

Development of the Spinal Cord and the Vertebral Column

LECTURE

#1





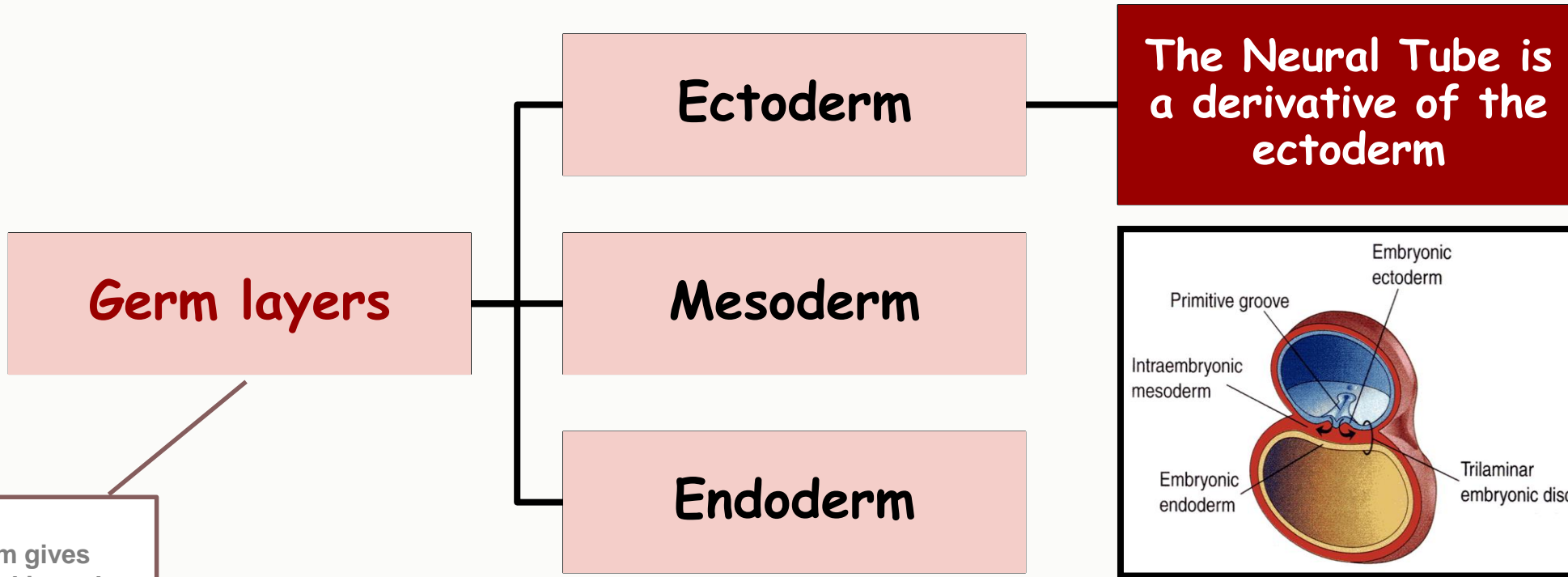
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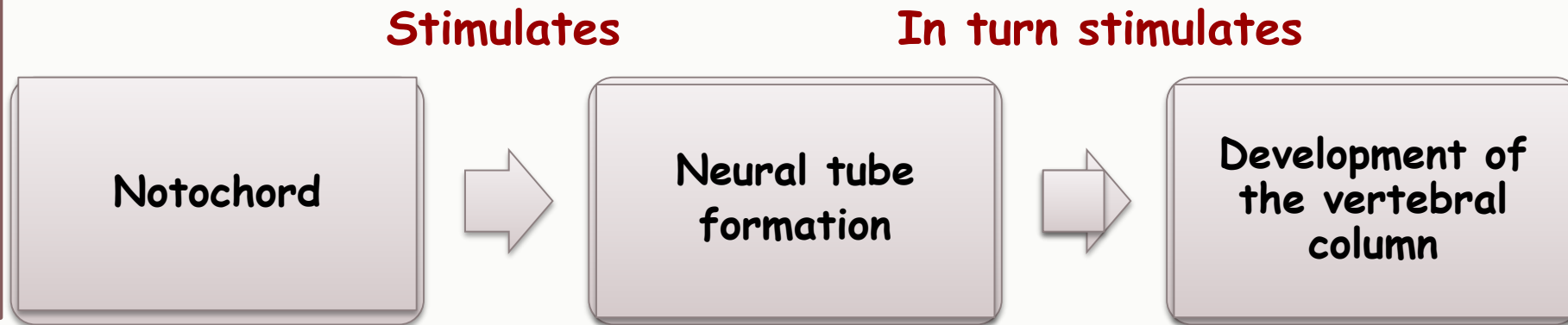
OBJECTIVES

By the end of the lecture, you 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.

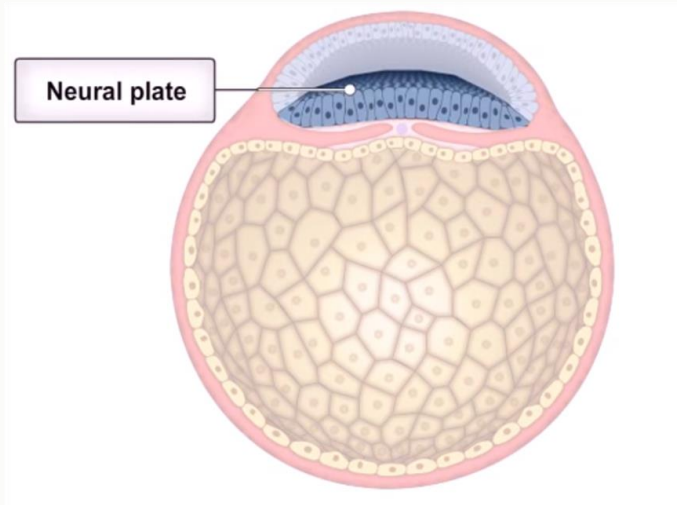


- Remember:**
- Ectoderm gives rise to skin and nervous system
 - Mesoderm gives rise to skeletal, muscular and connective tissues
 - Endoderm gives rise to respiratory and genitourinary tracts

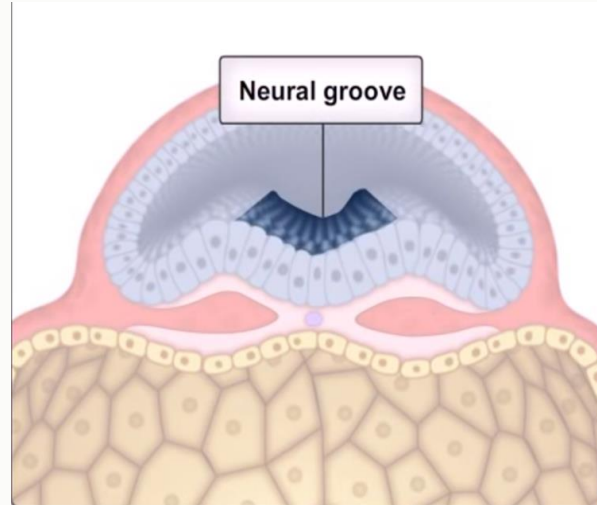




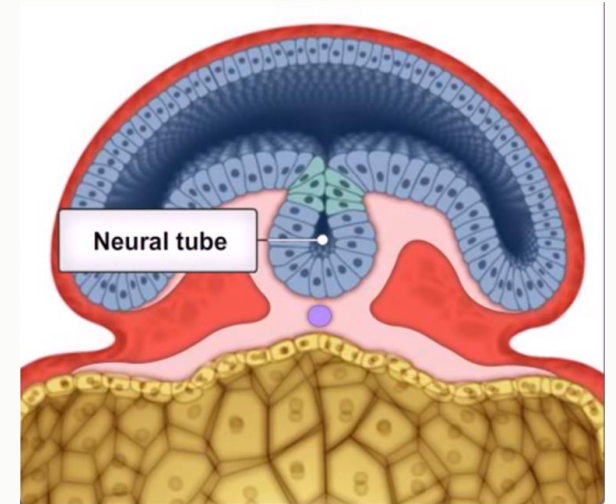
The development of the neural tube



1. **Ectodermal cells** dorsal to notochord thicken to form the **neural plate**.



2. A longitudinal groove, **neural groove, develops** in the neural plate. The two lateral margins of the neural plate elevate forming neural folds on each side of the longitudinal groove



3. The margins of the neural plate (**neural folds**) approach to each other and fuse to form the **neural tube**.



The development of the spinal cord

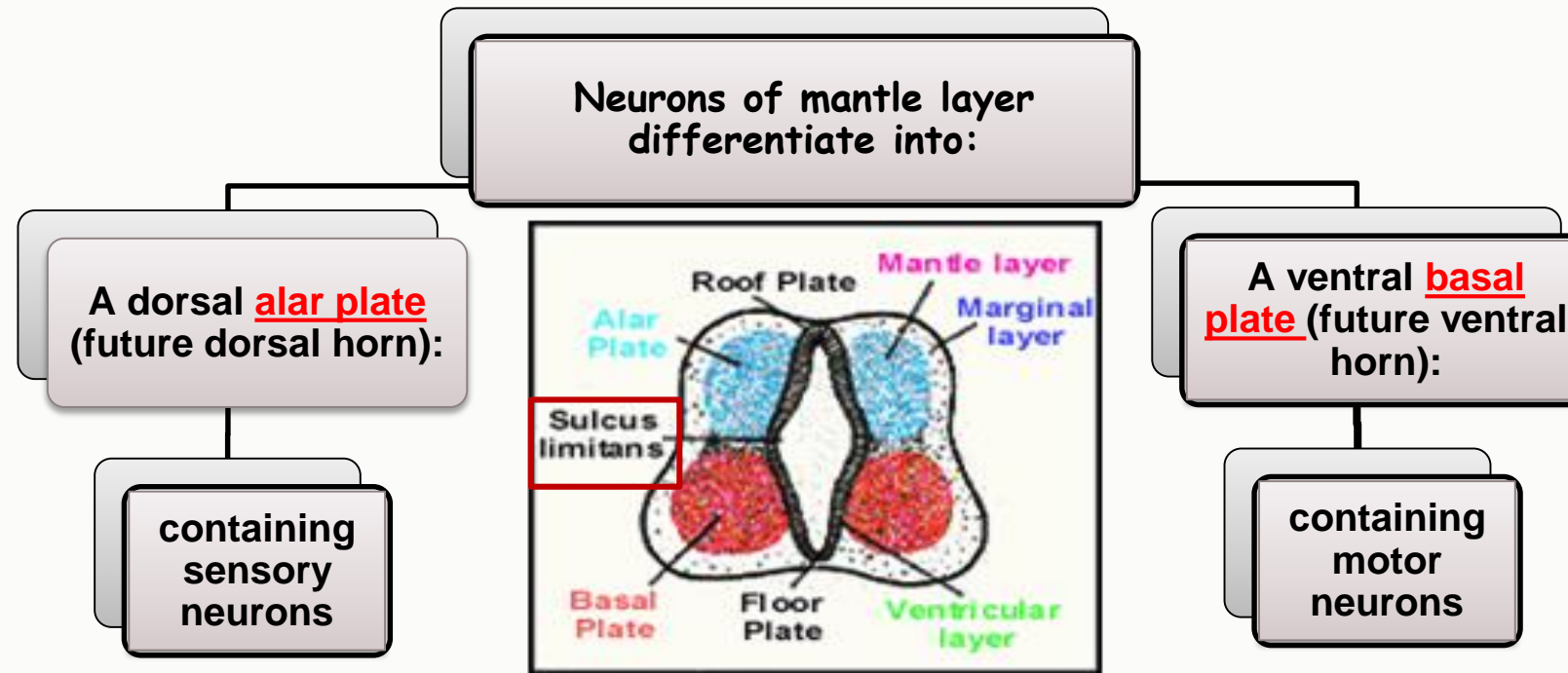
- The spinal cord develops from the **caudal 2/3** of the **neural tube**.
- The cells of the neural tube are arranged in three layers:

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)

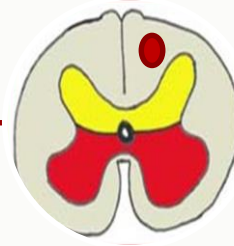
Mantle layer of spinal cord (future grey matter)



- ❑ The 2 areas are separated by a longitudinal groove (**sulcus limitans**).
- ❑ Proliferation and bulging of both alar & basal plates **result in:**
 1. Formation of **dorsal median septum**
 2. Formation of **ventral median fissure**
 3. Narrowing of the lumen of the neural tube to form a small **central canal**

Marginal layer of Spinal cord (future white matter)

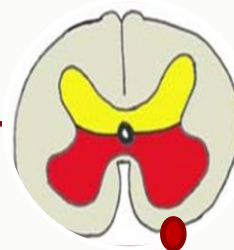
The marginal layer **increases** in size due to addition of ascending, descending & intersegmental nerve fibers & is divided into



Dorsal funiculus



Lateral funiculus



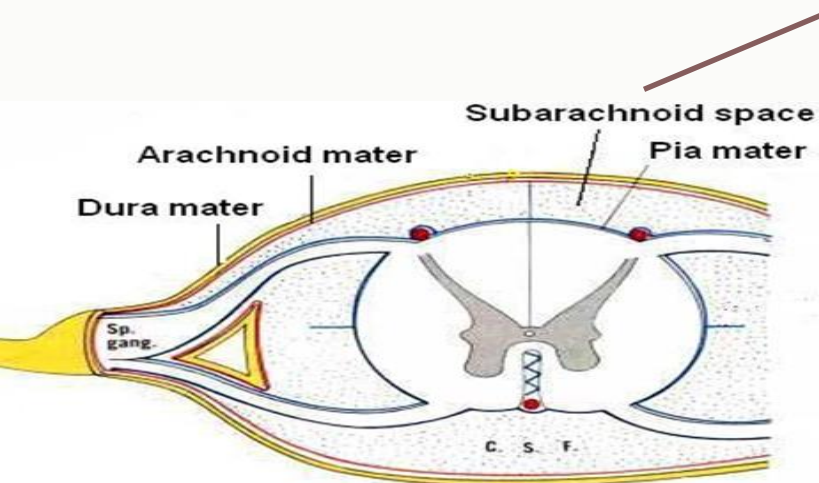
Ventral funiculus

Myelination of nerve fibers starts at 4th month & continues during the 1st postnatal year. **Motor fibers myelinate before sensory fibers.**


development of spinal 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)**.

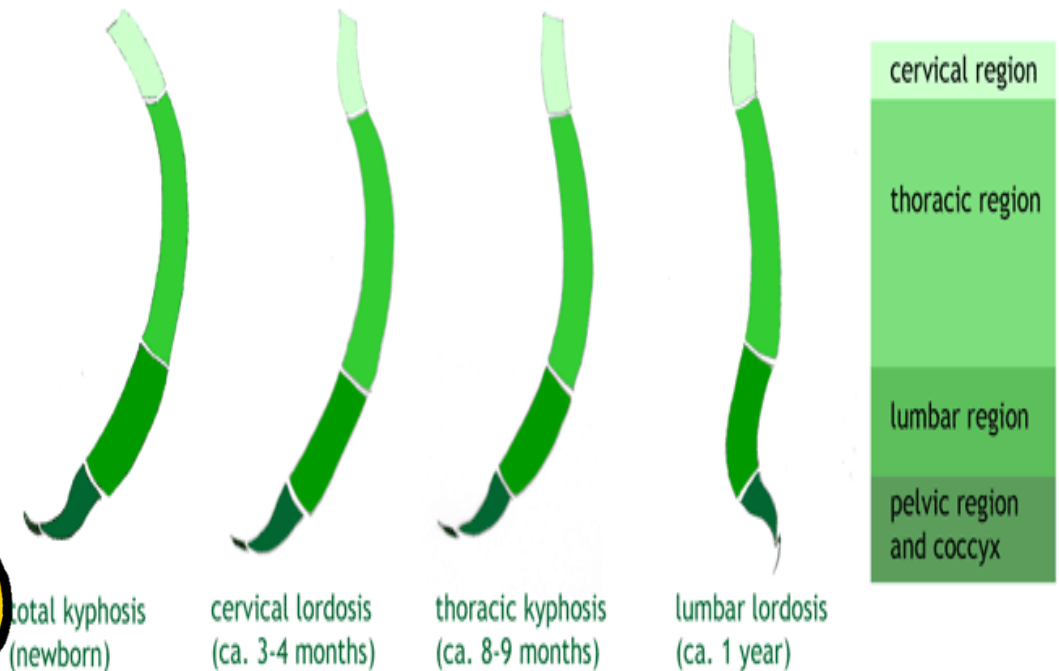


Since the dura mater is the outer most layer and in close contact with the vertebrae so it shares the origin of musculoskeletal system which is **MESODERM**.



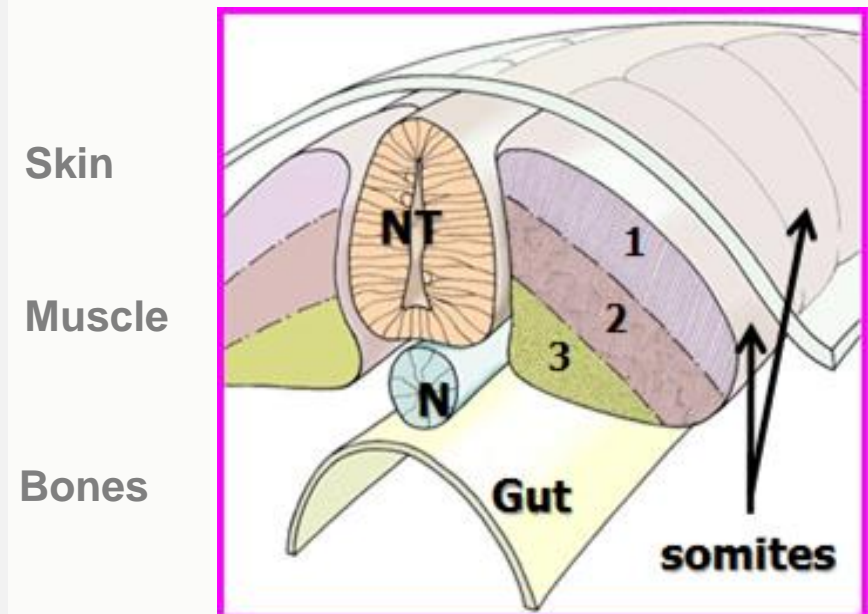
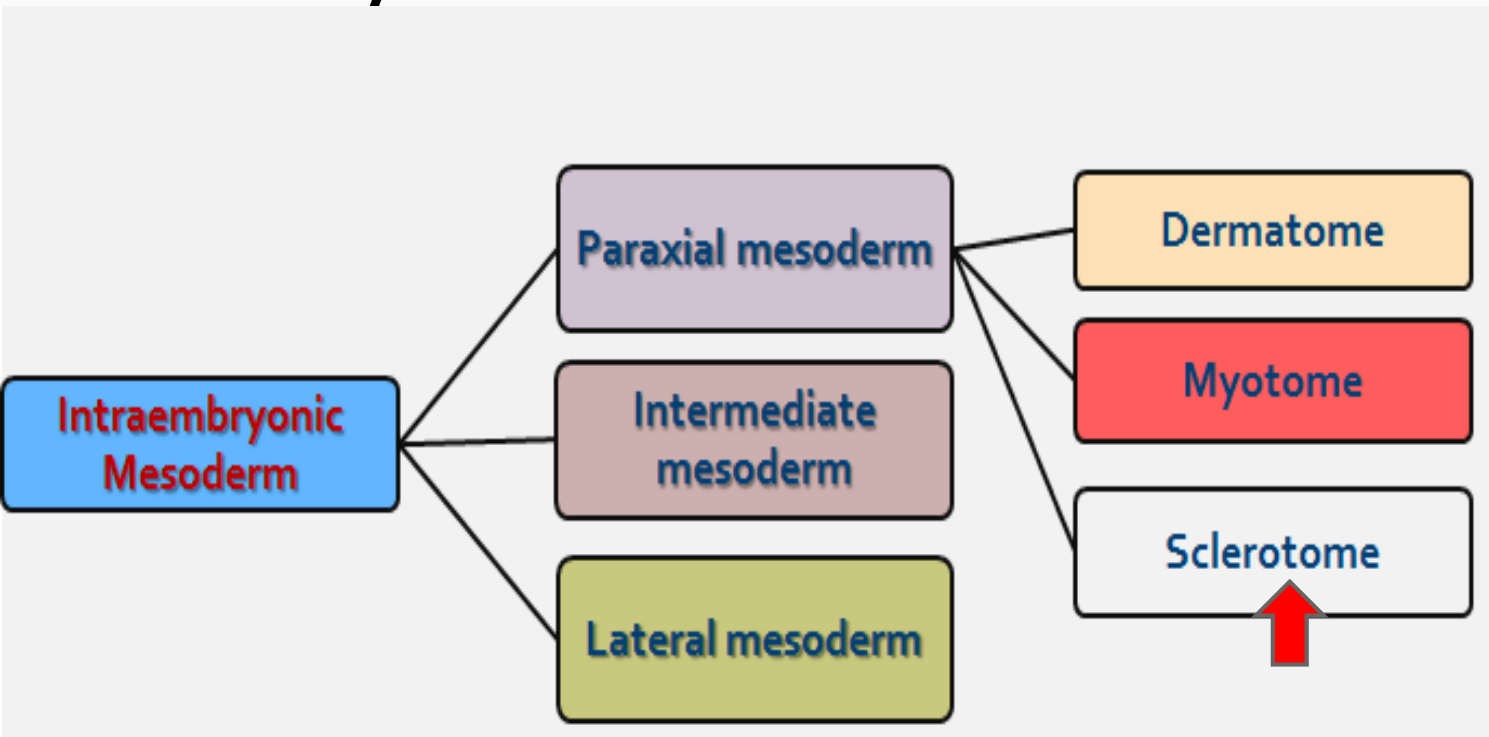
Positional Changes of Spinal Cord

- 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 which is derived from intraembryonic mesoderm that is Located between Ectoderm & Endoderm EXCEPT in the central axis of embryo where NOTOCHORD is found.





Formation of Body of Vertebra



At 4th week, each sclerotome becomes subdivided into two parts

a cranial part, consisting of loosely arranged cells

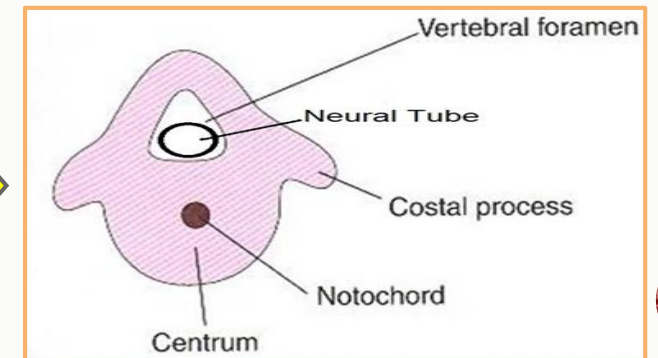
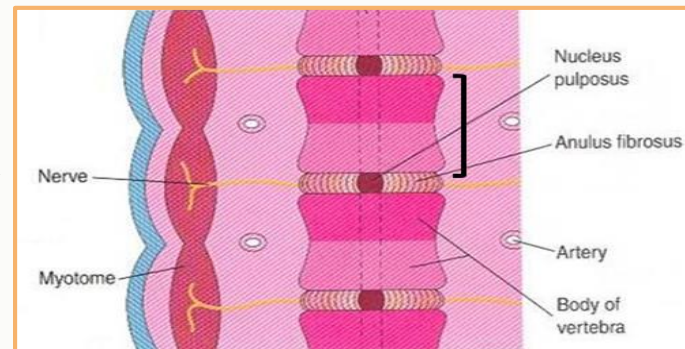
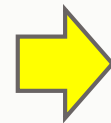
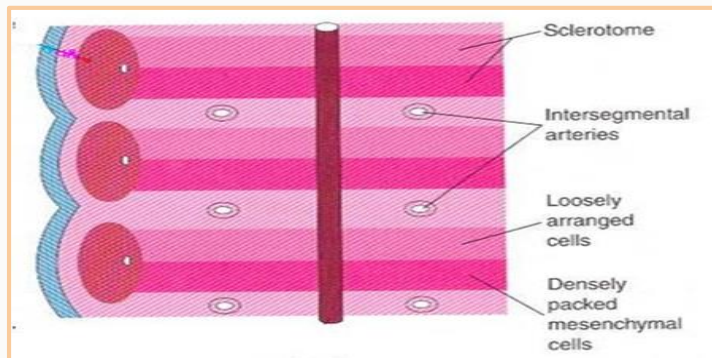
a caudal part, of more condensed tissue.

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**.

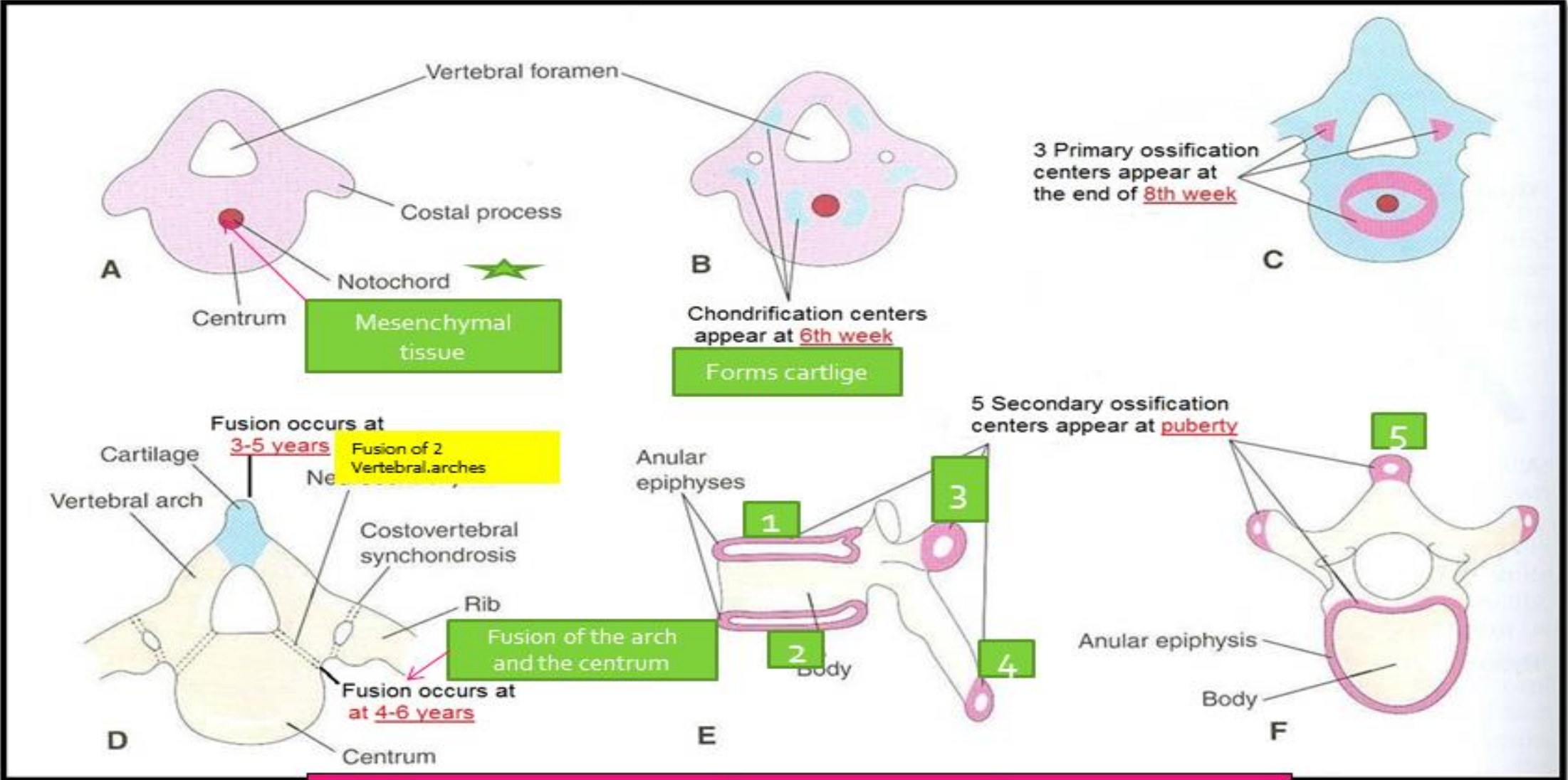
Thus each centrum develops from 2 adjacent sclerotome

§ 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.

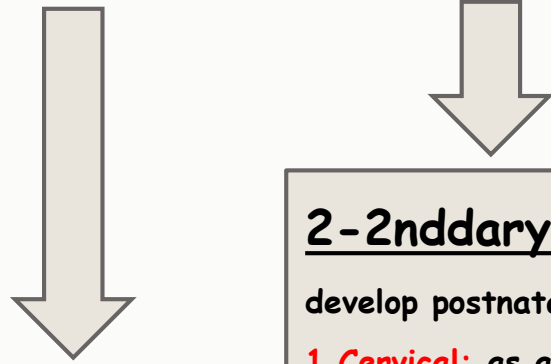


Vertebral Development



All centers unite around 25 years

Curvatures of Vertebral Column



2-Secondary curvatures :

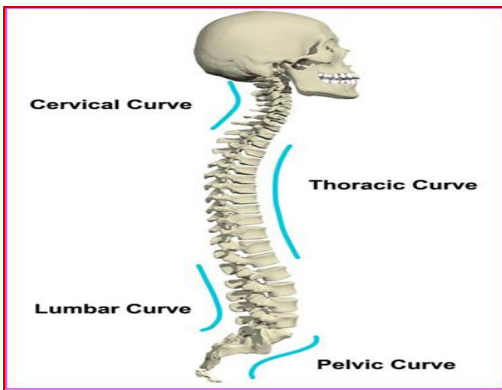
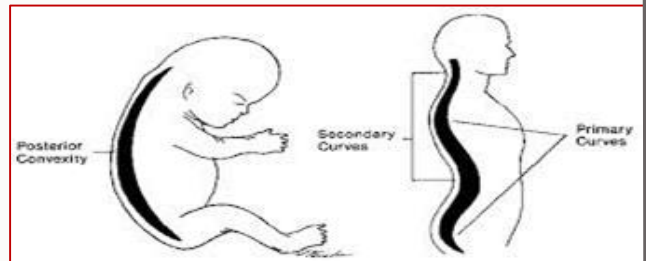
develop postnatally

- 1. **Cervical:** as a result of lifting the head
- 2. **Lumbar:** as a result of walking

1-Primary curvatures:

develop prenatally

- 1. **Thoracic**
- 2. **Pelvic or Sacral**



Fate of Notochord



1-At region of bodies of vertebrae

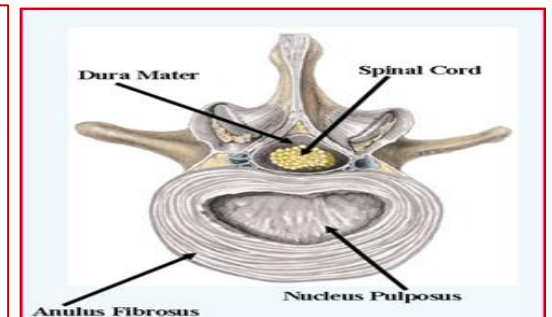
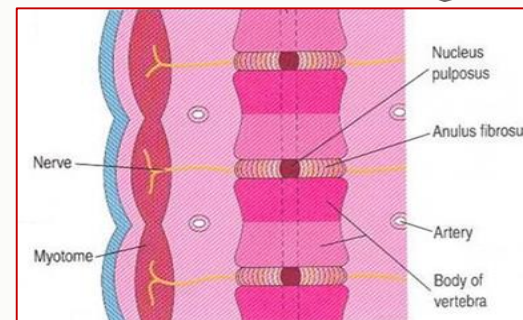
2-Between bodies of vertebrae:

it degenerate

It forms the central part, 'nucleus pulposus*' of the intervertebral discs

additional note :*gelatinous part

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



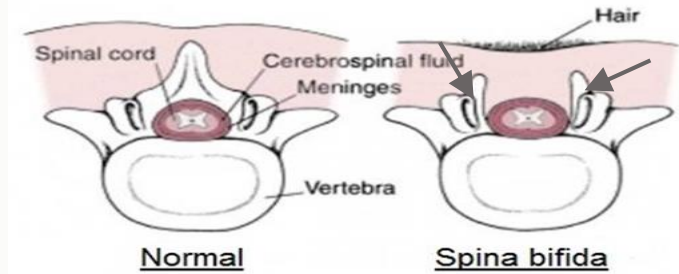
Spina Bifida



Cause: Failure of fusion of the halves of vertebral arches

Incidence: 0.04-0.15%

Sex: more in **females**



Types of Spina Bifida

1. Spina bifida occulta (20%)

- Closed type
- Only one vertebra is affected
- No clinical symptoms
- Skin overlying it is intact
- Sometimes covered by a tuft* of hair

خصل*

A. Spina bifida with meningocele: protrusion of sac containing meninges & cerebrospinal fluid

2. Spina bifida cystica* (80%)

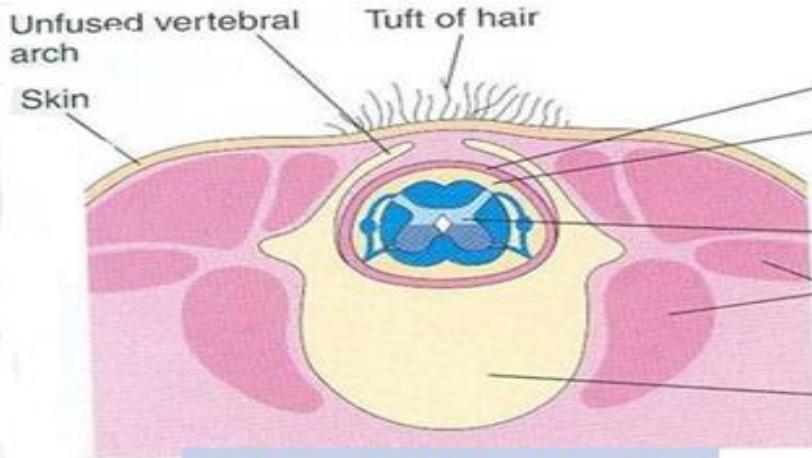
- Open type
- Neurological symptoms are present

Subdivided into*:

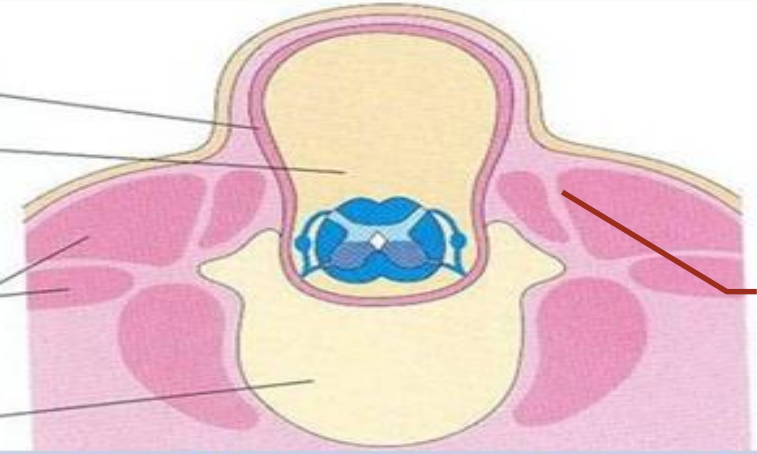
*according to the content of the sac

B. Spina bifida with meningocele: protrusion of sac containing meninges with spinal cord and/or nerve roots

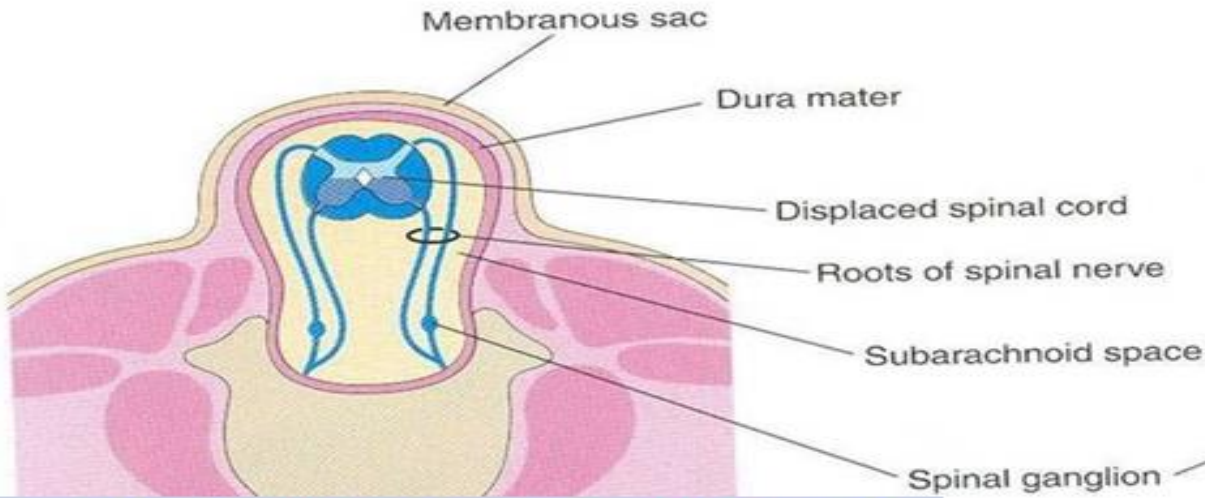
C. Spina bifida with myeloschisis: spinal cord is open due to failure of neural folds to develop.



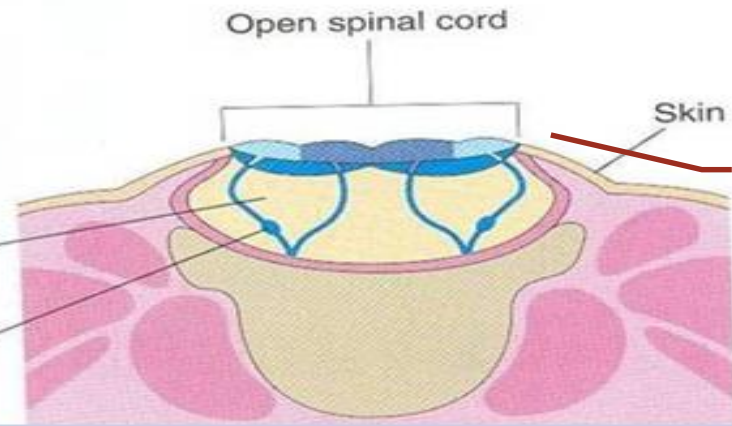
Spina bifida occulta



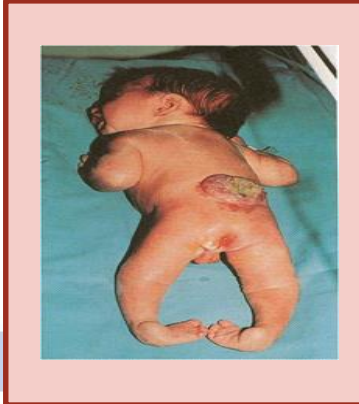
Spina bifida with meningocele



Spina bifida with meningo(myelo)*coele



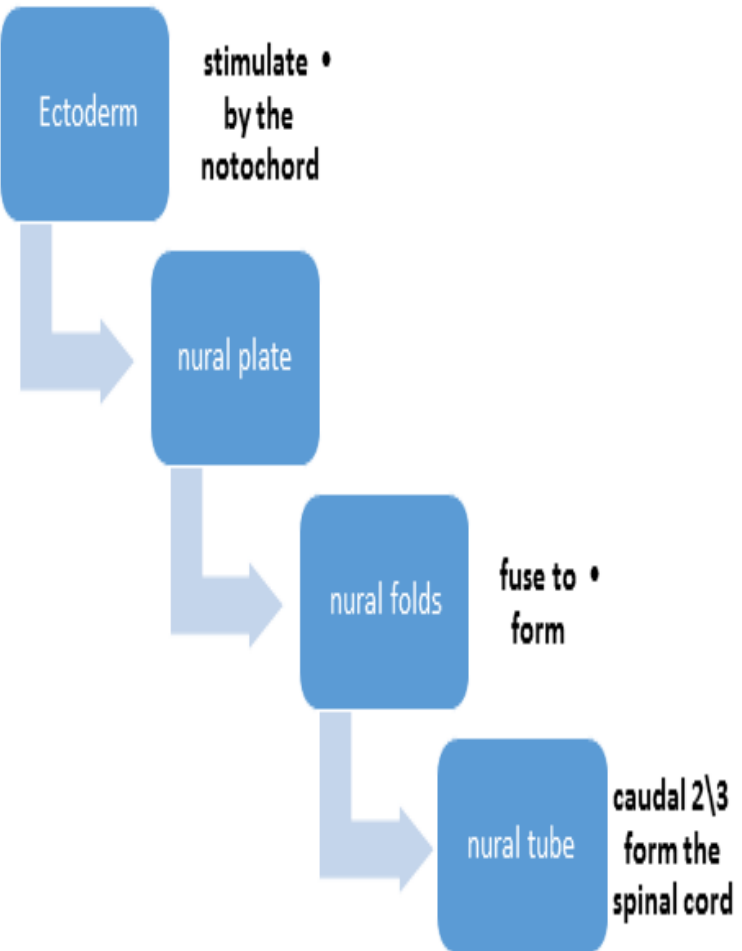
Spina bifida with myeloschisis



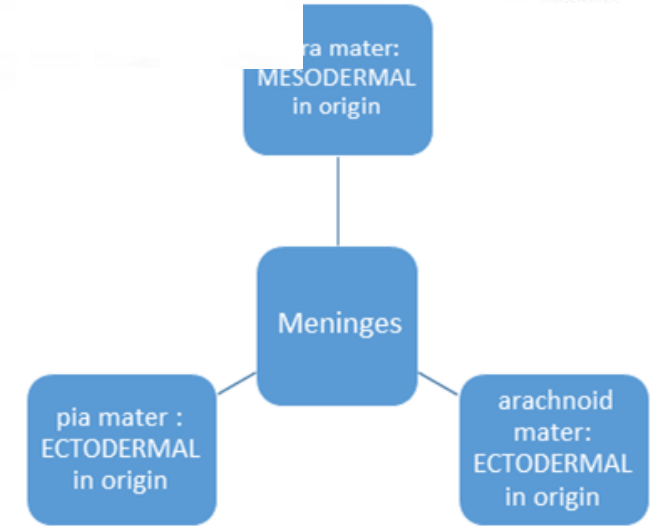
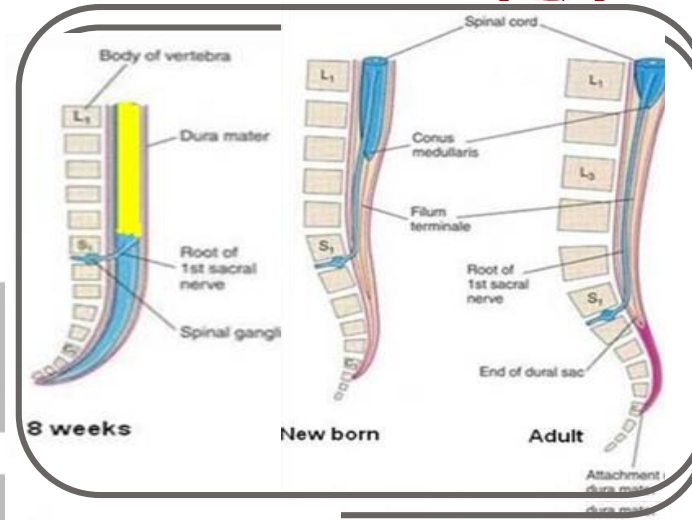
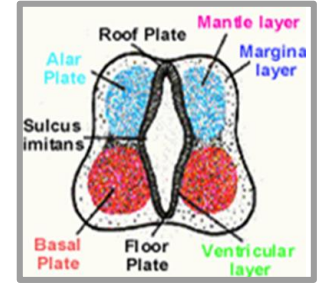
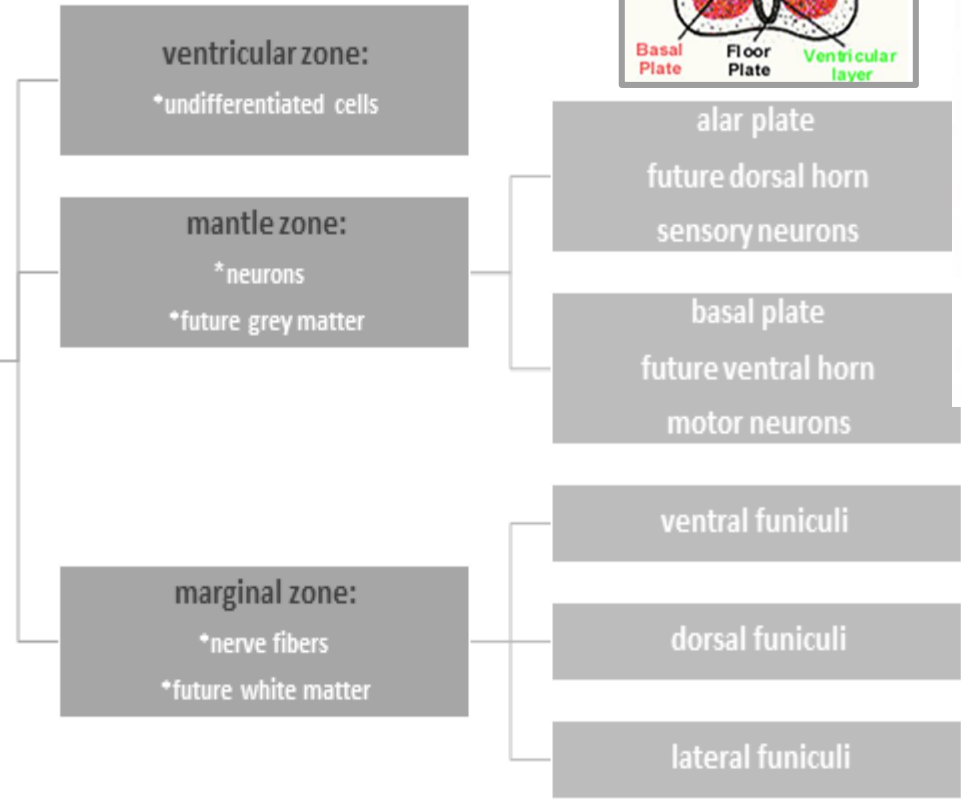
*Means part of spinal cord



SUMMARY



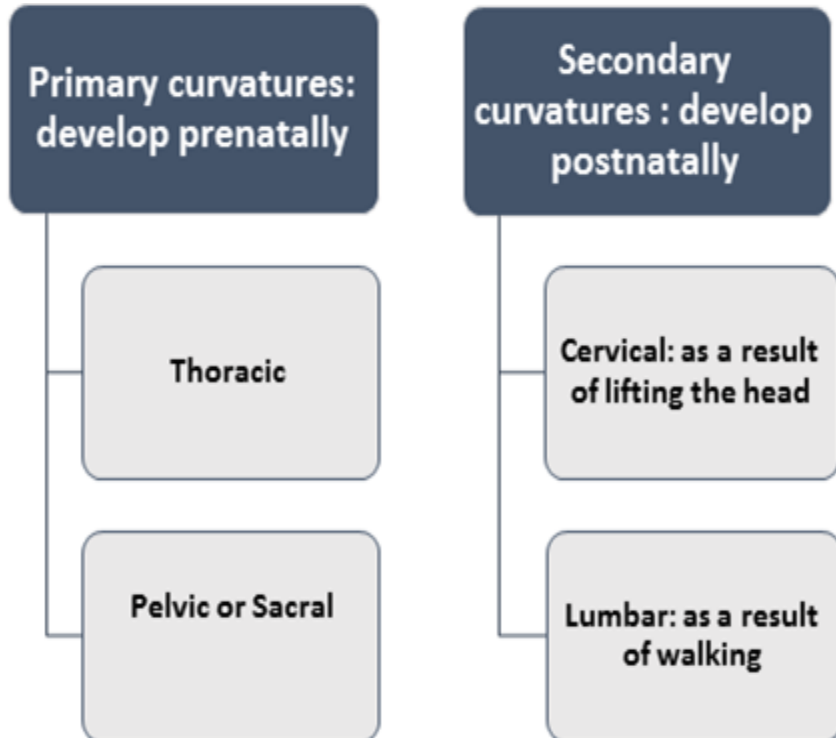
Neural tube layers



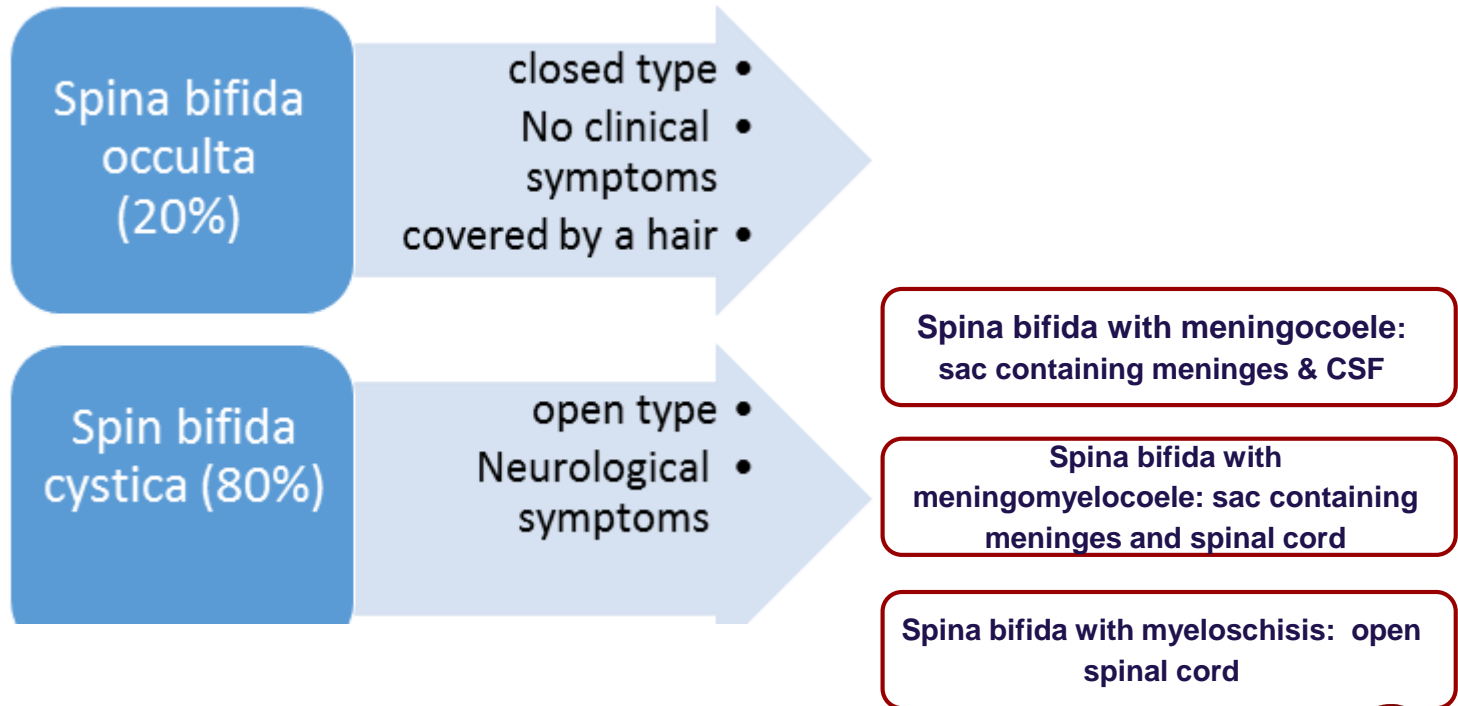


SUMMARY

- Proliferation and bulging of alar & basal plates → Formation of dorsal median septum and ventral median fissure
- Narrowing of the lumen of the neural tube → Formation of small central canal
- The vertebral column develops from the sclerotomes of the somites in the paraxial MESOderm



Spina Bifida: Failure of fusion of the halves of vertebral arches



❖ MULTIPLE CHOICES QUESTIONS

1-1 - The Neural Tube is a derivative of the:

- A - Ectoderm
- B- Mesoderm
- C- Endoderm

2- 4- When does the myelination of nerve fiber start?

- A- at 4h day
- B- at 4th month
- C- at 4th weeks

3- 5- A cavity appears between the arachnoid & the pia mater:

- A- subarachnoid space
- B- Epidural
- C- Subdural

4- 6- The somites are developed from the:

- A - para-axial Endoderm
- B- para-axial Ectoderm
- C- para-axial Mesoderm

5- the Sclerotome is subdivided into two parts at ..

- A- the 4h days
- B- the 4th month
- C- the 4th weeks

6- Spina bifida is more common in?

- A- male
- B- Females
- C- the incidence is equal in both female and male

7- Which of the following types of spina bifida doesn't have Neurological symptoms?

- A-Spina bifida with meningocele
- B- Spina bifida with meningocele
- C-Spina Bifida Occulta
- D-Spina bifida with myeloschisis

8- which of the following meninges is developed from MESODERM?

- A- pia
- B-arachnoid
- C-dura



- 1-A
- 2-B
- 3-A
- 4-C
- 5-B
- 6-B
- 7- C
- 8-C



❖ MULTIPLE CHOICES QUESTIONS ❖ SHORT ANSWERS QUESTIONS

9-Which one of the following regions of spinal cord contains cell bodies of sensory neurons?

- A- Alar plate
- B- Ventricular zone
- C- Basal plate
- D- Dorsal funiculus

10- At which one of the following periods of life fusion between vertebral arch & body of vertebra occurs?

- A- 8th week
- B- Puberty
- C- 3-6 years
- D- Around 25 years

11- Regarding spina bifida which one of the following statements is correct?

- A- The closed type is more frequent than the open type.
- B- The closed type presents with clinical symptoms.
- C- Spina bifida is due to failure of fusion between the halves of vertebral arch.
- D- In cases of spina bifida with meningocele, the spinal cord is open.

❖ Mention the three layers of neural tube cells.

- 1) 1 – inner ventricular zone
- 2) 2 - middle mantle zone
- 3) 3 -An outer marginal zone

❖ What are the results of the proliferation and bulging of both alar & basal plates?

- 1) Formation of dorsal median septum
- 2) Formation of ventral median fissure
- 3) form a small central canal

❖ what are the 3 membranes covering the neural tube ?

- 1) dura mater >> MESODERMAL
- 2) arachnoid mater >>ECTODERMAL
- 3) pia mater >>ECTODERMAL

❖ what is the cause of Spina Bifida ?

Failure of fusion of the halves of vertebral arches



- 9- A
- 10- C
- 11- C

DONE BY:

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