



Development of Spinal Cord & Vertebral Column

NEUROPSYCHIATRY BLOCK

Embryology team

Color Code:

- **Important**
- **Doctors Notes**
- Extra explanation

Done



MED437
KING SAUD UNIVERSITY



Embryology 437

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.

The Three Germ Layers:

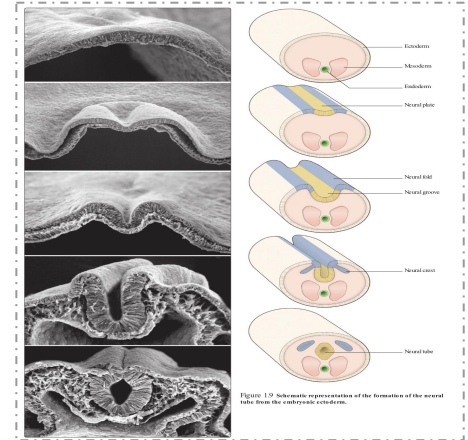
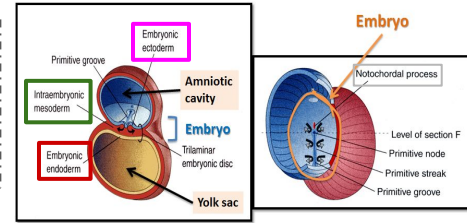
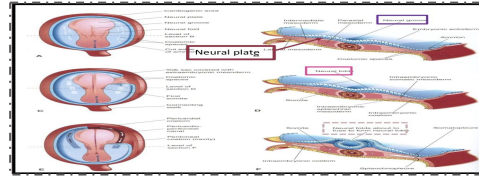
Ectoderm, Mesoderm, Endoderm

The Neural Tube is a derivative of the **ectoderm**. Neural tube gives rise to Spinal Cord and Brain
Notochord stimulates neural tube formation which in turn stimulates development of the vertebral column. Notochord acts as an axis which will be formed around it the Vertebral column. It helps in vertebral column development

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

neural plate يتحفر الـ notochord على الـ ectoderm على أنها تتكثف وتكون لي شكل مسطح اللي هو neural plate بعد كذا هذا الـ neural plate يبدا يسوي لي شكل زيدية وهو نسميه neural groove نهاية هذا الـ neural groove فيه طبقات نسميها neural fold اللي راح يلتحم مع بعض ويتسكر علشان يسوي لي neural tube

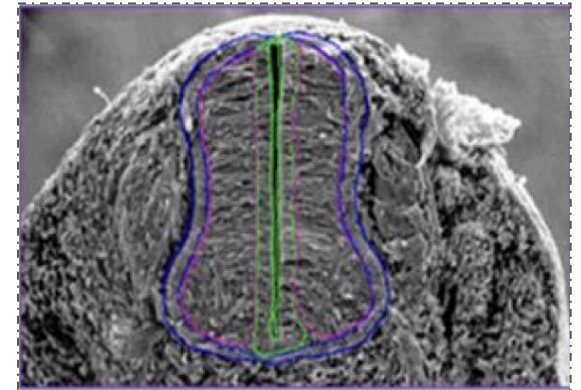
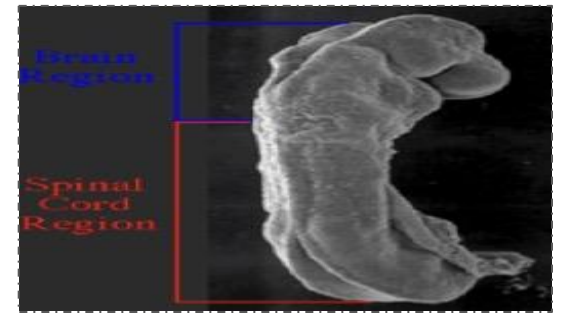


Development of the Spinal Cord: brain الثالث الأول يتكون منه الـ

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

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 grey matter)	nerve fibers or axons of neurons (future white matter)



هنا الـ neural tube مكون من ثلاث طبقات، أول طبقة (الداخلية) مكونة من خلايا غير معروفة. الطبقة الثانية (الوسطى) يتكون Grey matter مستقبلاً، والطبقة الأخيرة (الخارجية) يتكون White matter مستقبلاً

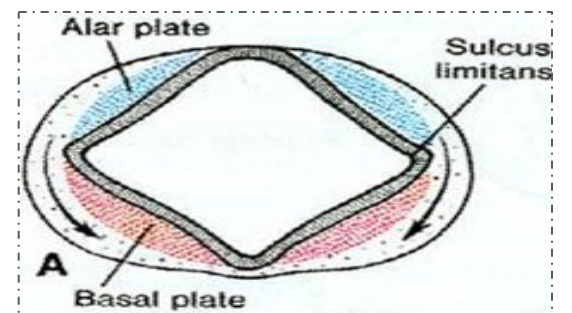
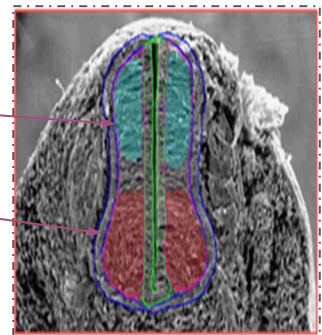
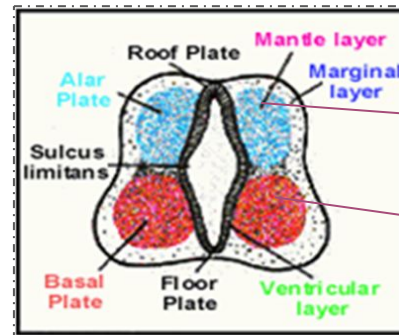
Mantle Layer of Spinal Cord:

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

Dorsal alar plate	Ventral basal plate
future dorsal horn	future ventral horn
containing sensory neurons	containing motor neurons

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

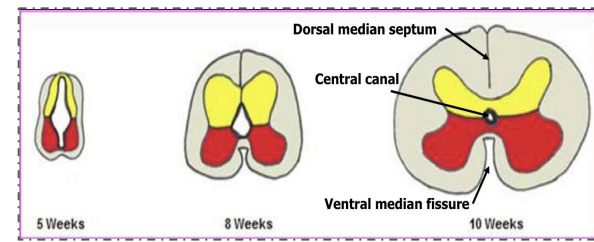
مثل ما قلنا الطبقة الوسطى راح تكون grey matter مستقبلاً، لذلك بتتقسم إلى قسمين:
 1- القسم الخلفي (Dorsal alar plate) اللي راح يكون Dorsal horn مستقبلاً
 2- القسم الأمامي (Ventral basal plate) اللي راح يكون Ventral horn مستقبلاً



تبدأ الخلايا الموجودة في Dorsal alar plate والـ Ventral basal plate تتكاثر وتتكثف إلى أن تقترب المنطقتين من بعض، هذا التقارب يبصير له نتائج

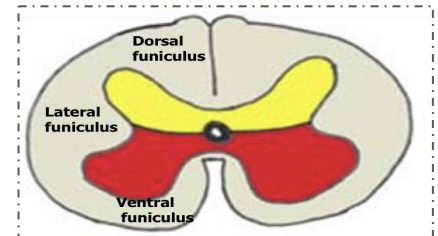
Proliferation and bulging of both **alar & basal** plates result in:

- 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 and it is divided into : **dorsal, lateral and ventral funiculi (white column)**



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

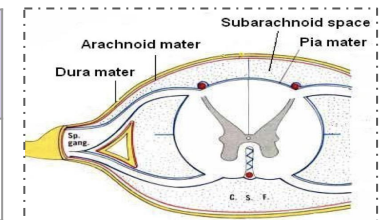
Motor fibers myelinate **before** sensory fibers. So, After a nerve injury, both motor and sensory axons have the ability to regenerate and, given a proper pathway.

Motor fibers myelination is faster than sensory fibers

Meninges:

These Are 3 Membranes covering the neural tube:

Outer thick dura mater	Middle arachnoid mater	Inner thin pia mater
MESODERMAL in origin	ECTODERMAL in origin	

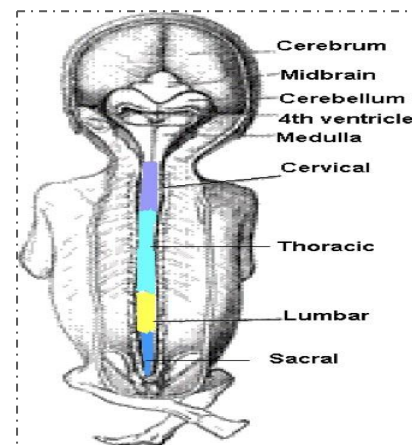
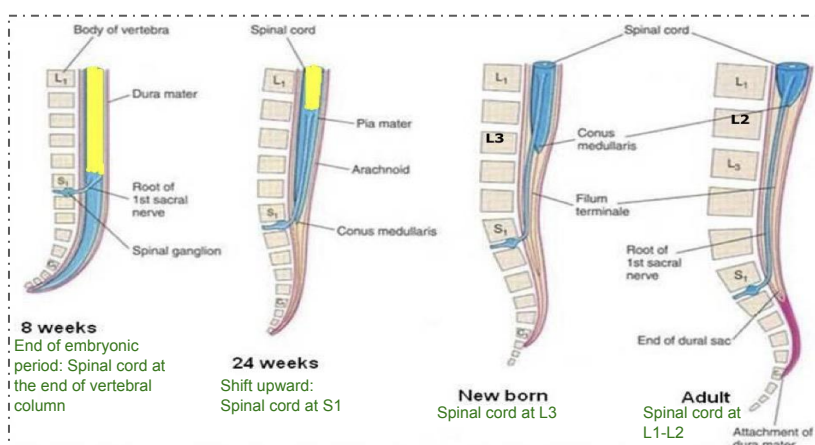


A cavity appears between the **arachnoid & the pia mater (subarachnoid space)** becomes filled with cerebrospinal fluid (CSF)

Positional Changes of Spinal Cord:

في البداية يكون طول الـ spinal cord مساوي لطول فقرات الظهر... لكن بعد ما تبدأ تنمو فقرات الظهر تصير أطول من الـ spinal cord

1. Initially, the spinal cord occupies the **whole length of the vertebral canal**.
2. As a result a **faster growth of vertebral column**, the caudal end of spinal cord (**conus medullaris**) shifts gradually to a higher level



Prenatal periods is consistent of two periods:
 1- embryonic period: since fertilization to the end of 8th week
 2- fetal period: beginning of 9th week to birth

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:

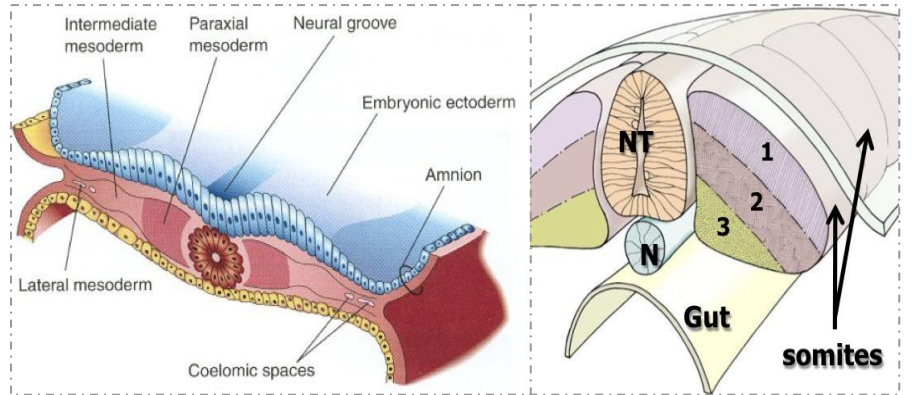
1. Paraxial mesoderm
2. Intermediate mesoderm
3. Lateral mesoderm

Paraxial mesoderm divides into segments called '**somites**'.

Each somite divides into 3 parts:

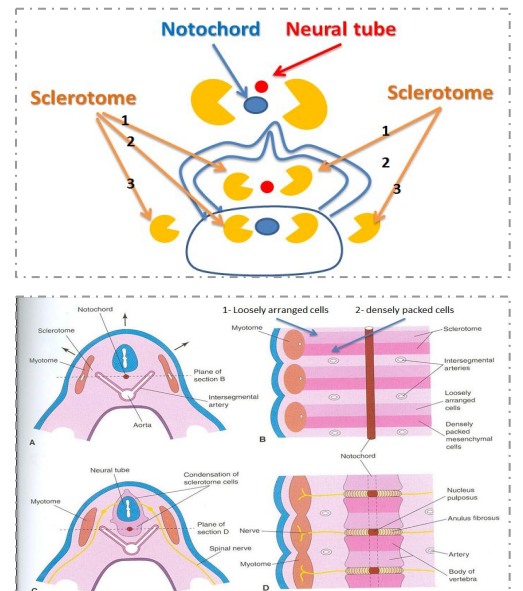
1. **Dermatome** Future skin
2. **Myotome** Future muscles
3. **Sclerotome** Future bones

طبقة الـ mesoderm تقسم إلى ثلاث أقسام من اليمين واليسار ويفصل بين اليمين واليسار الـ notochord. أول قسم هو الـ para-axial mesoderm وهذا القسم يقسم إلى ثلاث أجزاء: Sclerotome, Dermatome, Myotome. من الـ Sclerotome يتكون لنا عظام فقرات الظهر.



DEVELOPMENT OF VERTEBRA:

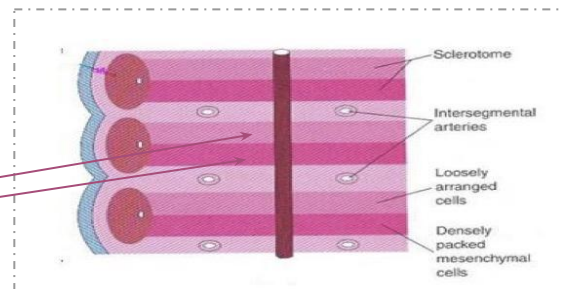
1. Sclerotome around neural tube: forms vertebral (neural) arch.
2. Sclerotome around notochord: forms body of vertebra.
3. Sclerotome in body wall near to neural tube and notochord: forms costal process (gives ribs in thoracic region only).



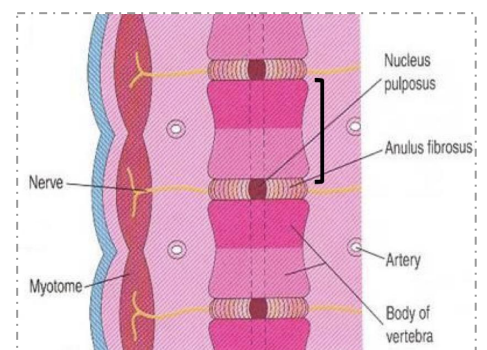
Formation of Body of Vertebra:

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

- an 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 sclerotomes.



Fate of Notochord:

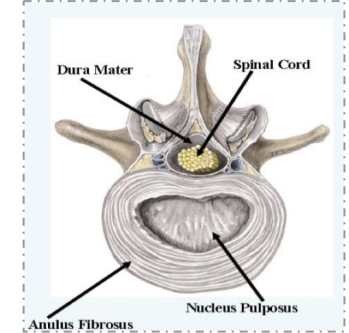
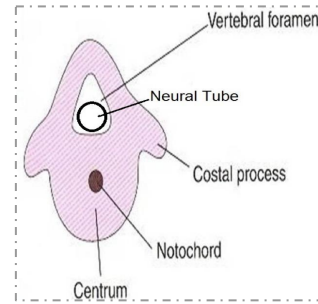
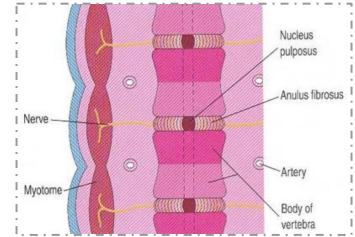
In the region of the bodies of vertebrae: It degenerates

Between bodies of vertebrae: It forms the central part, 'nucleus pulposus' of the intervertebral discs.

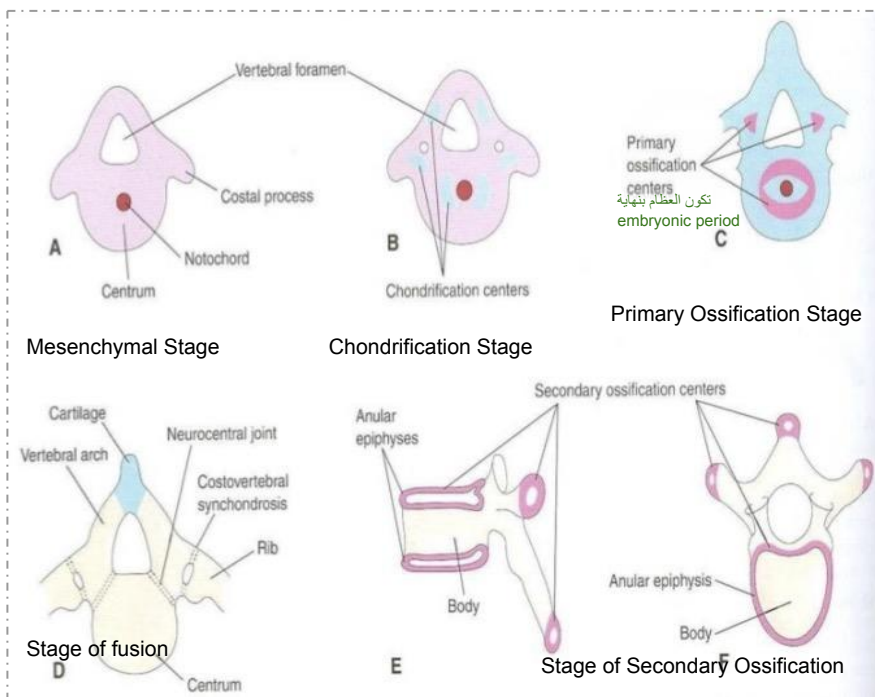
Annulus fibrosus part of the intervertebral discs is formed by the mesoderm surrounding the notochord.

- 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.

Nucleus pulposus developed from the remnants of notochord
Annulus fibrosus developed from mesoderm surrounding the notochord



Vertebral Development:



This picture represents the changes that occurs into 2 stages : **chondrification** stage and **ossification** stage.

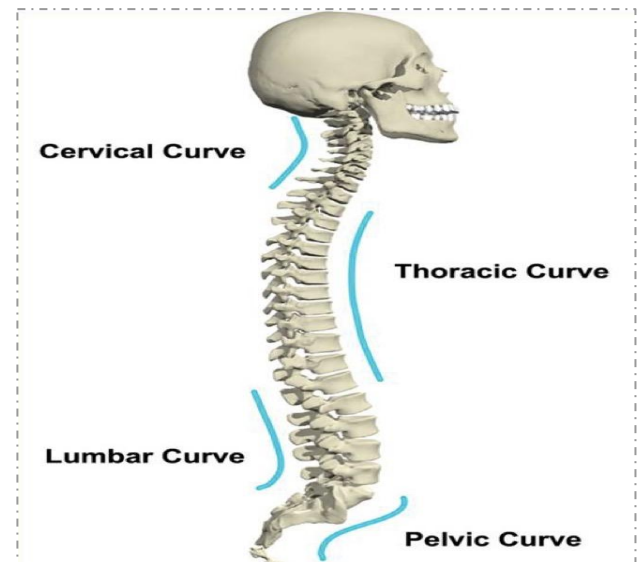
- The **chondrification centers** appears at **6th week (cartilage)**: (Pic.B)
- And by the **(at the end of 8th week) the 3 primary ossification centers appears (bone)**: (Pic.c)
- And The **5 secondary ossification centers appear at puberty.**

Fusion of bony halves of vertebral arch occurs at 3-5 years (pic.D). and **Fusion of centrum with vertebral arch occurs at 4-6 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.

Dr.sanaa Notes (435 team)

Curvatures of Vertebral Column:

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



Vertebral column is concave anterior during the prenatal period
The it convex in 2 areas
Cervical - as results when baby is lifting his head
Thoracic - as result when the baby walks

Spina Bifida

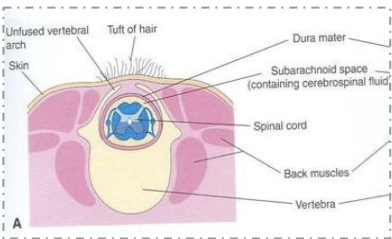

Cause: Failure of fusion of the halves of vertebral arches

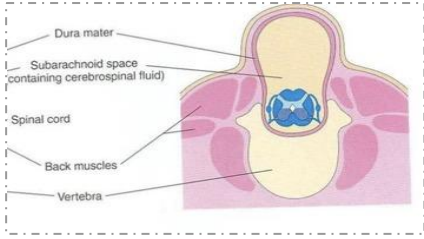
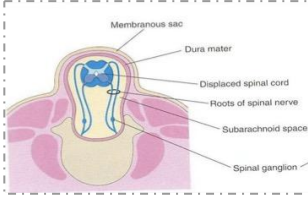

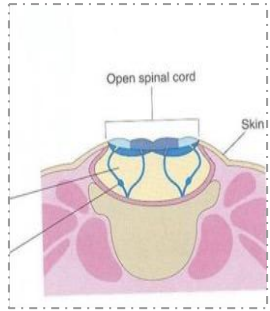

Incidence: 0.04-0.15%

Sex: more frequent in females

Types:

Meningo = meninges
myelo = spinal cord
ocoele = sac contains fluid or cysts
schisis = opening

1.Spina bifida occulta (20%) Better prognosis	2.Spina bifida cystica (80%)
<ul style="list-style-type: none"> The closed type Only one vertebra is affected No clinical symptoms Skin overlying it is intact. Sometimes covered by a tuft of hair. Usually Doesn't Involve underlying neural tissue.   <p>هنا فقط الفقرة هي اللي تأثرت وما في أي شيء طالع من السباينل كورد</p>	<ul style="list-style-type: none"> The open type Cystica is the most severe and complex form of spina bifida. It usually involves serious or fatal neurological problems. A portion of the nerves and the spinal cord are exposed outside the body Neurological symptoms are present Subdivided into: <ol style="list-style-type: none"> Spina bifida with meningocele Spina bifida with meningocele Spina bifida with myeloschisis

1.Spina bifida with meningocele	2.Spina bifida with meningocele	3.Spina bifida with myeloschisis
<p>protrusion of sac containing meninges and cerebrospinal fluid.</p> 	<p>protrusion of sac containing meninges with spinal cord and/or nerve roots.</p>  	<p>spinal cord is open due to failure of fusion of neural folds.</p> <p>Failure in development of neural tube and neural fold</p>  
<p>هنا الفقرة تأثرت وطالع زي الكيس داخله Meninges and CSF</p>	<p>هنا الفقرة تأثرت وطالع زي الكيس داخله Meninges and spinal cord</p>	<p>هنا الفقرة تأثرت والسباينل كورد طالع وما في أي شيء يغطيه</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.
Somaitis	Para-axial mesoderm.
nucleus pulposus	Notochord between the bodies of vertebrae.
Annulus fibrosus	Mesoderm

Time	Changes
3rd week (early)	Three germ cell layers
4th week	Each sclerotome becomes subdivided into cranial and caudal part.
6th week	Chondrification centers appear.
End of 8th week	3 primary ossification centers appear.
4th month	Starting of myelination of nerve fibers.
During 1st 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.
25 years	All centers unite.

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

Questions

1. spina bifida with Is a protrusion of sac containing meninges with spinal cord:		2. Mantle zone is a future and marginal is zone is a future						
A.	Spina Bifida Occulta	A.	Grey Matter-white matter					
B.	Spina bifida with meningocele	B.	Central canal - grey matter					
C.	Spina bifida with meningocele	C.	White matter - grey matter					
D.	Spina bifida with myeloschisis	D.	White Matter-central canal					
3. 16-Which one of the following regions of spinal cord contains cell bodies of sensory neurons?		4. As a result of fast growth of vertebral column, which part of spinal cord shifts gradually up?						
A.	Alar plate	A.	Cauda Equina					
B.	Ventricular zone	B.	Conus Medullaris					
C.	Basal plate	C.	Clarke's column					
D.	Dorsal funiculus	D.	Central canal					
5. The dorsal alar plate and ventral basal plate are separated by:		6. which one of the following periods of life fusion between vertebral arch & body of vertebra occurs?						
A.	Marginal layer	A.	8th week					
B.	Ventricular layer	B.	Puberty					
C.	Sulcus limitans	C.	4-6 years					
D.	Ventral Media Fissure	D.	Around 25 Years					
7. 14-Regarding spina bifida which one of the following statements is correct?		8. Myelination of nerve fibers continues after birth during:						
A.	The Closed Type Is More Frequent Than The Open type	A.	First 2 Months					
B.	The closed type presents with clinical symptoms.	B.	First 4 Months					
C.	Spina bifida is due to failure of fusion between the halves of vertebral arch.	C.	First 8 Months					
D.	In cases of spina bifida with meningocele, the spinal cord is open.	D.	First 12 Months					
Q	1	2	3	4	5	6	7	8
Answers	B	A	A	B	C	C	C	D

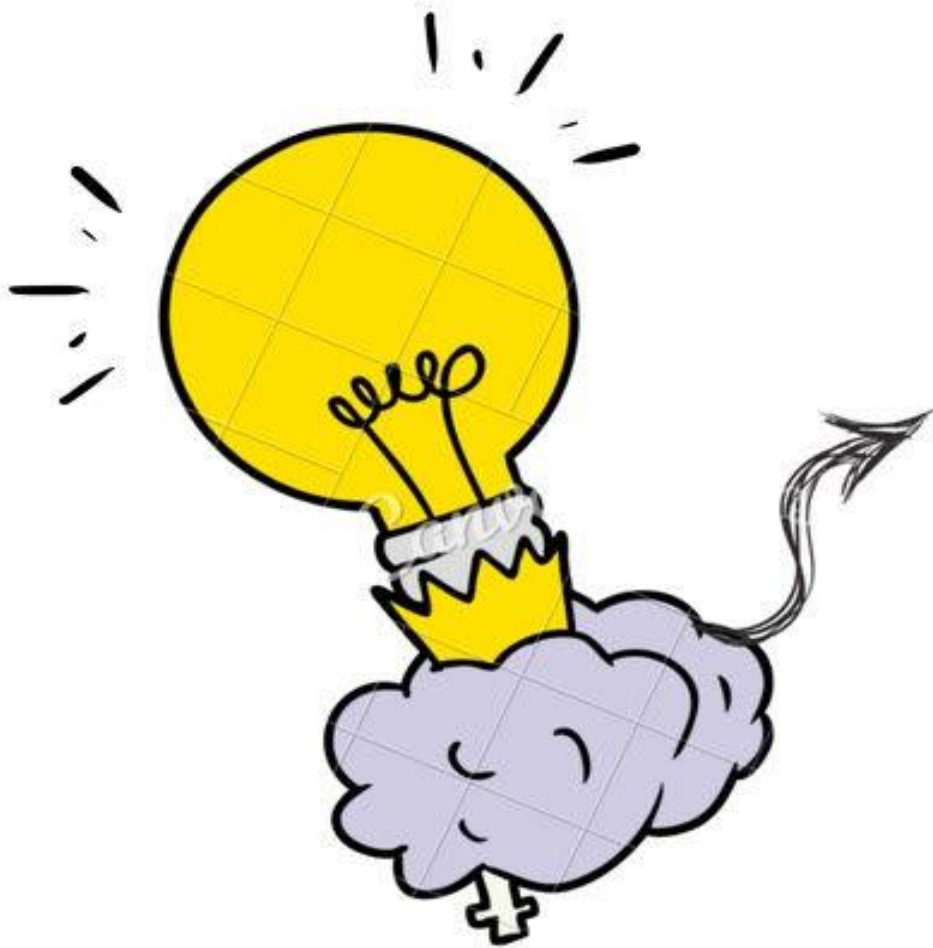
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Team leaders

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