Development of Spinal Cord
&
Vertebral Column

Dr. Sanaa Alshaarawi
&
Prof. Ahmed Fathalla

OBJECTIVES

At the end of the lecture, students should be able to:

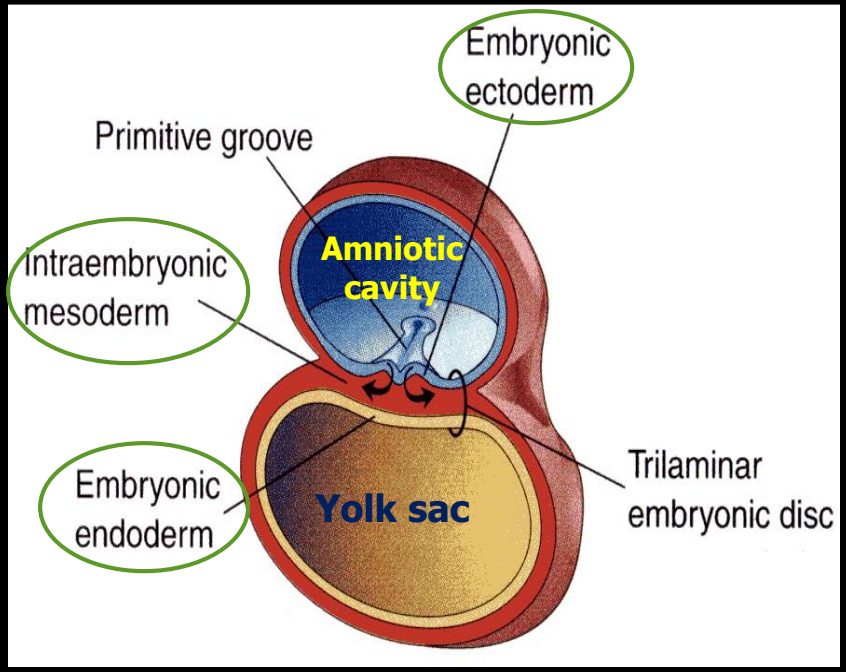
- Describe the development of the spinal cord from the neural tube.
- List the layers of the spinal cord and its contents.
- List subdivisions of mantle & marginal zones.
- List meningeal layers and describe positional changes of spinal cord.
- Describe development of vertebral column from sclerotomic portion of paraxial mesoderm.
- Describe chondrification & ossification stages in vertebral development.
- Describe spina bifida and its types.

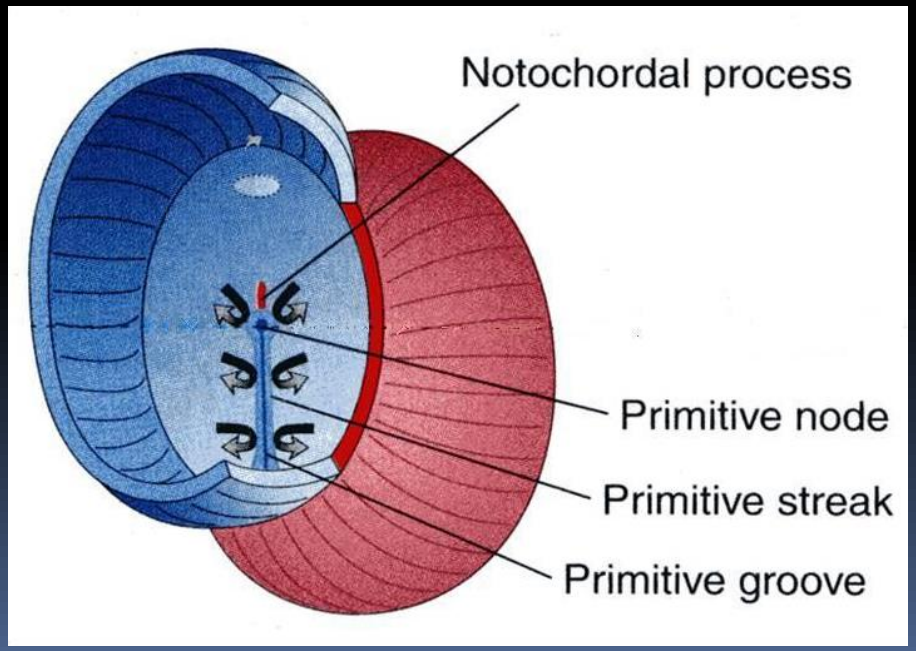
The Three Germ Layers

- Ectoderm
- Mesoderm
- Endoderm

Notochord stimulates neural tube formation which in turn stimulates development of the vertebral column.

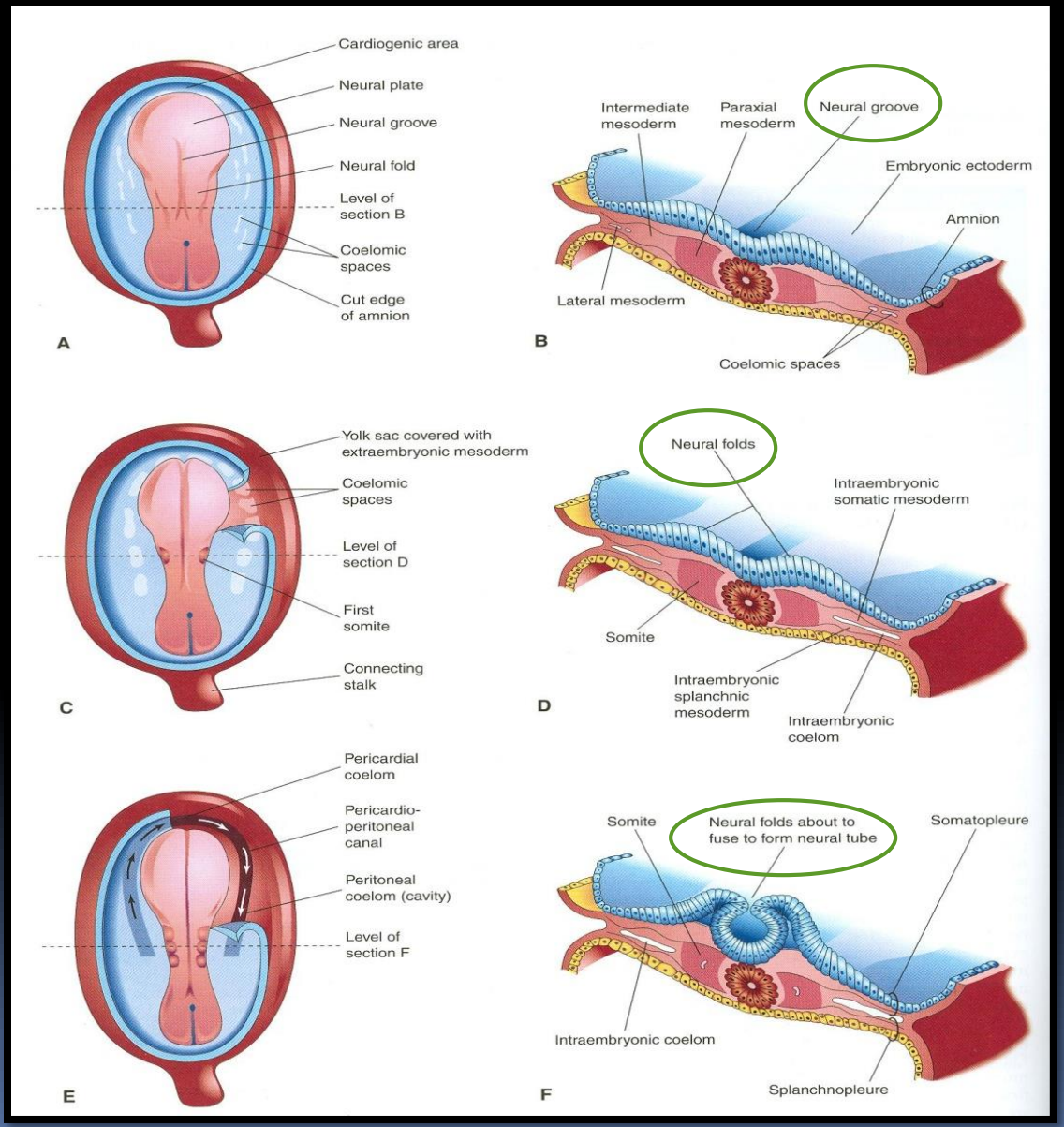
The Neural Tube is a derivative of the ectoderm





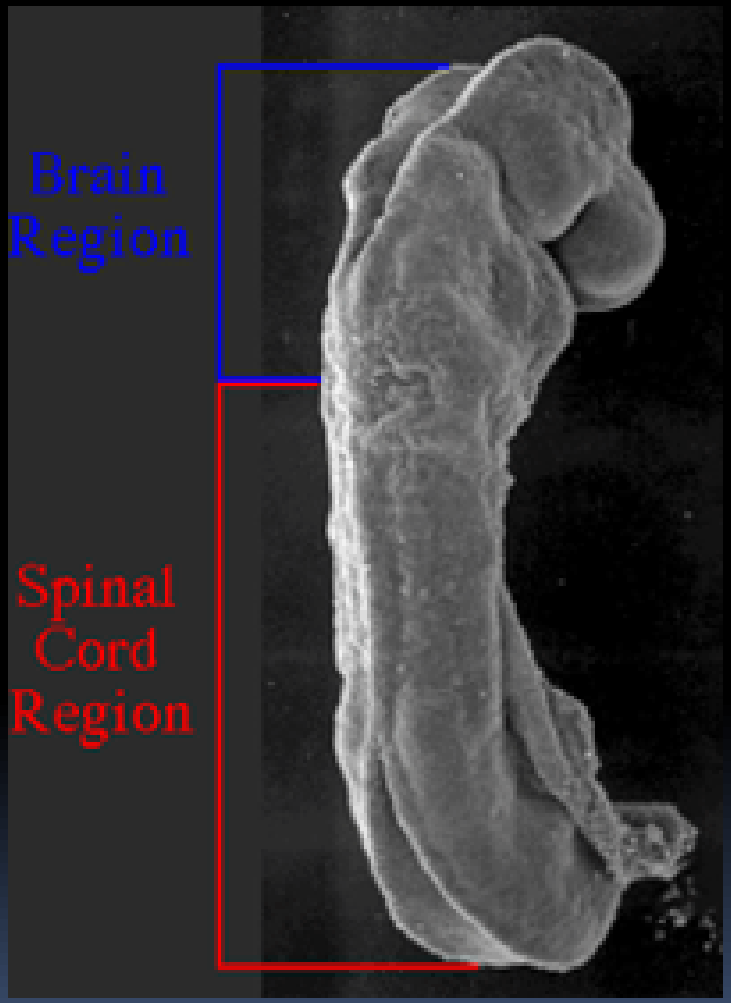
Development of Neural Tube

- Ectodermal cells dorsal to notochord thicken to form the **neural plate.**
- A longitudinal groove, **neural groove,** develops in the neural plate.
- The margins of the neural plate **(neural folds)** approach to each other and **fuse** to **form the neural tube.**



Development of the Spinal Cord

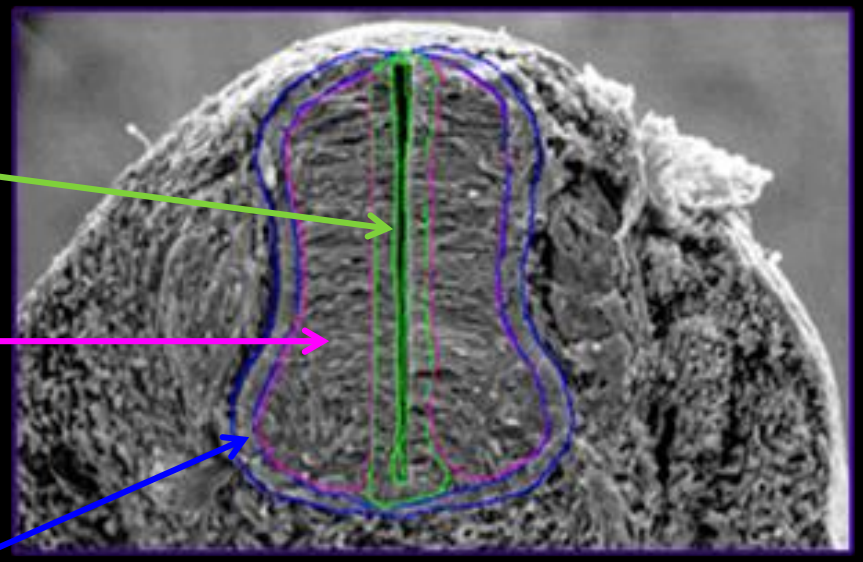
- The spinal cord develops from the caudal 2/3 of the neural tube



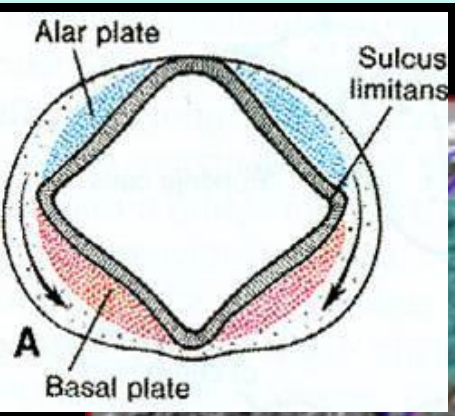
Layers of the spinal cord :

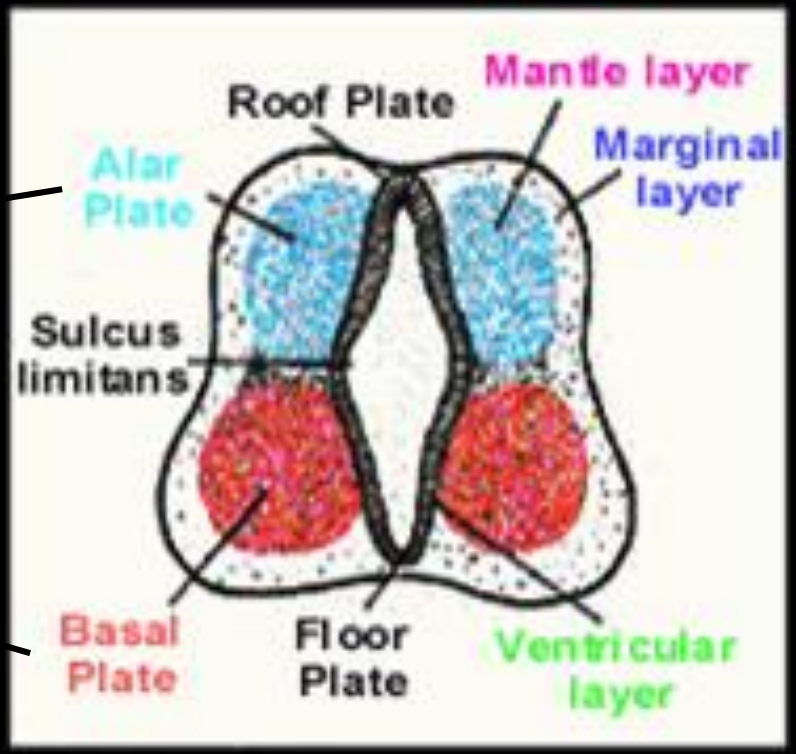
The cells of the neural tube are arranged in three layers :

- An inner ventricular zone of undifferentiated cells
- A middle mantle zone of **cell bodies** of **neurons** (future grey matter)
- An outer marginal zone of **nerve fibers** or **axons** of neurons (future white matter)



Mantle Layer of Spinal Cord

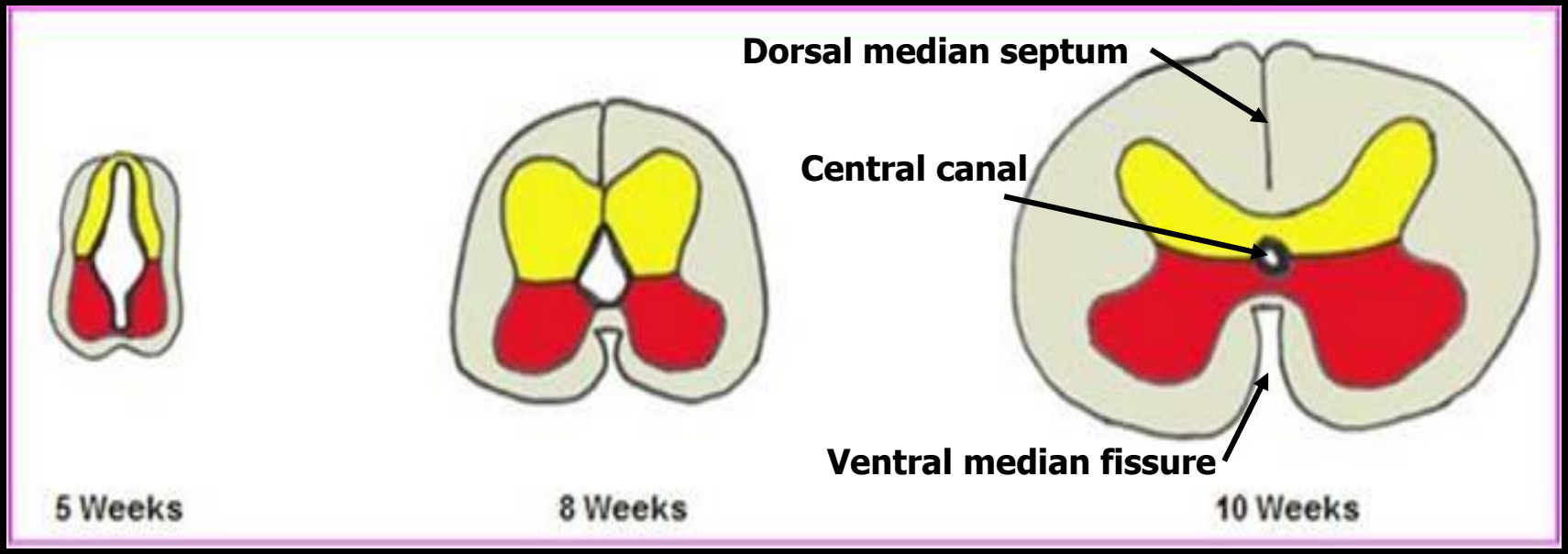




- Neurons of mantle layer (future grey matter) differentiate into :

1. A dorsal alar plate (future dorsal horn): containing sensory neurons
2. A ventral basal plate (future ventral horn): containing motor neurons

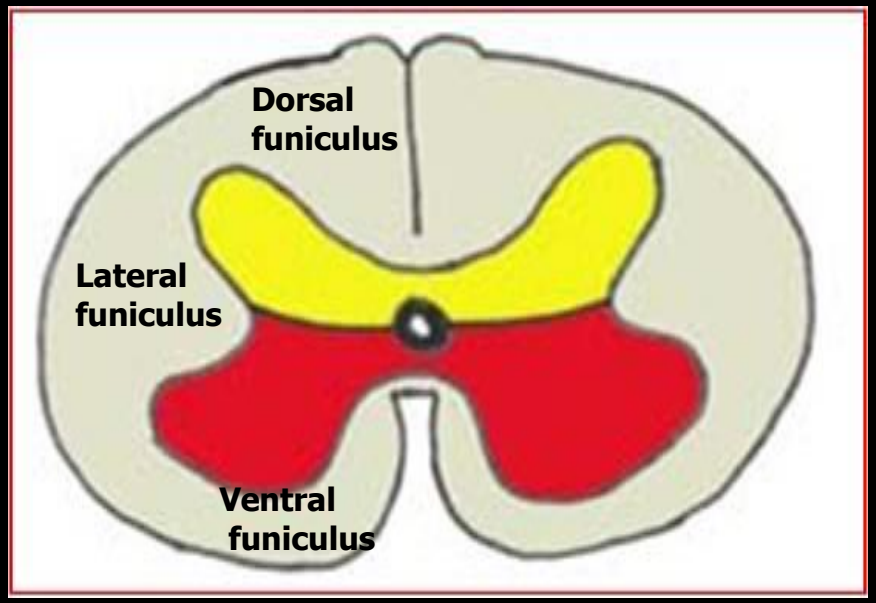
- The 2 areas are separated by a longitudinal groove (sulcus limitans).



Proliferation and bulging of both alar & basal plates result in:

- Formation of dorsal median septum
- Formation of ventral median fissure
- Narrowing of the lumen of the neural tube to form a small central canal

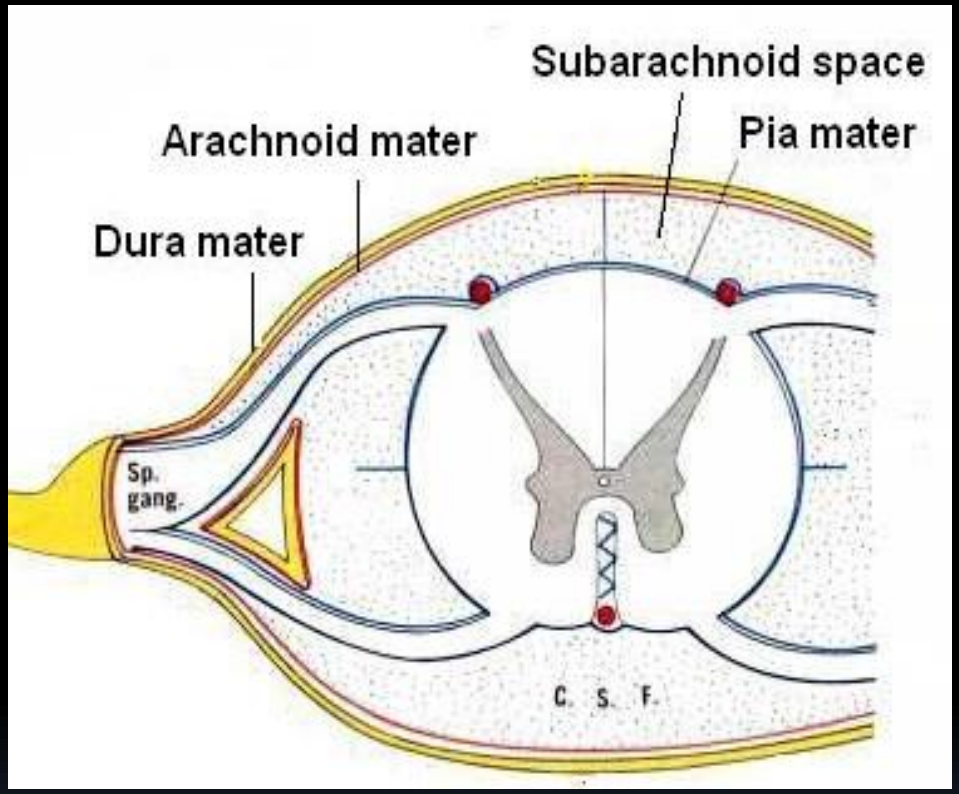
Marginal Layer of Spinal cord



- **The marginal layer** (future white matter) increases in size due to addition of ascending, descending & intersegmental nerve fibers & is **divided into** : **dorsal, lateral** and **ventral funiculi**
- **Myelination** of nerve fibers **starts** at **4th month** & **continues** during the **1st postnatal year. Motor fibers myelinate before sensory fibers.** So, After a nerve injury, both motor and sensory axons have the ability to regenerate and, given a proper pathway.

Meninges

- These are **3 membranes covering the neural tube:**
- Outer thick **dura mater**: **MESODERMAL** in origin
- Middle **arachnoid mater** & Inner thin **pia mater** are **ECTODERMAL** in origin

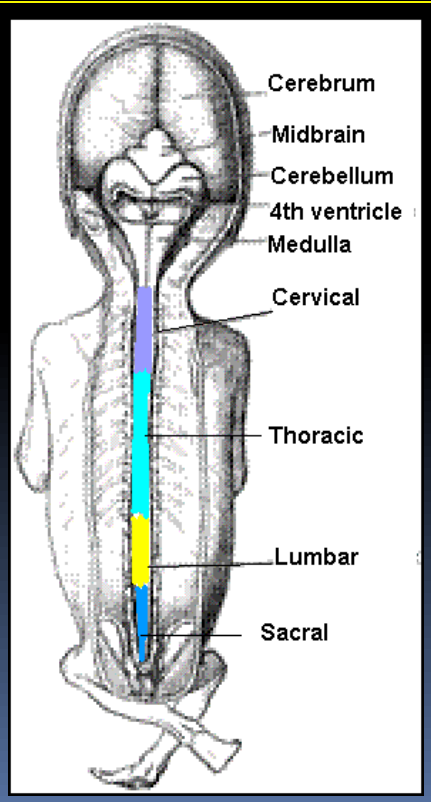


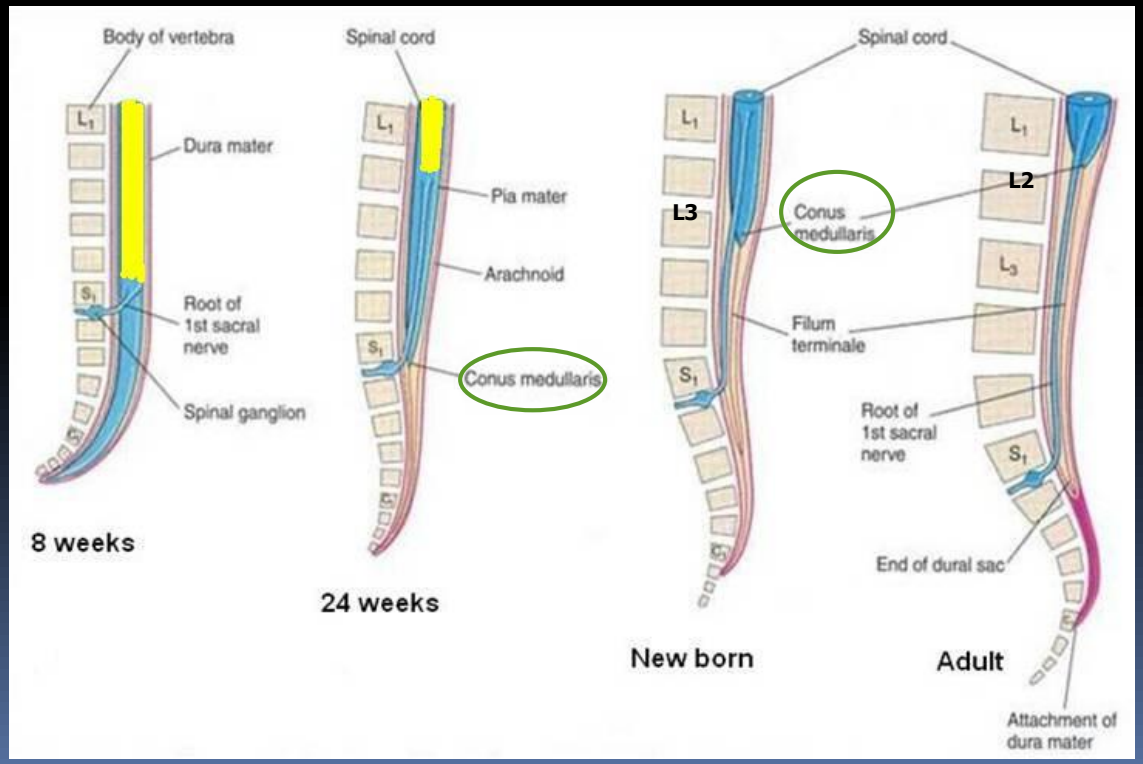
- A cavity appears between the arachnoid & the pia mater (subarachnoid space) & becomes filled with cerebrospinal fluid (CSF).

Positional Changes of Spinal Cord

- Initially, the spinal cord occupies the whole length of the vertebral canal.

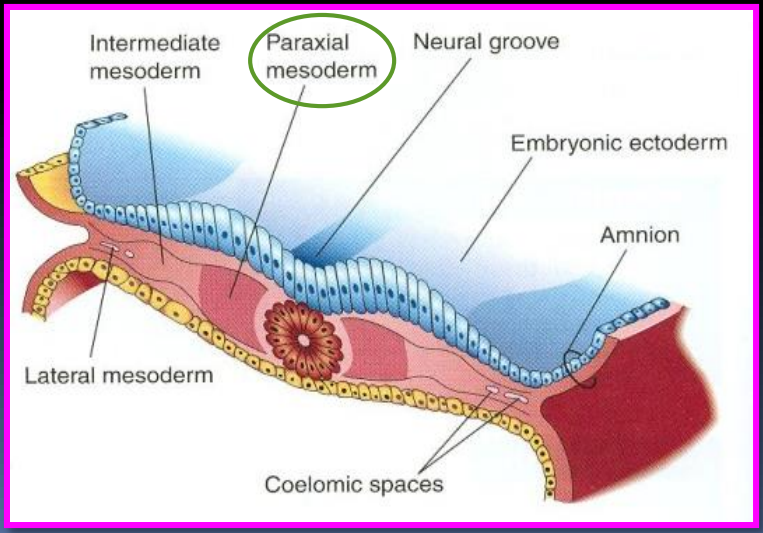
- As a result a **faster growth** of **vertebral column**, the caudal end of spinal cord (conus medullaris) shifts gradually to a higher level.

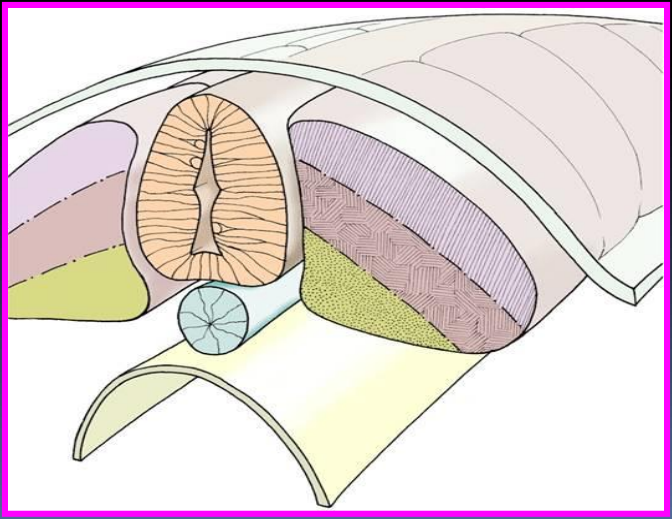




Development of the Vertebral Column

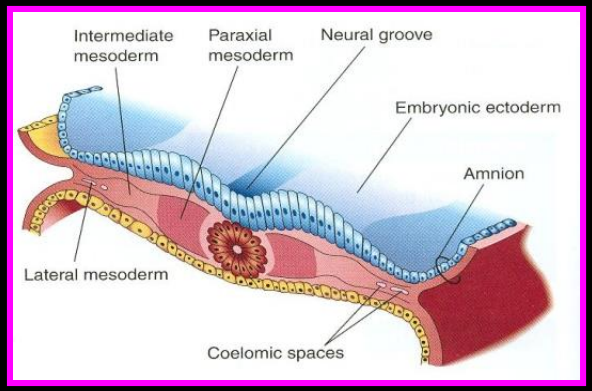
- The vertebral column develops from the ventromedial parts (sclerotomes) of the somites
- The somites develop from the para-axial mesoderm.



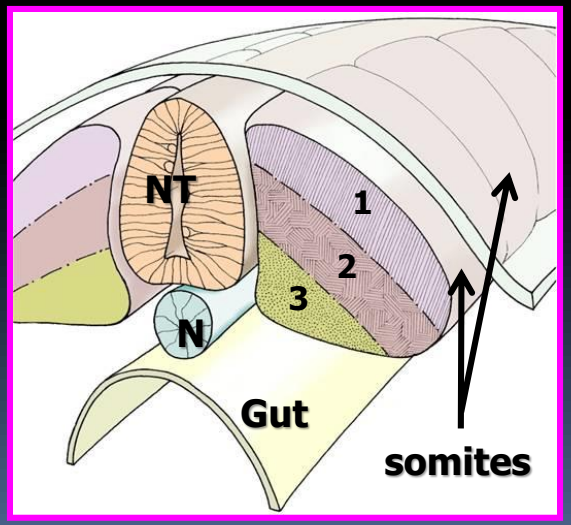


Intraembryonic Mesoderm

- Located between Ectoderm & Endoderm EXCEPT in the central axis of embryo where NOTOCHORD is found.
- Differentiates into 3 parts:
  1. Paraxial mesoderm
  2. Intermediate mesoderm
  3. Lateral mesoderm

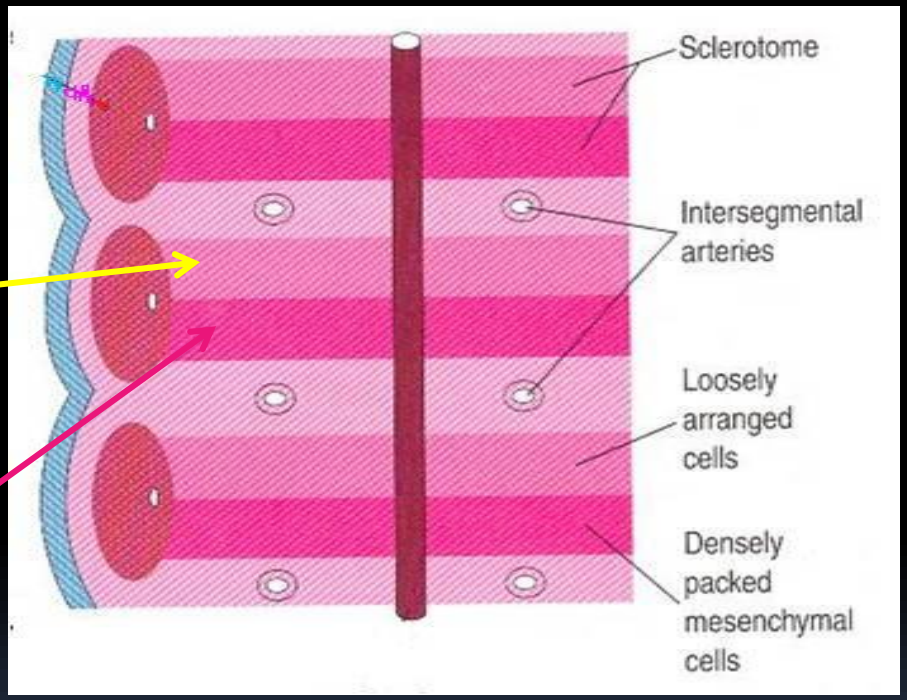


- Paraxial mesoderm divides into segments called 'somites'.
- Each somite divides into 3 parts:
  1. Dermatome
  2. Myotome
  3. Sclerotome



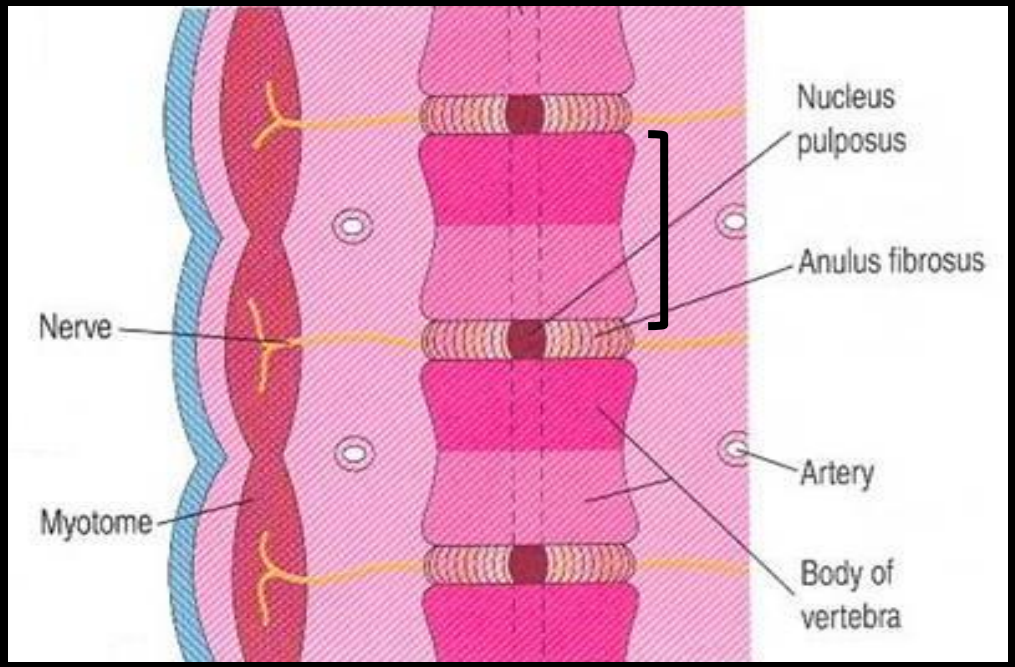
Formation of Body of Vertebra

- At **4th week**, **each sclerotome** becomes **subvidided** into two parts :
  - an cranial part, consisting of loosely arranged cells
  - a caudal part, of more condensed tissue.



Formation of Body of Vertebra

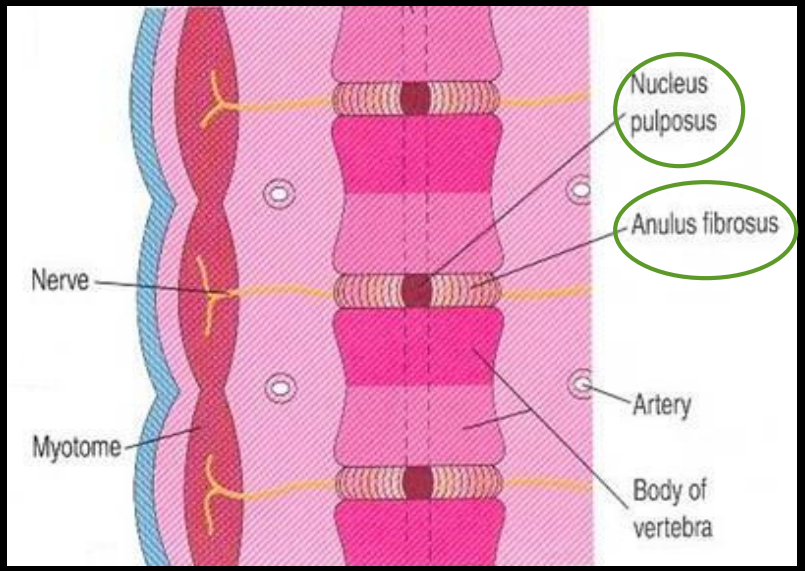
- The caudal part of each somite fuses with the cranial part of the consecutive somite, around the notochord to form the body of the vertebra, called **the centrum.**

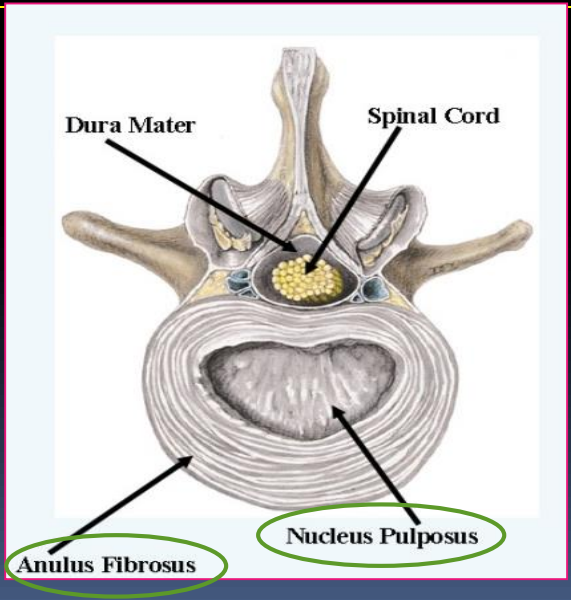


Thus each centrum develops from 2 adjacent sclerotomes

Fate of Notochord

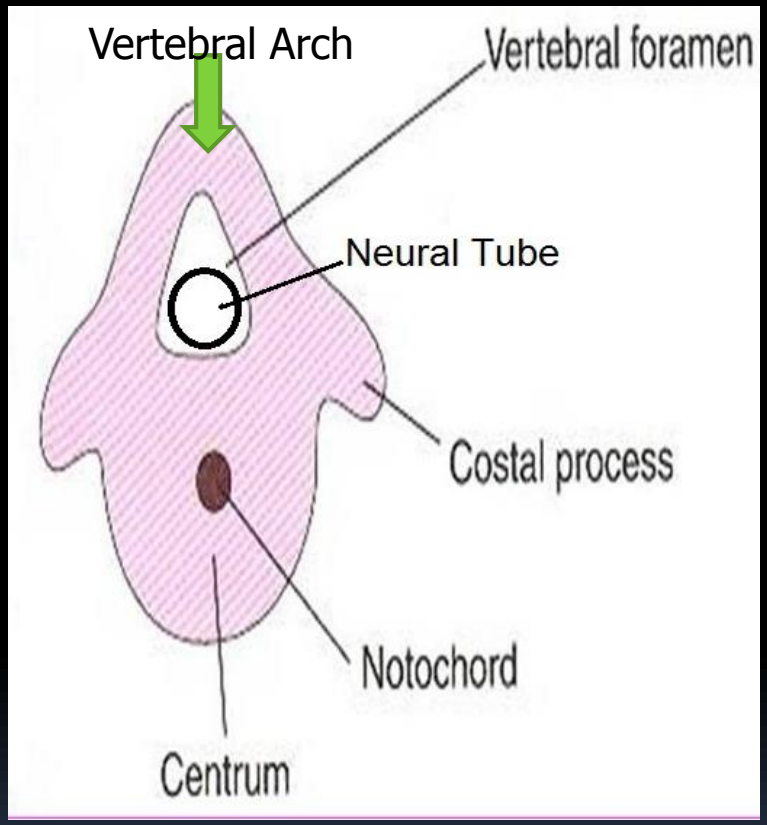
- **In the region of the bodies of vertebrae:** It degenerates
- **Between bodies of vertebrae:** It forms the central part, **'nucleus pulposus'** of the intervertebral discs



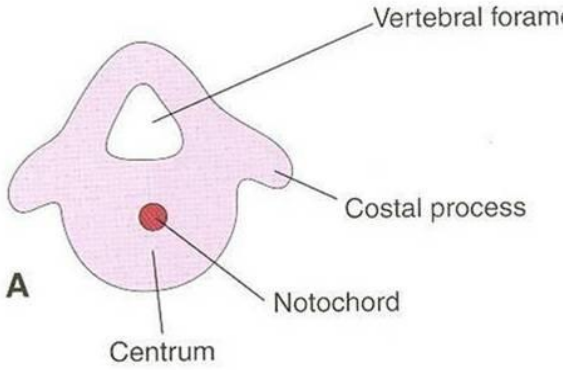


- **Annulus fibrosus** of the intervertebral discs is **formed by the mesoderm** surrounding the notochord.

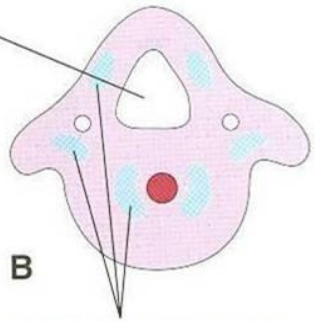
- The fused sclerotomes grow dorsally around the neural tube and form the vertebral (neural) arch.
- Ventrolaterally, costal processes develop that give rise to ribs in thoracic region.



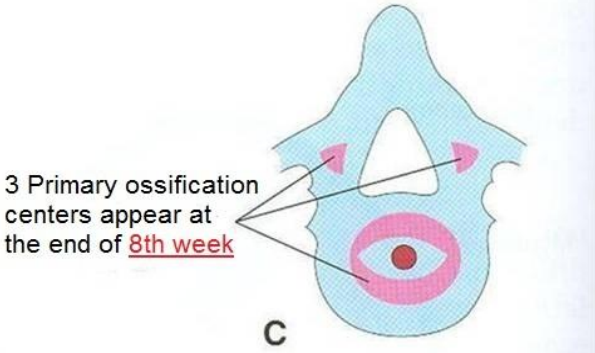
Vertebral Development



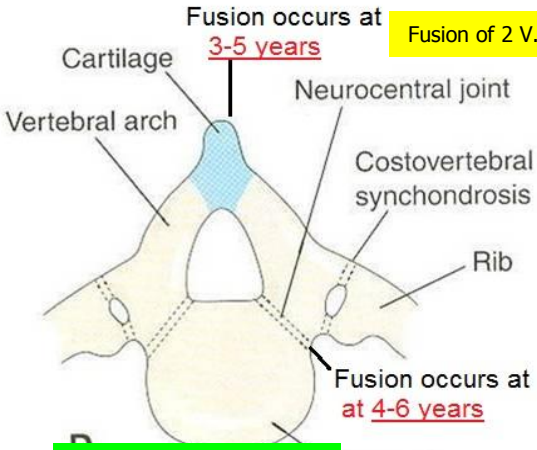
Mesenchymal Stage



Chondrification Stage

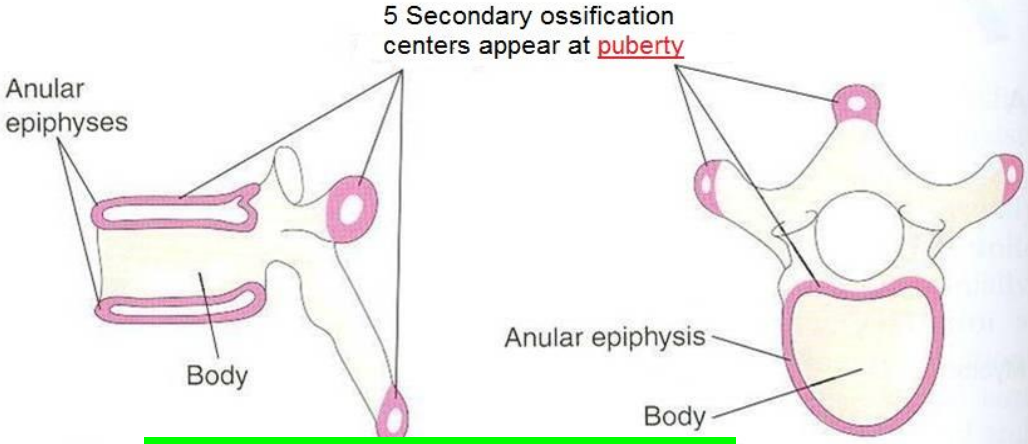


Primary Ossification Stage



Fusion of 2 V.arches

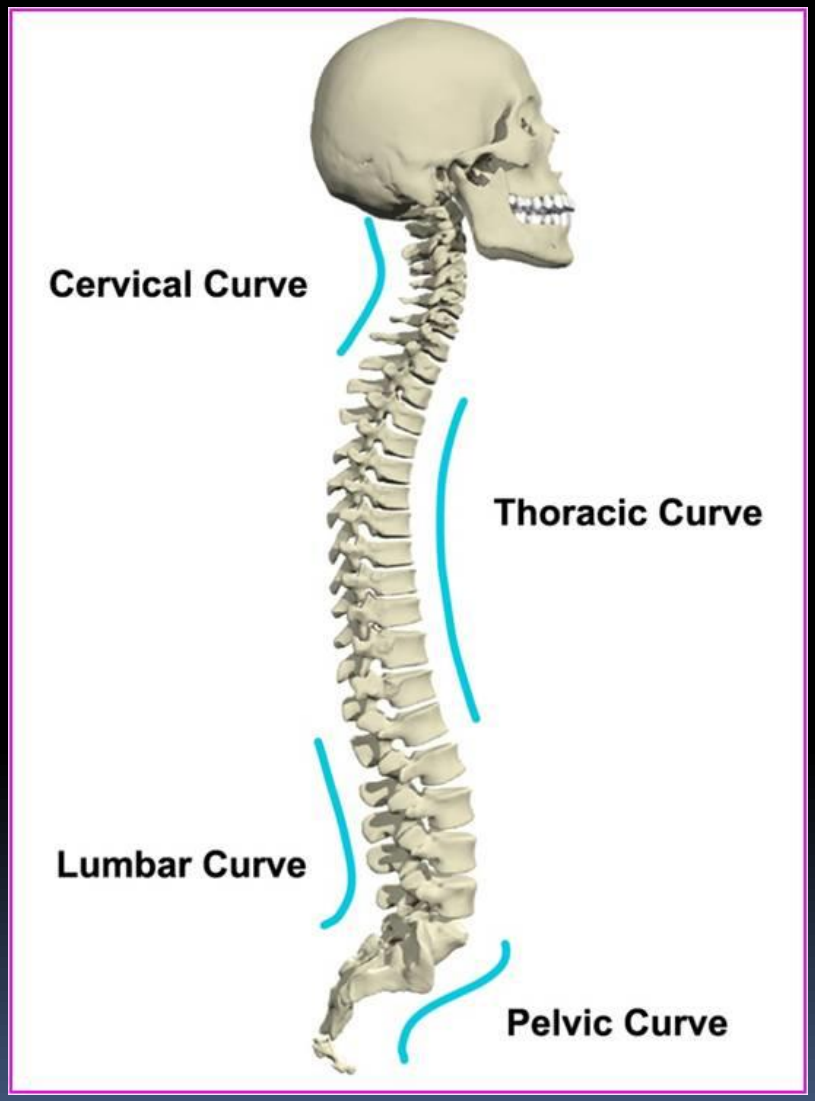
Stage of Fusion



Stage of Secondary Ossification

All centers unite around 25 years

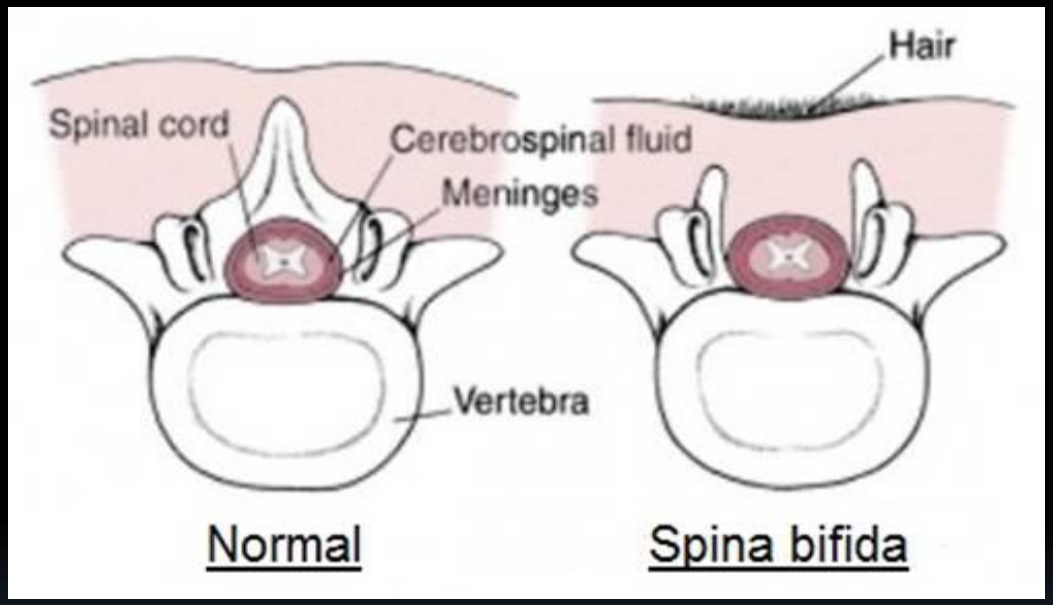
Curvatures of Vertebral Column



- Primary curvatures (concave anterior) : develop prenatally
  1. Thoracic
  2. Pelvic or Sacral
- Secondary curvatures (convex anterior) : develop postnatally
  1. Cervical: as a result of lifting the head
  2. Lumbar: as a result of walking

Spina Bifida

- **Cause:** Failure of fusion of the halves of vertebral arches
- **Incidence:** 0.04-0.15%
- **Sex:** more frequent in females
- **Types:**
  1. **Spina bifida occulta** (20%)
  2. **Spin bifida cystica** (80%)



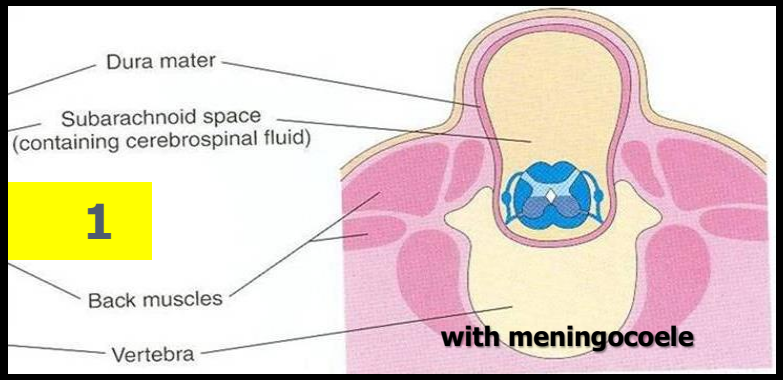
Spina Bifida Occulta

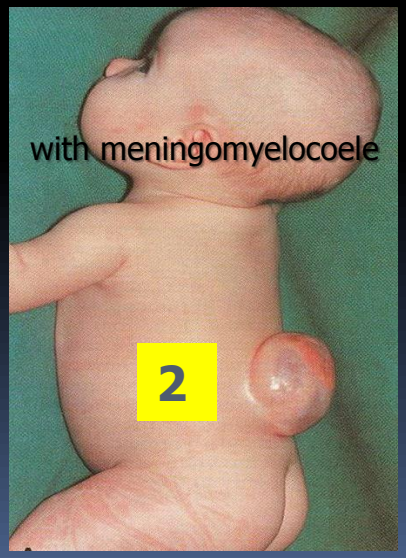
- The closed type
- Only one vertebra is affected
- No clinical symptoms
- Skin overlying it is intact.
- **Sometimes covered by a tuft of hair.**
- Usually does not involve underlying neural tissue.

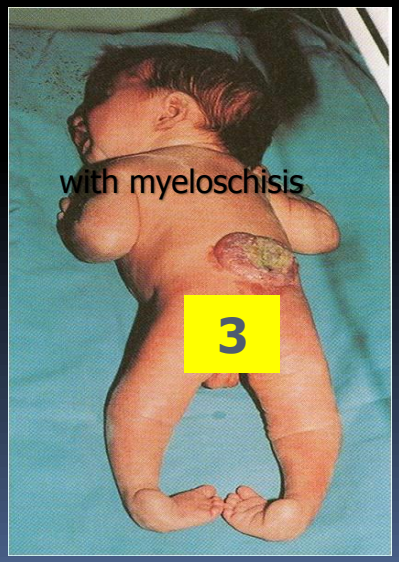
Spina Bifida Cystica

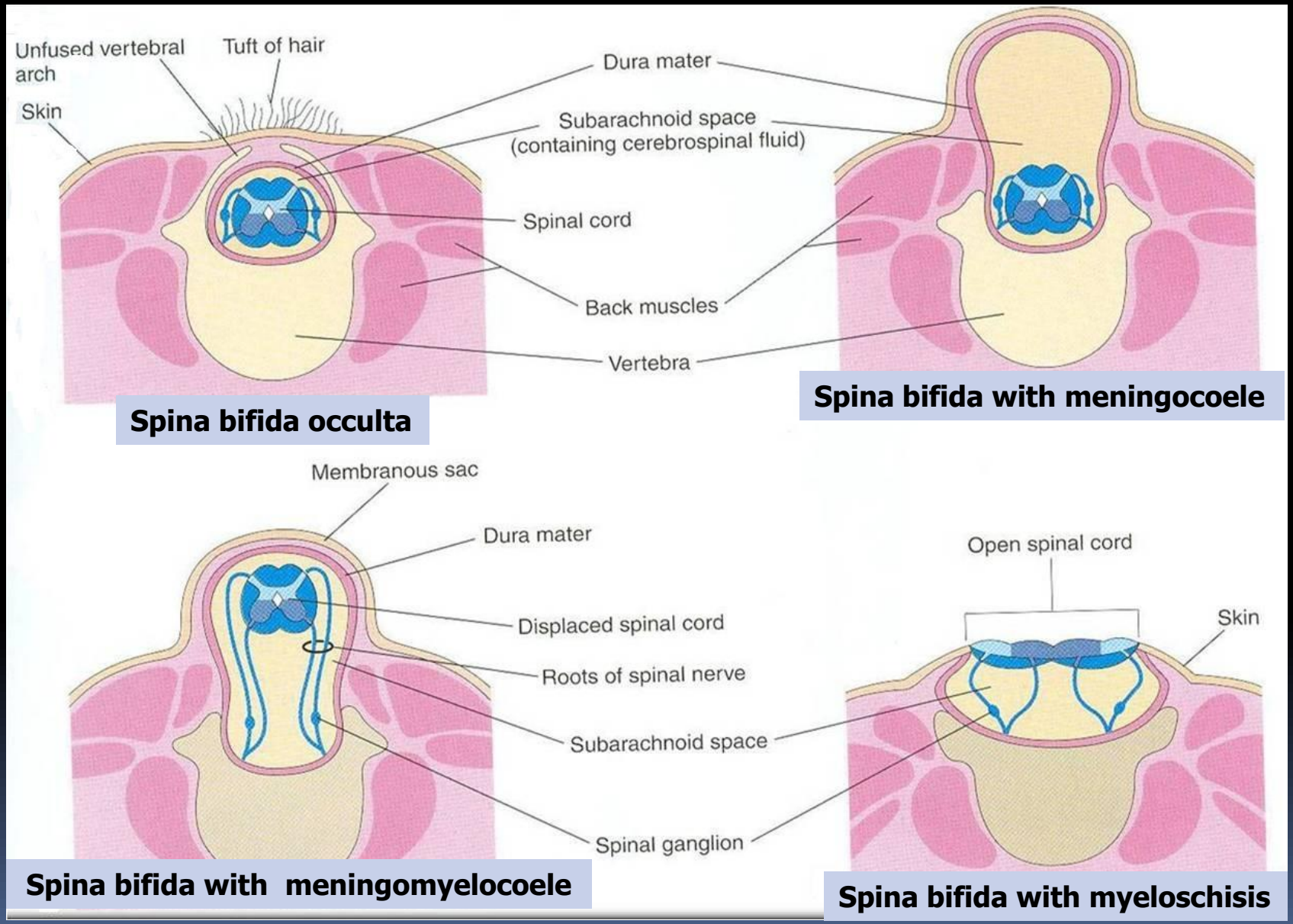
- **The open type**
  - Cystica is the most severe and complex form of spina bifida. It usually involves serious neurological problems. A portion of the nerves and the spinal cord are exposed outside the body
- **Neurological symptoms are present**
- **Subdivided into:**

1. **Spina bifida with meningocoele**: protrusion of sac containing meninges & cerebrospinal fluid
2. **Spina bifida with meningomyelocoele**: protrusion of sac containing meninges with spinal cord and/or nerve roots
3. **Spina bifida with myeloschisis** : spinal cord is open due to failure of neural folds to develop.








Unfused vertebral arch
Tuft of hair
Skin
Dura mater
Subarachnoid space (containing cerebrospinal fluid)
Spinal cord
Back muscles
Vertebra
Spina bifida occulta
Spina bifida with meningocoele
Membranous sac
Dura mater
Displaced spinal cord
Roots of spinal nerve
Subarachnoid space
Spinal ganglion
Spina bifida with meningomyelocoele
Open spinal cord
Skin
Spina bifida with myeloschisis


Thank You & Good Luck