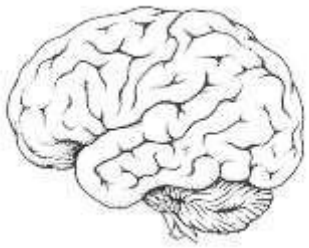
BAU-Medicine



Sheet No. 11

Lecture Title: Development of CNS I

Lecture Date : 2.3.2021

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Edited By: Naheel Shaban

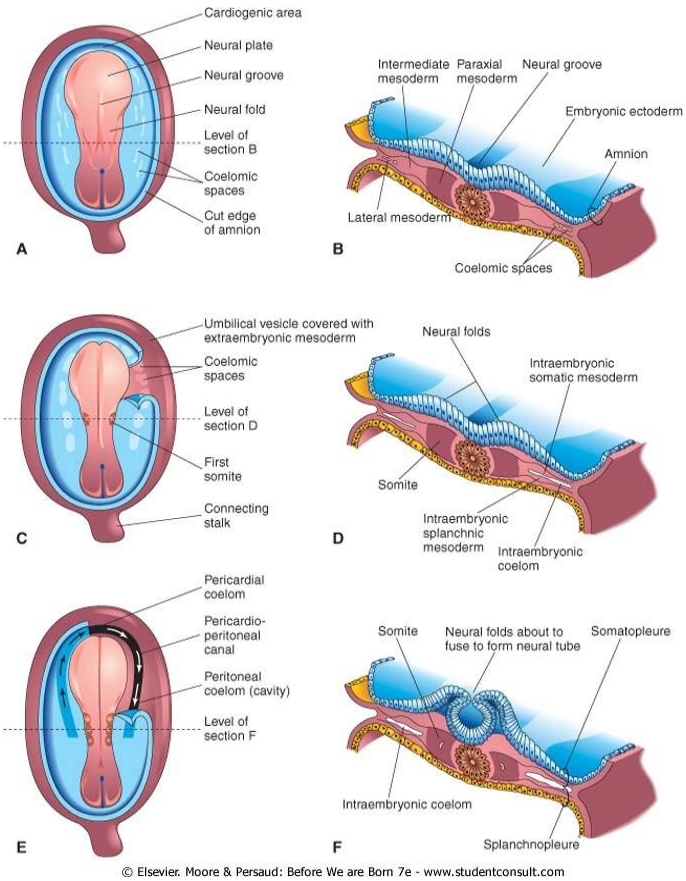
دعاء لزميلنا رشيد:

اللهمّ افسح له في قبره مدّ بصره، وافرش قبره من فراش الجنّة ،اللهمّ أعذه من عذاب القبر، وجفاف

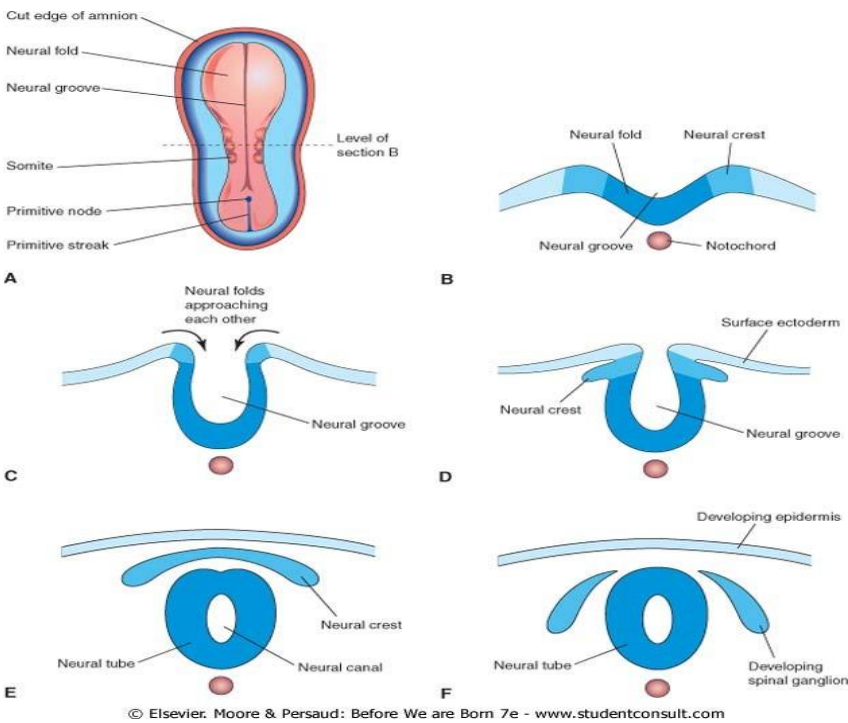
Lectures Objectives

- Describe the formation of neural tube and neural crest.
- Describe the development of brain and spinal cord.
- Describe the positional changes of spinal cord.
- Describe the development of the spinal nerves and their spinal ganglia.
- Describe the development of meninges.
- Describe the development of brain vesicles from the neural tube.
- Describe the development of the different parts of brain.
- Describe the development of brain ventricles and choroid plexuses.
- Describe the development of the cranial nerves and their ganglia.
- Describe the congenital anomalies of brain and spinal cord.

Neurulation



- The trilaminar embryo is composed of: Endoderm, Mesoderm & Ectoderm.
- The steps of Neural Tube formation:
  1. The <u>notochord</u> induces the ectodermal cells over it to proliferate; however, they remain as one layer of cells hence this proliferation induces folding of the layer above the notochord forming **<u>Neural Plate.</u>**
  2. Enlargement of the Neural plate making its two tips' Apex to increase forming folds that will start getting close to each other forming **<u>Neural Canal.</u>**
  3. The Neural Folds and Neural Groove fuse together to form the **<u>Neural Tube</u>** (the primordium of the CNS)
  4. Neural tube forms and separates from the above ectoderm (the primordium of epidermis) and dives within the mesodermal layer in the third week.
  5. During the neural tube formation, cells on the crest of the neural folds (**Neural crest cells**) migrate laterally.
  6. Neural crest cells form the ganglia in the PNS and other tissues.



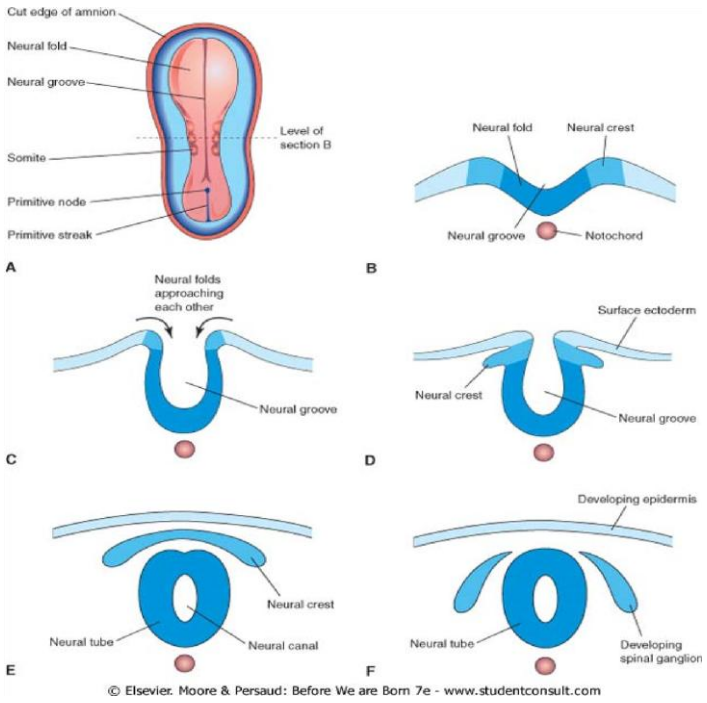
Development of NS

Neural plate forms the nervous system

Neural tube forms the CNS

Neural crest forms the PNS and ANS

Neural canal becomes the ventricles and spinal canal



Contribution of the Neural Crest

- Derived from neuro ectoderm.
- When we want to decide whether a neuron is part of the CNS or the PNS we go back to its cell body's location and decide accordingly; for example:
  - Lower motor neurons (Somatic) cell bodies are found in the anterior horn of the Spinal Cord; hence they are part of the CNS even though their axons leave.
  - Sensory neurons' cell bodies: in dorsal root ganglion so they are part of the PNS.
  - Autonomic fibers:
    Preganglionic: cell bodies in CNS
    Postganglionic: cell bodies in Autonomic ganglia in PNS
- All neurons with cell bodies outside the CNS originate from neural crest.

- Give rise to or participate in the formation of many cells' types and organs:

1. Sensory neurons of the spinal nerves, cranial nerves (V, VII, IX, and X)
   These cranial nerves have sensory nuclei outside CNS.
2. Autonomic ganglia
   Postganglionic Neurons: Sympathetic or Parasympathetic
3. Sheathing cells of the peripheral nervous system
   Neuroglia (Shwan & Satellite cells.)
4. Pigment cells of the dermis (melanocytes)
5. Pharyngeal Apparatus: Muscles, connective tissues, and bones of pharyngeal arch origin that's why their fibers are called special visceral efferent.
6. Suprarenal medulla
   Originally it is derived from postganglionic neurons as they are innervated by preganglionic neurons.
7. Meninges (coverings) of the brain and spinal cord

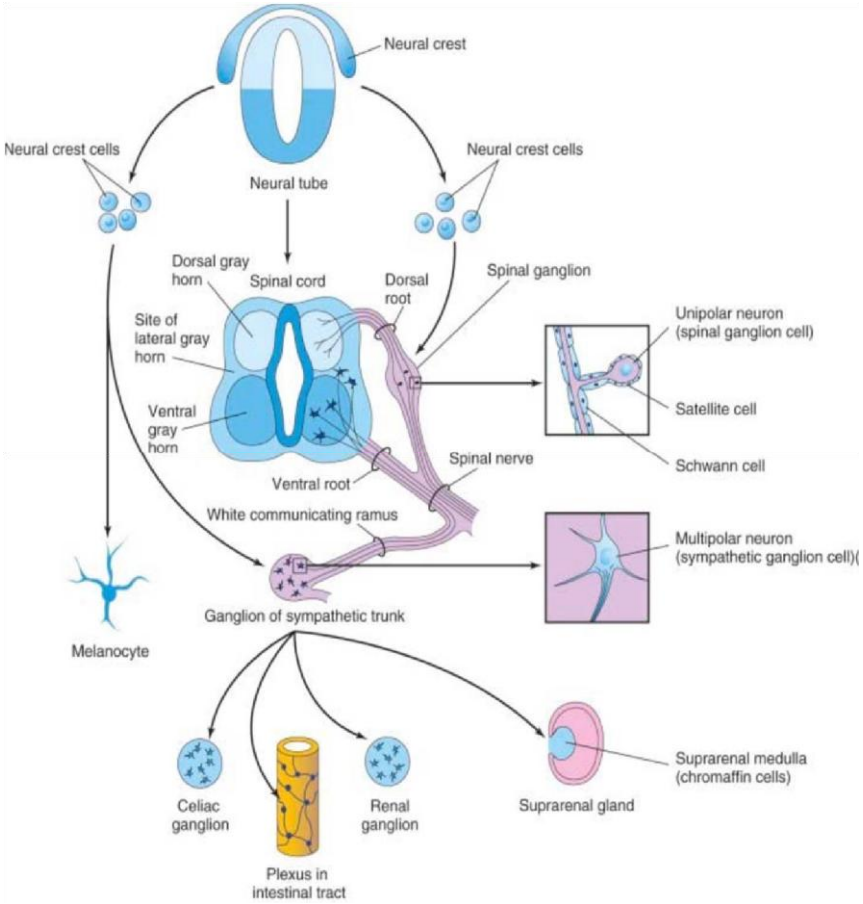


Table 1 | **Main derivatives of neural crest cells**

	Cranial Crest	Trunk Crest
Sensory nervous system	Ganglia of cranial nerves	Spinal ganglia
Autonomic nervous system	Enteric nervous system	Enteric nervous system (minor contribution)
	Parasympathetic ganglia: ciliary, pterygopalatine, otic and submandibular	Parasympathetic ganglia: pelvic plexus.
		Sympathetic ganglia: superior cervical, stellate, celiac, superior and inferior mesenteric, aorticorenal.
Non-neuronal cells	Satellite cells of ganglia. Schwann cells of cranial nerves	Satellite cells of ganglia. Schwann cells of peripheral nerves
Pigment cells	Melanocytes	Melanocytes
Endocrine and paraendocrine cells	Calcitonin-producing cells, type I cells of carotid body and parafollicular cells of thyroid	Adrenal medulla
Skeleton	Face and skull bones, and visceral cartilages	None
Connective tissue	Dermis, fat and smooth muscle of skin; ciliary muscles; cornea; stroma of head and neck glands; dental papilla; walls of aortic and arch-derived arteries; meninges of prosencephalon and part of the mesencephalon	None

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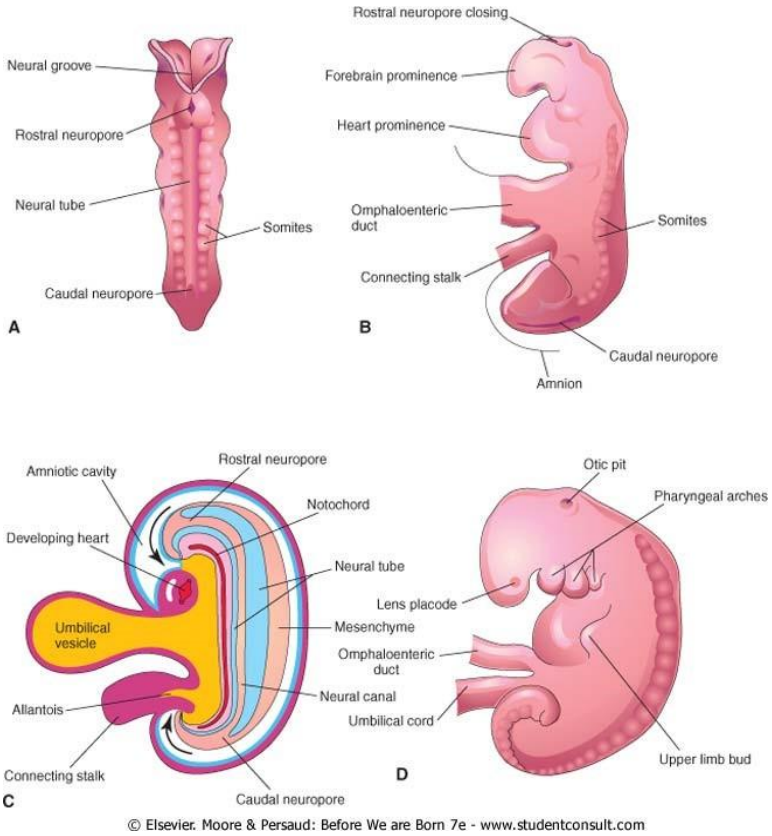
Development of NS

- When the Neural tube is first developed it is going to have two open ends called Rostral & Caudal Neuropores.
- By the end of the 4th week:
  - Rostral neuropore closed and forebrain develop.
  - Caudal neuropore closed and caudal eminence



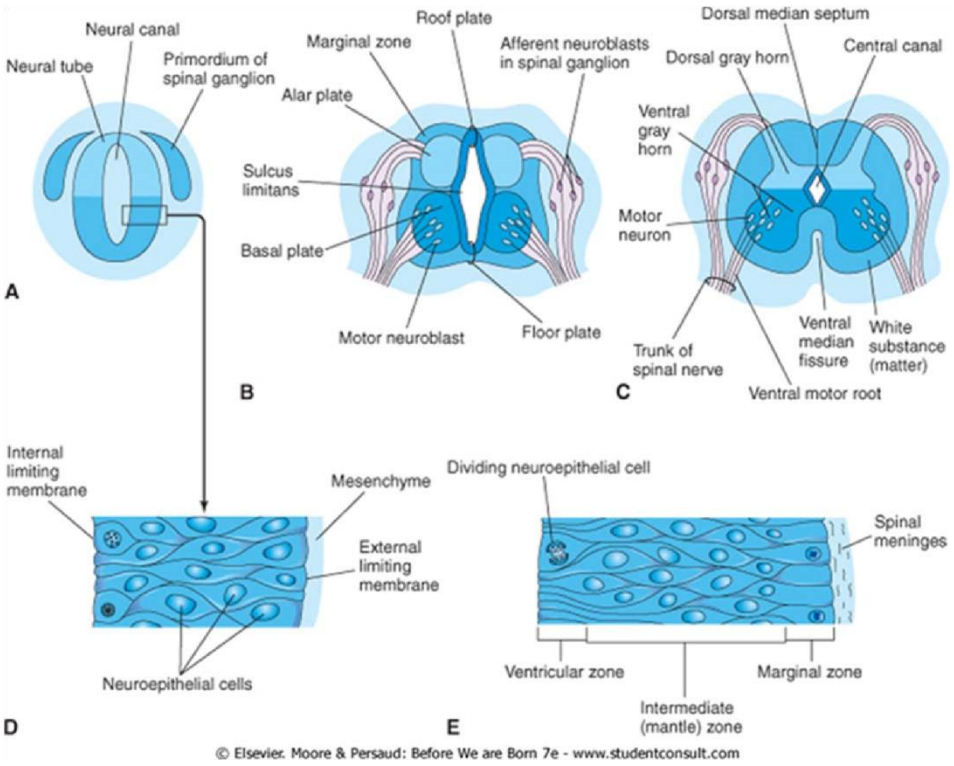
(Caudal part of Spinal Cord) develop

- Any failure or partial closure of these neuropores will cause somewhat highly prevalent specific Congenital Anomalies. (Spina Bifida)

Development of the Spinal Cord

- Neural tube caudal to the 4th somite forms SC.
- Neural tube is composed of Neural Canal surrounded by one layer of ectodermal cells:

  Neural canal stays as a space and becomes Central canal.



The ectodermal cells form the rest of the bulk of the spinal cord.

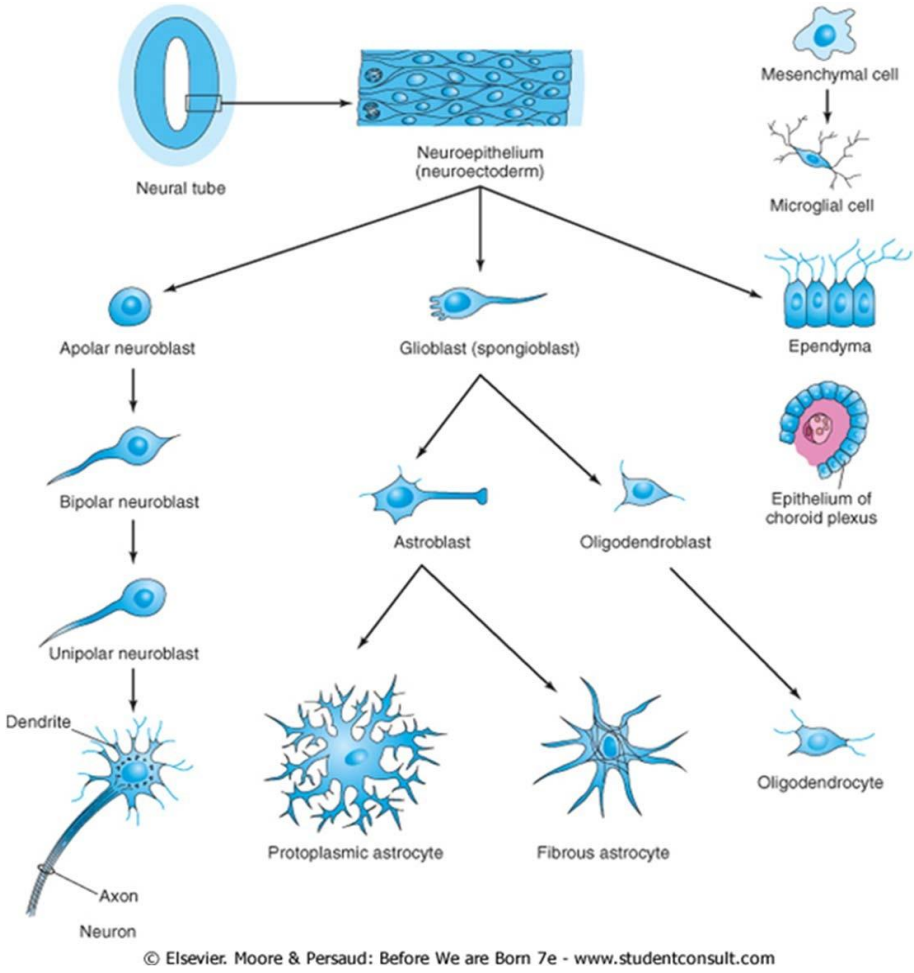
- Thickening of the neural tube (ectodermal cell layer) forming three layers:
  1. Ependymal (ventricular) layer
  2. Mantle layer
  3. Marginal Layer

Histogenesis of the Neural Tube

- Ependymal (ventricular) layer gives
  1. blast cells that migrate to mantle layer.
  2. Remaining cells form ependymal cells that are going to envelope the Central Canal.

  Note: ependymal cells in spinal cord do not produce CSF.

  Note: Microglia originates from bone marrow.



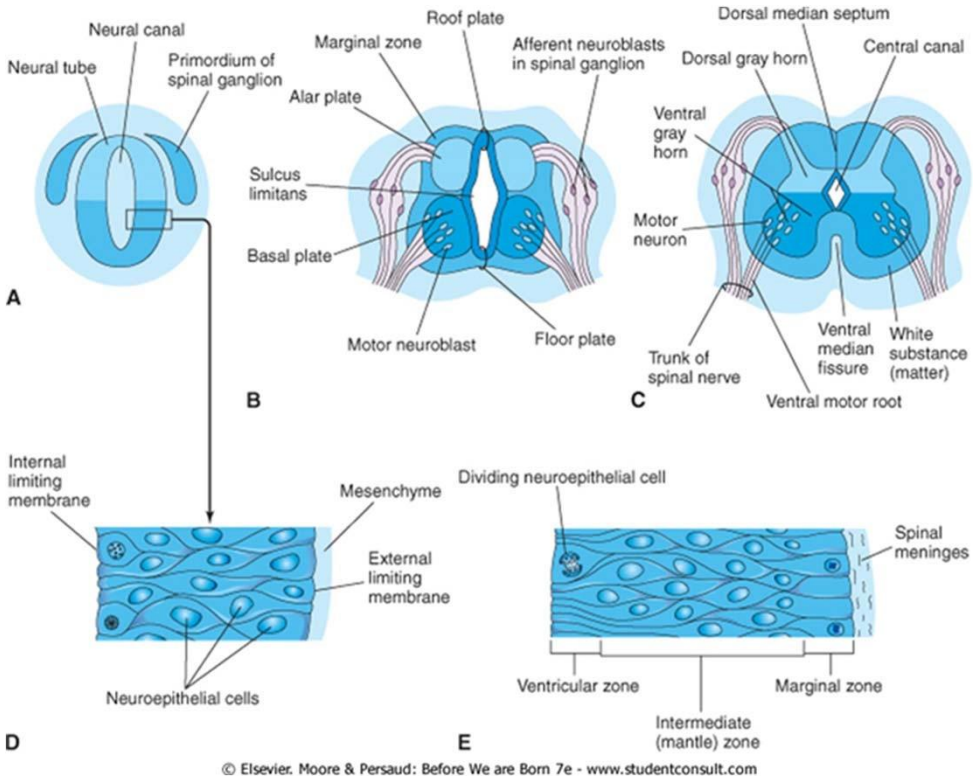
- Mantle layer → cells of CNS
  - Neuroblasts
    - Motor neurons (somatic & Autonomic)
    - Interneurons
  - Glia blasts (invade both mantle and marginal layers)
    - Astrocytes will differentiate into their different types.
    - Oligodendrocytes
- Marginal Layer – white mater

Motor neurons differentiation sequence:

The cells start differentiating and branching in the Mantle layer → Development of axons that will form the white mater of the Marginal Layer.

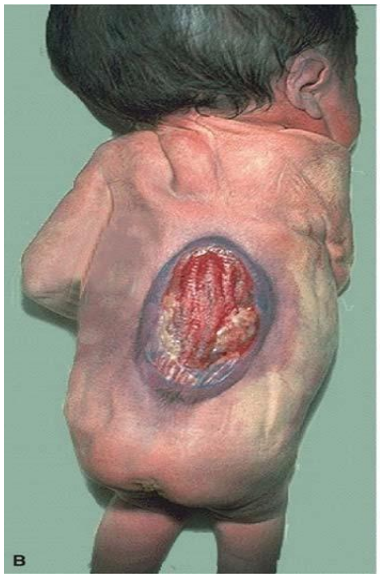
Regions of the Spinal Cord

- Ependyma
- Marginal Layer
- Roof & floor plates
  When mantle layer starts to develop it proliferates mainly on the sides (right & left) anteriorly & posteriorly remains a thin layer of cells forming roof & floor plates.



- Sulcus Limitans
  It separates between the two masses of Mantle layer (Alar & Basal plates)
- Mantle Layer
  - Alar plates – dorsal gray columns sensory input
    Internuncials, Commissurals, Tract fibers
    (Interneurons: Substantia gelatinosa , Proprius nucleus , Clark's Nucleus)Thickening forms dorsal septum
    (they enlarge and become very close to each other until they overlap & close the plate forming externally Dorsal Median Nucleus)
  - Basal plates – ventral gray columns
    Somatic & visceral motor neurons (Intermediolateral Nuclei)
    Thickening forms ventral median fissure

Neural Tube Defects



- **Spina bifida:** results from failure of the neural tube to close in the vertebral column. It has different severities:
- **Spina bifida occulta**
  - It is considered mild as usually there is a partial closure of the neuropores with small opening hence no effects on neuronal part.
  - Defect in vertebral arch
  - L5-S1
  - No clinical symptoms

- **Spina bifida cystica**
  1. <u>With meningocele</u>
     - 1/1000
     - No neural content of spinal cord or neurons
     - Sac contains meninges & CSF
  2. <u>With meningomyelocele</u>
     - 2-4/1000
     - Sac contains spinal cord and/or nerves
     - Neurological deficits (motor or sensory)

Thank you