
 - Posterior part forms the pineal body.
- **Floor plate** :-
forms the posterior lobe of the pituitary gland $\frac{1}{2}$ the mamillary body.
- A hypothalamic sulcus appears in the lateral wall which separates the thalamus above from hypothalamus below.

* Telencephalon :-

- formed by the lateral part of forebrain
- two cerebral hemispheres arise.
- the cavity of each hemisphere expand to form the lateral ventricle.
- the wall of the hemisphere consist of 3 layers :-
 - ① Ependymal
 - ② Mantal
 - ③ Marginal.
- the mantal layer at the base of hemisphere forms **basal ganglia**.
- the brain enlarges and overlaps the brain stem $\frac{1}{2}$ cerebellum.

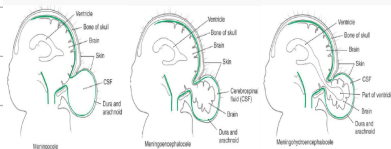
* Congenital malformations of the brain development

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.

