Embryology team

Development of vertebral column & spinal cord

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The important things in red

DEVELOPMENT OF SPINAL CORD

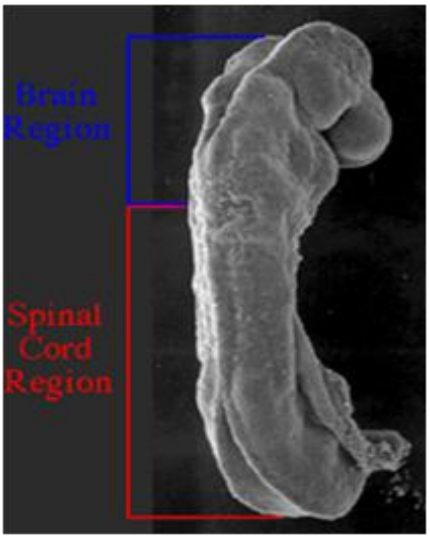
❑ **The spinal cord develops from the caudal 2/3 of the neural tube (v.imp)**

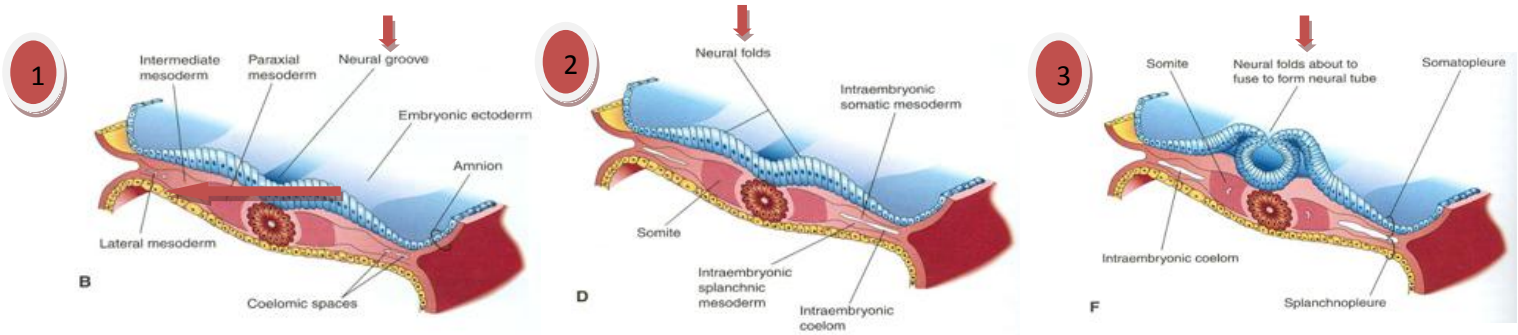
DEVELOPMENT OF NEURAL TUBE

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

2-A longitudinal groove develops in the neural plate **(neural groove).**

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





#Embryonic ectoderm: this layer forms the nervous system. (V.imp)

Notochord stimulates neural tube formation and it will stimulates vertebral column

The neural tube develops on the floor of the amniotic cavity.

The cells of neural tube

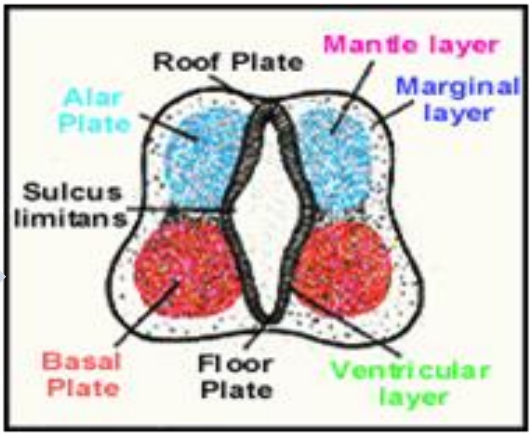
- An inner **ventricular zone** of undifferentiated cells
- A middle **mantle zone** of cell bodies of neurons **(future grey matter)**
- An outer **marginal zone** of nerve fibers or axons of neurons **(future white matter)**

MANTLE LAYER OF SPINAL CORD

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

A dorsal alar plate (future dorsal horn): **containing** **sensory** neurons

A ventral basal plate (future ventral horn): **containing** **motor** neurons

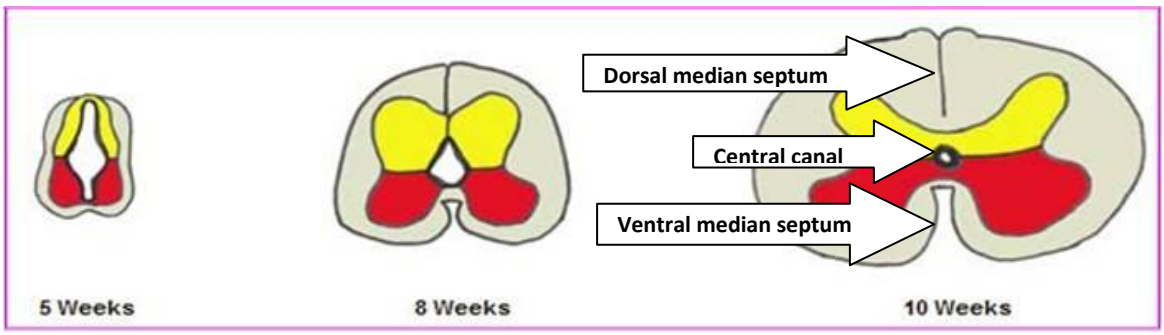


#The 2 areas are separated by a longitudinal groove **(sulcus limitans).**

 # Proliferation and bulging of both alar & basal plates cause:

Formation of longitudinal **dorsal & ventral median septa**

Narrowing of the lumen to form **a small central canal**



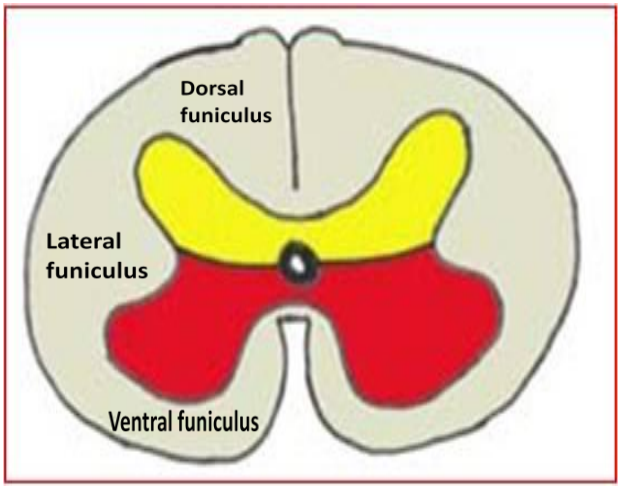
MARGINAL LAYER OF SPINAL CORD

-Marginal layer (future white matter)

increases in size due to addition of ascending, descending & intersegmental nerve fibers.

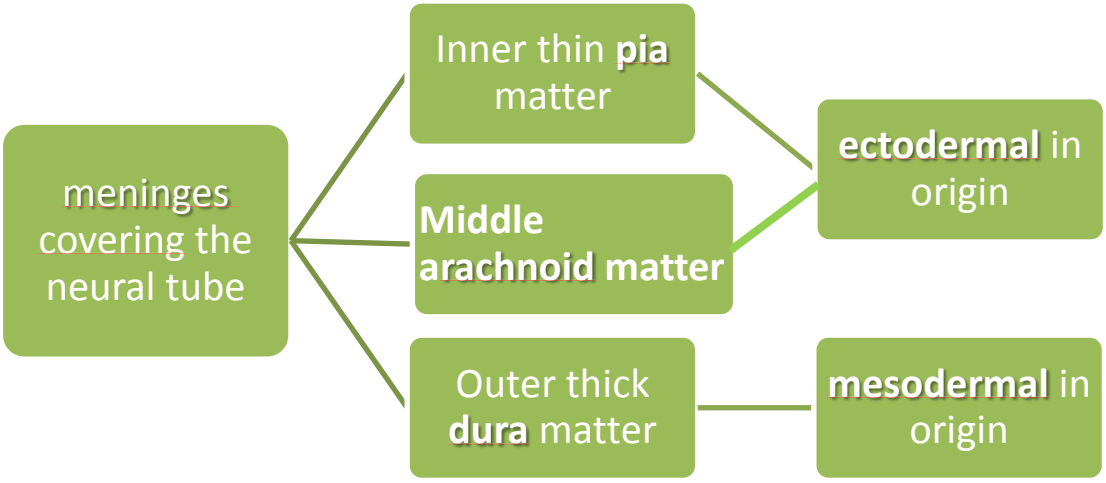
-Myelination of nerve fibers starts at 4th month & continues during the 1st postnatal period. Motor fibers myelinate before sensory fibers.

-Marginal layer is divided into: **dorsal, lateral and ventral funiculus (white column)**



-Nerve fibers will start functioning after myelination.

- Schwann cells form the myelin sheath by wrapping around axons of sensory and motor neurones.

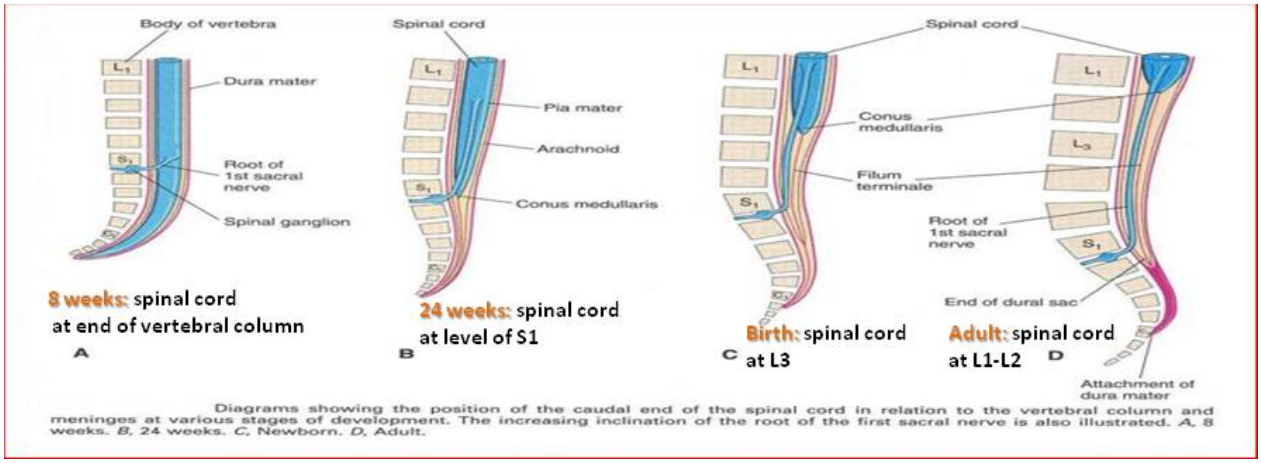


A cavity appears between **arachnoid & pia (subarachnoid space)** & becomes filled with **cerebrospinal fluid.**

POSITIONAL CHANGES OF SPINAL CORD

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

As a result of faster growth of vertebral column, the caudal end of spinal cord

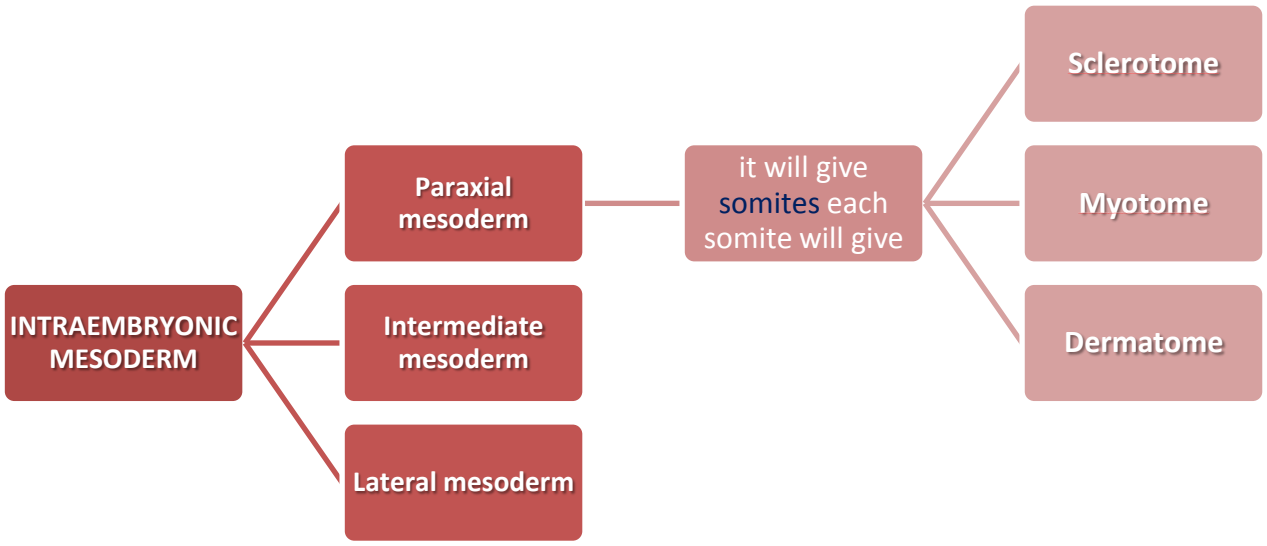


(<u>conus medullaris</u>) shift gradually to a higher level.

 # Very important to know timeline for each stage.

INTRAEMBRYONIC MESODERM

Proliferates between Ectoderm & Endoderm EXCEPT in the central axis of embryo where NOTOCHORD is found.

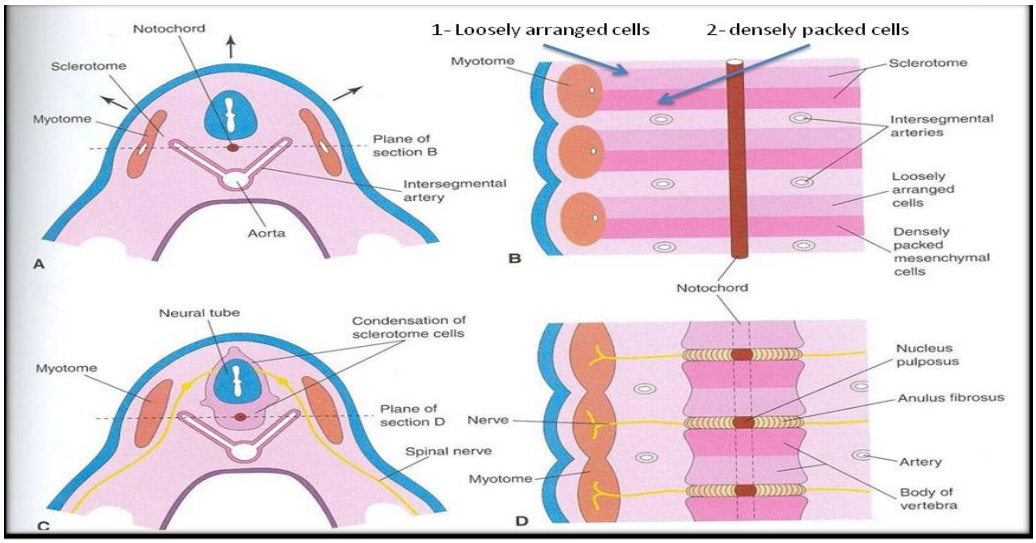


DEVELOPMENT OF VERTEBRA

1- Sclerotome around neural tube: forms **vertebral (neural) arch**.

2- Sclerotome around notochord: forms **body of vertebra**.

3-Sclerotome in body wall near to neural tube & notochord: forms **costal process (gives ribs in thoracic region).**



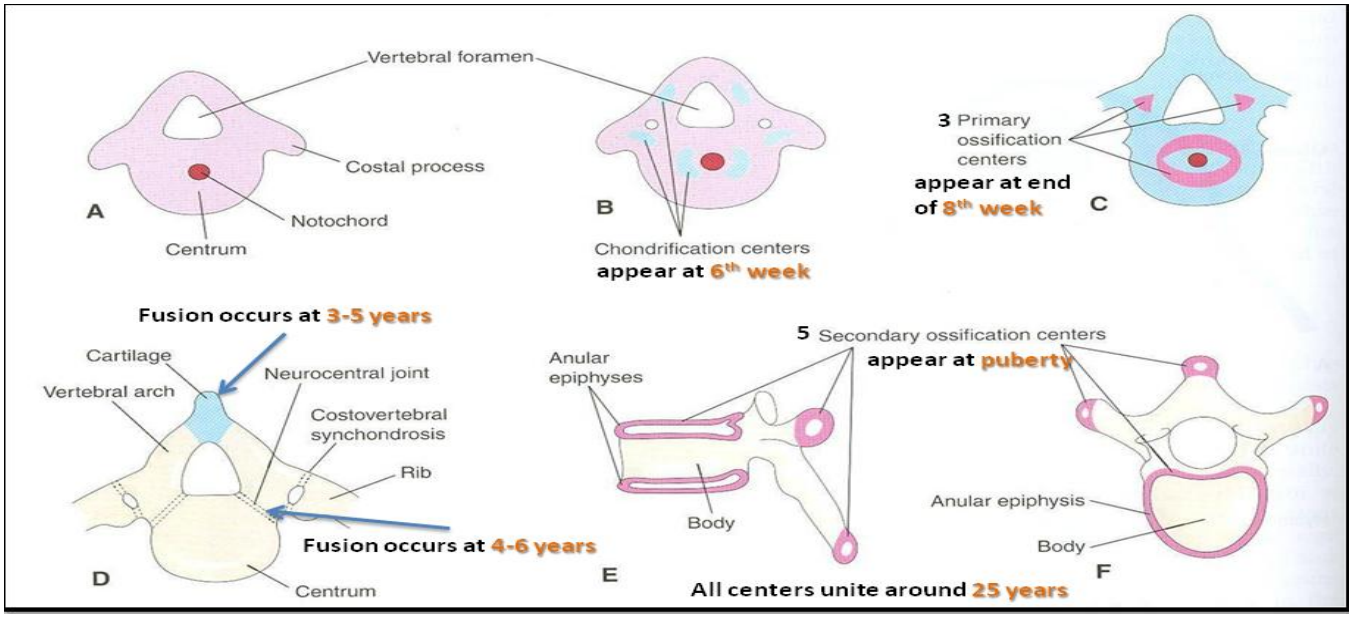
At **4th week**, each sclerotome is formed of:

1. A cranial part of **loosely arranged cells.**
2. A caudal part of **densely packed cells.**

-**The caudal part** of each sclerotome fuses with **the cranial part** of succeeding sclerotome to form the centrum (body primordium)

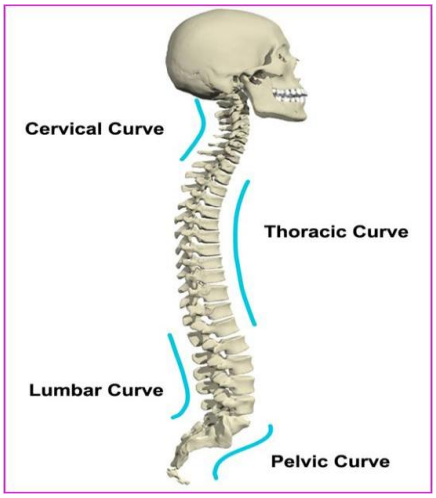
-Each centrum develops from **2 adjacent sclerotomes**.

#Annulus fibrosus part of the intervertebral discs are formed by the mesoderm surrounding the notochord



Very important to know the timeline of each stage

CURVATURES OF VERTEBRAL COLUMN



- **<u>Primary curves</u> develop prenatally:-**
  - **1-thoracic**
  - **2- pelvic or sacral**
- **<u>Secondary curves</u>: 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

Spin bifida cystica (80%)

The open type - -**Neurological symptoms are present** -divided into:

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

Spina bifida occulta (20%)

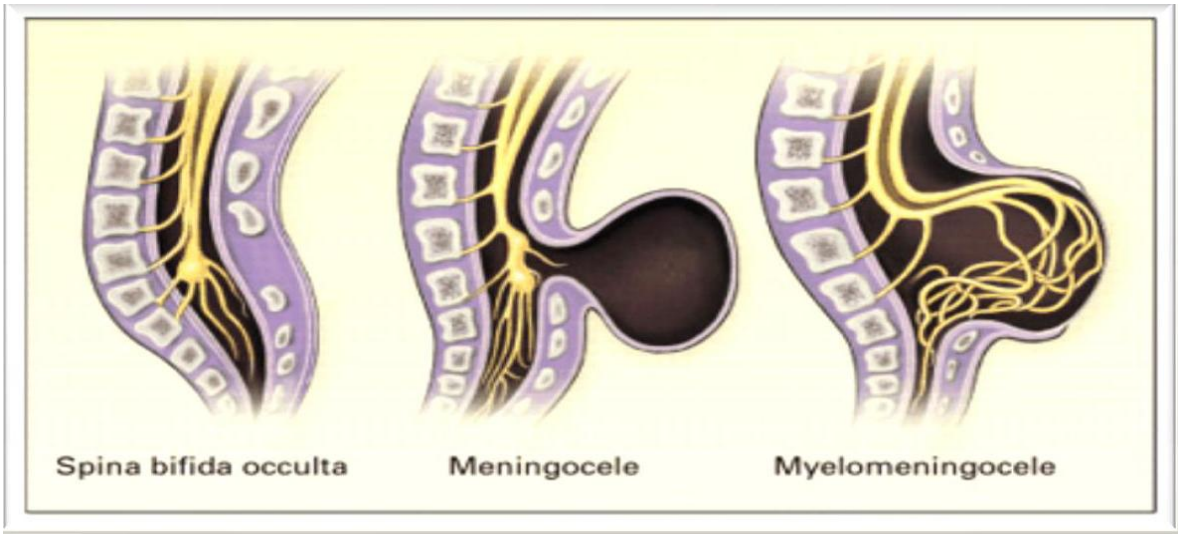
The closed type

- Only one vertebra is affected

- No clinical symptoms

-Skin overlying it is intact

- Sometimes covered by a tuft of hair



SUMMARY OF DEVELOPMENT OF SPINAL CORD

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

-Layers of spinal cord are (from inside outward): **ventricular, mantle (future grey matter) and marginal (future white matter).**

Mantle layer differentiates into **dorsal alar plate (with sensory neurons) & ventral basal plate (with motor neurons)** separated by sulcus limitans**.**

Marginal layer is divided into **dorsal, lateral & ventral funiculus.**

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

Meninges are 3 membranous sac covering the neural tube (from outside inward): dura (mesodermal in origin), arachnoid and pia (both are ectodermal in origin).

A cavity between arachnoid & pia matters (subarachnoid space) contains cerebrospinal fluid.

During development the end of spinal cord shifts its position: at 24 weeks (level of S1), at birth (level of L3), adult position (level of L1-L2).

SUMMARY OF DEVELOPMENT OF VERTEBRAL COLUMN

-Vertebral column develops from sclerotomic portion of paraxial mesoderm.

-Sclerotome around neural tube forms vertebral (neural) arch.

-Sclerotome around notochord forms body of vertebra. Each body develops from 2 adjacent sclerotomes.

-Notochord forms nucleus pulposus portion of the intervertebral discs.

-Chondrification centers appear at 6th week.

-Three primary ossification centers appear at 8th week.

-Fusion between halves of neural arch occurs at **3-5 years, between** neural arch & body at **4-6 years.**

-Five secondary ossification centers appear at puberty and fuse around **25 years.**

-Spina bifida is due to failure of fusion of the halves of the neural (vertebral) arch. It may be occulta (20%, closed type, no symptoms) or cystica (80%, open type, with symptoms).

time	event
4 weeks	FORMATION OF BODY OF VERTEBRA starts
6 weeks	Chondrification center appear and start chondrification
8 weeks	Three Primary ossification centers appear.
4 months	Myelination start and continues during the 1st postnatal period
5 to 6 months	the end of spinal cord shifts its position to (level of S1)
at birth	the end of spinal cord shifts its position to (level of L3)
3-5 years	Fusion between halves of neural arch occurs.
4-6 years	fusion between neural arch and body
at puberty	secondary ossification centers appear
Around 25 years	All centers unite
adult	the end of spinal cord shifts its position to (level of L1-L2)

Questions

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

1. Basal plate.
2. Ventricular zone.
3. Dorsal funiculus .
4. Alar plate.

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

1. 3-5 years
2. Around 25 years
3. Puberty
4. 8^{th} week

- **Regarding <u>spina bifida</u> which one of the following statements is correct?**

1. In cases of spina bifida with meningocoele, the spinal cord is open.
2. The closed type presents with clinical symptoms.
3. The closed type is more frequent than the open type.
4. Spina bifida is due to failure of fusion between the halves of vertebral arch.

Answers : 4,1,4