

## NERVOUS SYSTEM

### Neuropsychiatry block

#### DEVELOPMENT OF SPINAL CORD AND VERTEBRAL COLUMN

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##### Objectives

- ✓ 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.

##### References

- ✓ 435 embryology (males&females) slides.
- ✓ Pathoma Book ( IN DEVELOPMENTAL ANOMALIES PART ).

##### Color index

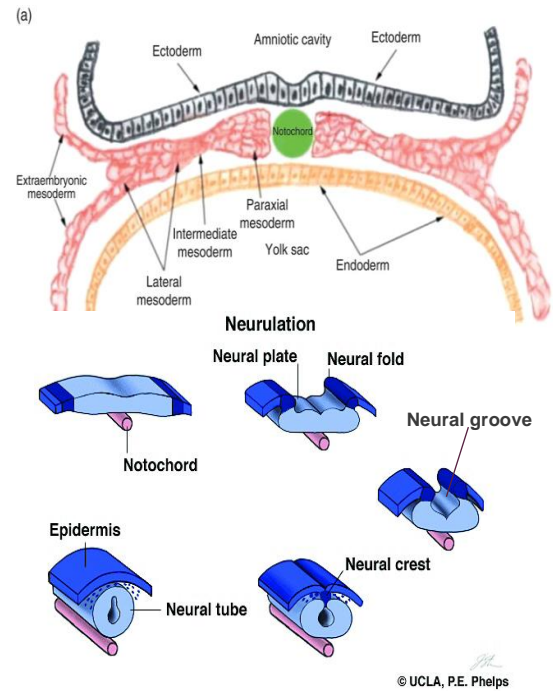
- ✓ **IMPORTANT**
- ✓ **Day, Week, Month**
- ✓ Doctor notes and extra information.

## ✓ development of neural tube:

By the beginning of the **3rd week** of development, three germ cell layers become established, Ectoderm, Mesoderm and Endoderm.

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

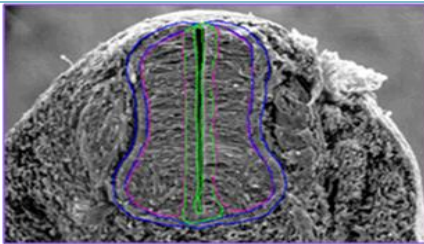
The Neural Tube is a derivative of the ectoderm. **Notochord stimulates neural tube** formation which in turn **stimulates** development of the **vertebral column**.



## ✓ development of spinal cord:

The spinal cord develops from the caudal 2\3 of the neural tube ( the cranial (Rostral) part of the neural tube will develop the brain.) . The **cells** of the neural tube are arranged in **three layers**:

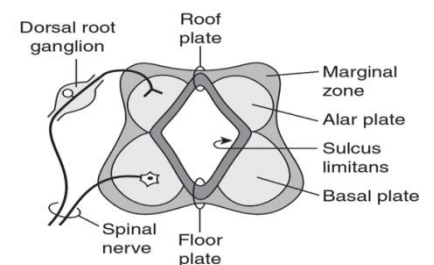
ventricular zone	mantle zone	marginal zone
Inner	Middle	Outer
undifferentiated cells.	cell bodies of neurons (future <b>grey matter</b> )	nerve fibers or axons of neurons (future <b>white matter</b> )



الطبقة الخارجية ( marginal ) بتكون في البداية ضيقة ولكن مع استمرار نمو الجنين تصبح طبقة واسعة بسبب العدد الكبير لـ ( nerve axon )

- **Mantle Layer of Spinal Cord**, Neurons of mantle layer (future grey matter) differentiate into:

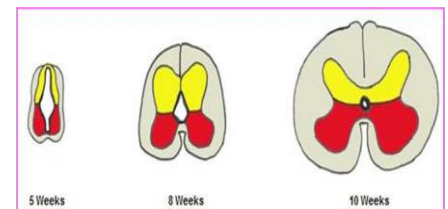
dorsal Alar plate	ventral Basal plate
future dorsal horn	future ventral horn
containing <b>sensory</b> neurons	containing <b>motor</b> neurons



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**.

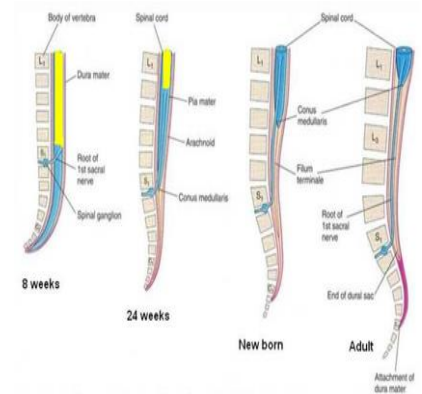


- **The marginal layer** (future white matter) increases in size due to addition of ascending, descending & intersegmental nerve fibers & is divided into: **dorsal, lateral and ventral funiculi**.

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.

• **Positional Changes of Spinal Cord:**

- Initially at the ( 8 week ) 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 ( S1 ).



**\*The spinal cord in Adult between L1 and L2 and new born in L3\*.**

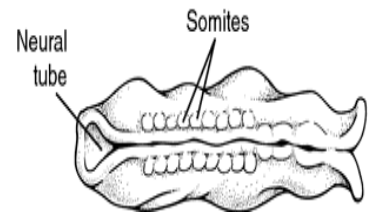
• **Meninges** These are 3 membranes covering the neural tube:

Outer thick <b>dura</b> mater	Middle <b>arachnoid</b> mater	Inner thin <b>pia</b> mater
<b>MESODERMAL</b> in origin	<b>ECTODERMAL</b> in origin	

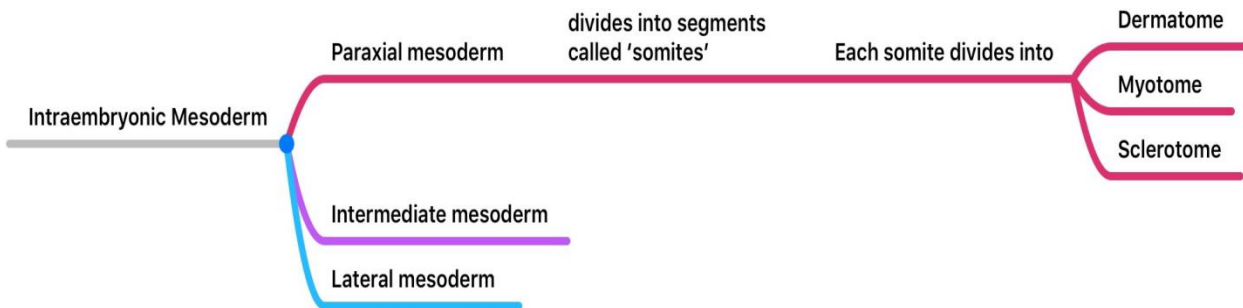
A cavity appears between the arachnoid & the pia mater (**subarachnoid space**) & becomes filled with cerebrospinal fluid (**CSF**).

✓ **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.



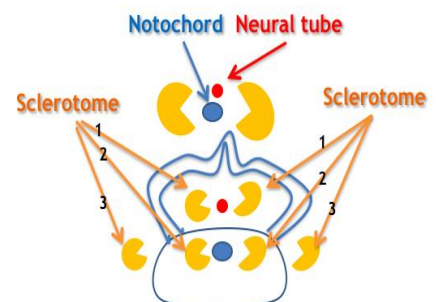
- **Intraembryonic Mesoderm** ( remember from MSK black ) : Located between Ectoderm & Endoderm **EXCEPT** in the central axis of embryo where **NOTOCHORD** is found.



• **Formation of Body of Vertebra:**

**( 1-2-3 from males lecture )**

- Sclerotome around neural tube: forms vertebral (neural) arch
- Sclerotome around notochord: forms body of vertebra
- Sclerotome in body wall near to neural tube & notochord : forms costal process (gives ribs in thoracic region)

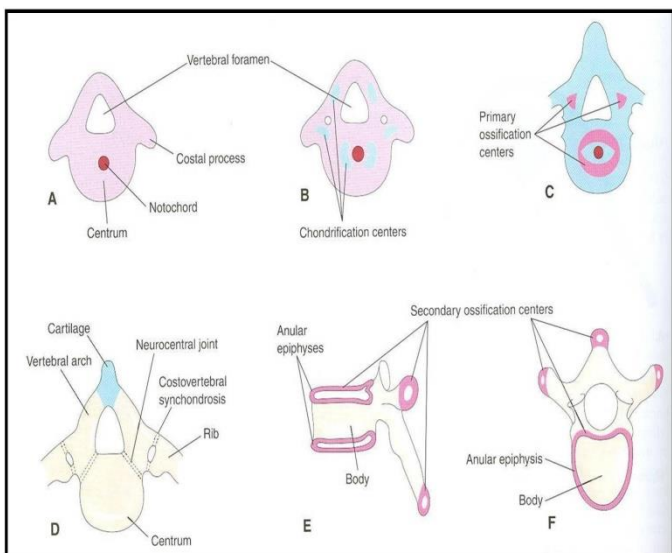
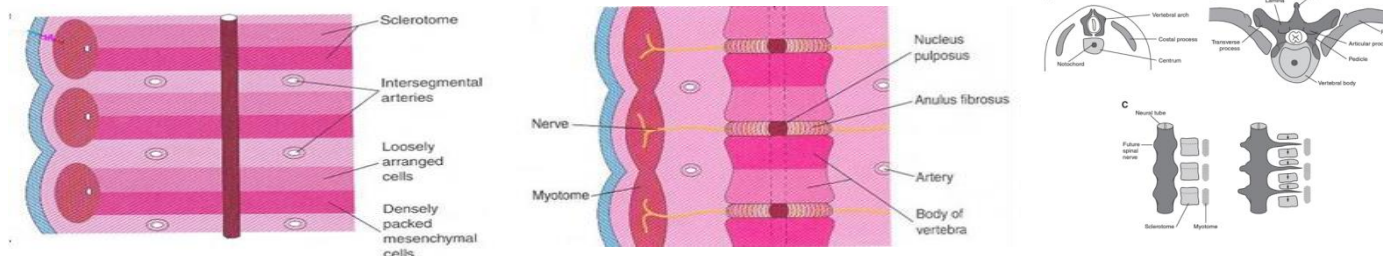


At **4th week**, each sclerotome becomes subdivided into two parts :

- cranial** part, consisting of **loosely arranged cells**.
- 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 sclerotomes.

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**.



**Dr.sanaa Notes** This picture represents the changes that occurs into 2 stages : **chondrotification** stage and **ossification** stage.

- The chondrotification centers appear at **6th week (cartilage)**:(Pic.B)
- And by the (at the end of **8th week**) the 3 primary ossification centers appears (**bone**): (Pic.c)
- And The 5 secondary ossification centers appear at **puberty**.

Fusion of bony halves of vertebral arch occurs at **3-5 years** (pic.D). and Fusion of centrum with vertebral arch occurs at **3-6 years** (pic.D).

All centers unite around **25 years**.

SO, Ossification starts at the end of embryonic period ( end of 8th week) and ends at adult age 25 years.

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

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

- **Curvatures of Vertebral Column**

Primary curvatures	Secondary curvatures
develop <b>prenatally</b> .	develop <b>postnatally</b> .
<ol style="list-style-type: none"> <li>Thoracic.</li> <li>Pelvic or Sacral.</li> </ol>	<ol style="list-style-type: none"> <li>Cervical: as a result of <b>lifting the head</b></li> <li>Lumbar: as a result of <b>walking</b></li> </ol>

✓ **Spina bifida :**

**Cause:** Failure of fusion of the halves of vertebral arches.

**Incidence:** 0.04-0.15%

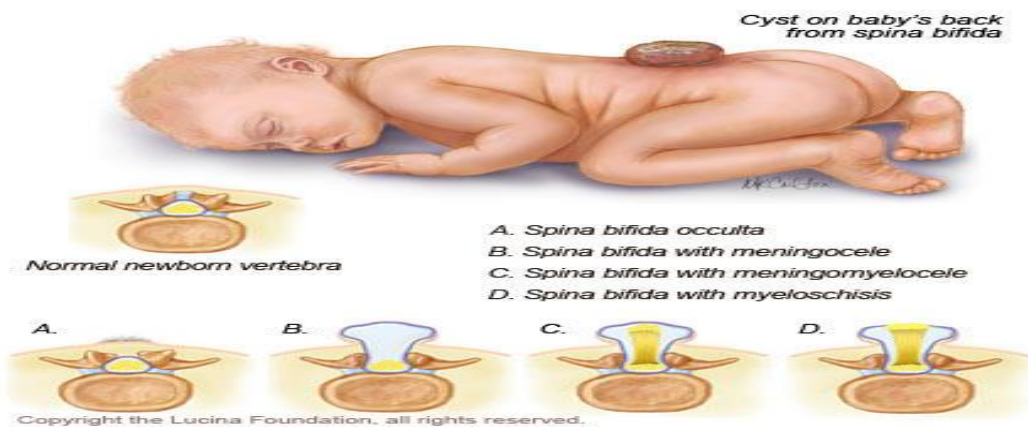
**Sex:** more frequent in females.

**Types:**

Spina bifida occulta (20%) (=hidden)	Spin bifida cystica (80%) (=Sac)
The <b>closed</b> type	The <b>open</b> type
<b>No</b> clinical symptoms	Neurological symptoms are <b>present</b>
<ul style="list-style-type: none"> <li>○ Only <b>one vertebra</b> is affected</li> <li>○ <b>Skin overlying it is intact</b></li> <li>○ <b>Sometimes</b> covered by a <b>tuft of hair</b>.</li> <li>○ Usually <b>dose not</b> involve underlying neural tubes. ( The spinal cord is <u>intact</u>.)</li> </ul>	<p><b>Cystica</b> is the most <b>severe</b> and complex form of spina bifida. It usually <b>involves</b> serious or fatal neurological problems. <b>A portion of the nerves and the spinal cord are exposed outside the body.</b></p> <p><u>Subdivided into:</u></p> <ul style="list-style-type: none"> <li>○ Spina bifida with <b>meningocele</b>.</li> <li>○ Spina bifida with <b>meningomyelocele</b>.</li> <li>○ Spina bifida with <b>myeloschisis</b>.</li> </ul>



Spina bifida with <b>meningocele</b> : protrusion of <b>sac</b> containing <b>meninges</b> & <b>cerebrospinal fluid</b> .	Spina bifida with <b>meningomyelocele</b> : protrusion of <b>sac</b> containing <b>meninges</b> with <b>spinal cord</b> and/or <b>nerve roots</b> .	Spina bifida with <b>myeloschisis</b> : <b>spinal cord is open</b> due to <b>failure of neural folds</b> to develop.
<p>Meningocele</p>		




## Summary

Structure	Origin
Neural tube	Ectoderm.
Spinal cord	Caudal 2/3 of the neural tube.
Grey matter	Mantle layer.
White matter	Marginal layer.
arachnoid mater and pia mater	Ectoderm.
Dura matter	mesoderm
Vertebral column	ventromedial parts (sclerotomes) of the somites.
Somites	Para-axial mesoderm.
nucleus pulposus	Notochord between the bodies of vertebrae.
Annulus fibrosus	Mesoderm.

Time	Changes
<b>3<sup>rd</sup> week (early)</b>	Three germ cell layers.
4 <sup>th</sup> week	Each sclerotome becomes subdivided into cranial and caudal part.
6 <sup>th</sup> week	Chondrification centers appear.
End of 8 <sup>th</sup> week	3 primary ossification centers appear.
<b>4<sup>th</sup> month</b>	Starting of myelination of nerve fibers.
During 1 <sup>st</sup> postnatal year	Continuation of the myelination of nerve fibers.
3-5 years	Fusion occurs (fusion of 2 vertebral arches)
4-6 years	Fusion of centrum with vertebral arch.
At puberty	5 secondary ossification centers appear.
<b>25 years</b>	All centers unite.
<b>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).</b>	

### Spina bifida : the Failure of fusion of the halves of vertebral arches.

Spina bifida occulta (20%) (=hidden)	Spin bifida cystica (80%) (=Sac)
The <b>closed</b> type	The <b>open</b> type
No clinical symptoms	Neurological symptoms are <b>present</b>
<ul style="list-style-type: none"> <li>Only one vertebra is affected</li> <li>Skin overlying it is intact</li> <li>Sometimes covered by a <b>tuft of hair</b>.</li> <li>Usually dose not involve underlying neural tubes. ( The spinal cord is <u>intact</u>.)</li> </ul> 	Cystica is the most <b>severe</b> and complex form of spina bifida. It usually involves serious or fatal neurological problems. <b>A portion of the nerves and the spinal cord are exposed outside the body.</b> <u>Subdivided into:</u> <ul style="list-style-type: none"> <li>Spina bifida with meningocele.</li> <li>Spina bifida with meningocele.</li> <li>Spina bifida with myeloschisis.</li> </ul>

Spina bifida with <b>meningocele</b>	Spina bifida with <b>meningocele</b>	Spina bifida with <b>myeloschisis</b>
protrusion of <b>sac</b> containing <b>meninges &amp; cerebrospinal fluid.</b>	protrusion of <b>sac</b> containing <b>meninges</b> with <b>spinal cord and/or nerve roots.</b>	<b>spinal cord is open</b> due to <b>failure of neural folds to develop.</b>

## MCQ's

- 1- Funiculi are bundles of nerve tracts that are associated with:
  - a- The gray matter of the spinal cord
  - b- The white matter of the spinal cord
  - c- The gray commissure of the spinal cord
  - d- A&C
  
- 2- The sclerotomes subdivide into cranial and caudal parts during:
  - a. 3<sup>rd</sup> week
  - b. 4<sup>th</sup> week
  - c. 5<sup>th</sup> week
  - d. 6<sup>th</sup> week
  
- 3- which of these layers is formed by the mesoderm:
  - a. pia mater
  - b. arachnoid mater
  - c. dura mater
  - d. subarachnoid space
  
- 4- spina bifida with ..... Is a protrusion of sac containing meninges with spinal cord:
  - a. Spina bifida occulta
  - b. Spina bifida with meningoencephalocele
  - c. Spina bifida with meningocele
  - d. Spina bifida with myeloschisis
  
- 5- A new born female is born with a cyst on the lower of her back, the doctor explained to her parents that the neural folds were failed to develop. what is the medical term of this condition:
  - a. Spina bifida with myeloschisis
  - b. Spina bifida with meningocele
  - c. Spina bifida with meningoencephalocele
  - d. Spina bifida occulta
  
- 6- Which of these vertebral curvatures develop postnatally:
  - a. Thoracic curve
  - b. Pelvic curve
  - c. Cervical curve
  - d. Sacral curve
  
- 7- As a result of fast growth of vertebral column, which part of spinal cord shifts gradually up?
  - a. Cauda equina

- b. Canus medullaris
- c. Calrk's column
- d. Central canal

8- Myelination of nerve fibers continues after birth during:

- a. First 2 months
- b. First 4 months
- c. First 8 months
- d. First 12 months

9- The dorsal alar plate and ventral basal plate are separated by:

- a. Marginal layer
- b. Ventricular layer
- c. Sulcus limitans
- d. Ventral median fissure

10-Which of these medical conditions usually does not include any clinical symptoms:

- a. Spina bifida with meningocele
- b. Spina bifida with meningocele
- c. Spina bifida with myeloschisis
- d. Spina bifida occulta

11-Each centrum develop from ..... adjacent sclerotomse.

- a. 2
- b. 4
- c. 8
- d. 6

12-Sensory fibers myelinated ..... motor fibers.

- a. Before
- b. After
- c. With
- d. Faster than

13-Mantale zone is a future ..... and marginal is zone is a future .....

- a. Grey matter – white matter
- b. Central canal – grey matter
- c. White matter – grey matter
- d. White matter – central canal

14-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.

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

- a. 8<sup>th</sup> week
- b. Puberty
- c. 3-6 years
- d. Around 25 years

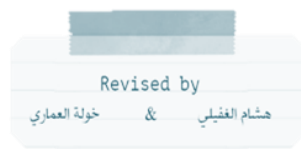
16-Which one of the following regions of spinal cord contains cell bodies of sensory neurons?

- a. Alar plate
- b. Ventricular zone
- c. Basal plate
- d. Dorsal funiculus

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
b	b	C	b	a	c	b	d	c	d	a	b	a	c	c	a

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