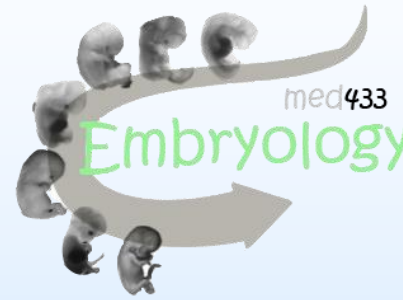


EMBRYOLOGY

DEVELOPMENT OF SPINAL CORD & VERTEBRAL COLUMN



Lecture Objectives :

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

It develops from the ventromedial parts (sclerotomes) of the somites and the somites develop from the para-axial mesoderm. Then each somite divides into: **1-Dermatome 2-Myotome 3-Sclerotome**; and at 4th week, each sclerotome subdivides into cranial and caudal parts. Then 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**. **All centers unite around 25 years.**

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

Primary curvatures: develop **prenatally**

1-Thoracic 2-Pelvic or Sacral

Secondary curvatures: develop **postnatally**

1-Cervical: as a result of lifting the head

2-Lumbar: as a result of walking

Development of Vertebral Column
Curvatures of Vertebral Column
Positional Changes of Spinal Cord
Meninges

MIND MAP-Development of Spinal Cord & Vertebral Column

3 membranes covering the neural tube:
Outer thick dura mater: MESODERMAL in origin, Middle arachnoid mater & Inner thin pia mater are ECTODERMAL in origin and a cavity appears between the arachnoid & the pia mater (subarachnoid space) & becomes **filled with cerebrospinal fluid (CSF)**.

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

Ectodermal cells dorsal to notochord thicken to form the **neural plate**. Then a **neural groove** develops longitudinally in the plate. After that the margins of the neural plate (neural folds) approach to each other and **fuse to form the neural tube**. Finally the spinal cord will develop from the caudal 2/3 of the neural tube.

The cells of the neural tube are in 3 layers:

1-An inner ventricular → undifferentiated cells

2-A middle mantle → cell bodies of neurons (future grey matter)

3-An outer marginal → nerve fibers or axons of neurons (future white matter)

Neurons are differentiated into

Please start here

- 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**).

Both alar and basal plates proliferate and bulge to form : **Dorsal median septum & ventral median fissure**

And narrowing of the lumen of the neural tube to form a **small central canal**

Increase in size due to addition of ascending, descending & intersegmental nerve fibers & is divided into: **dorsal, lateral and ventral funiculi**

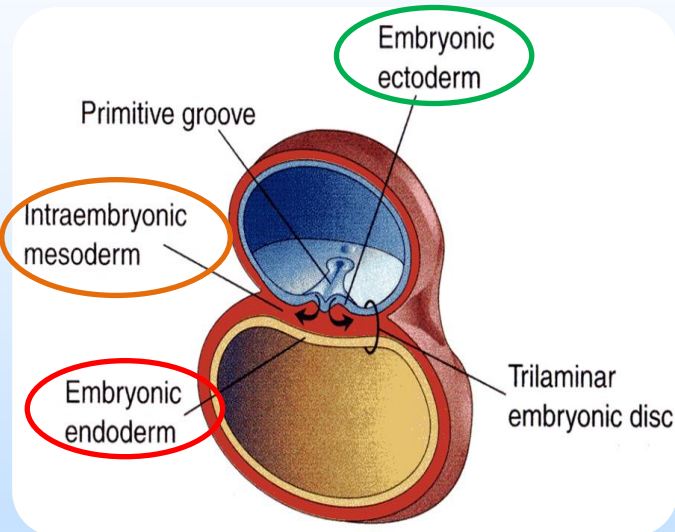
*Myelination of nerve fibers **starts at 4th month & continues during the 1st postnatal year**. Motor fibers myelinate before sensory fibers.*

First of all you should remember the 3 germ layers we studied last year :

1. Ectoderm

2. Mesoderm

3. Endoderm

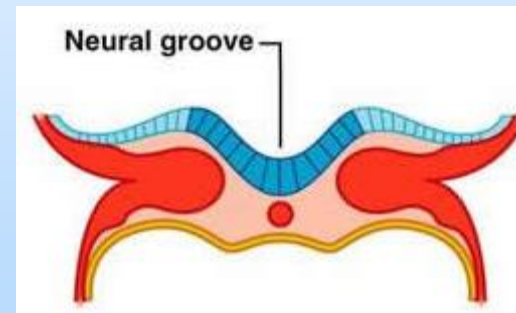
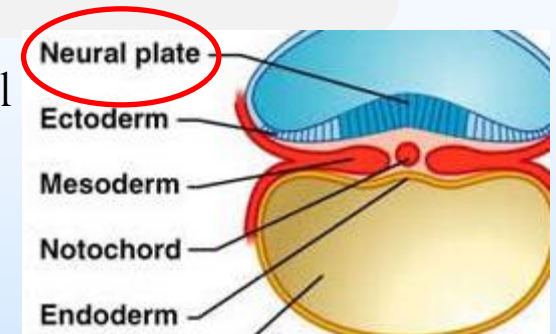


#The Neural Tube is a derivative of the ectoderm.

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

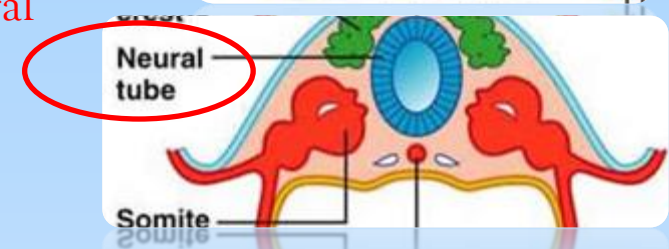
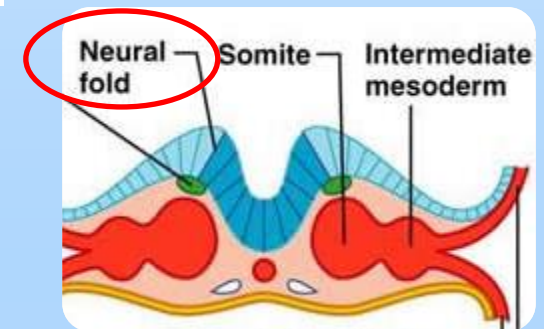
#DEVELOPMENT OF NEURAL TUBE :

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**.



#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:

1

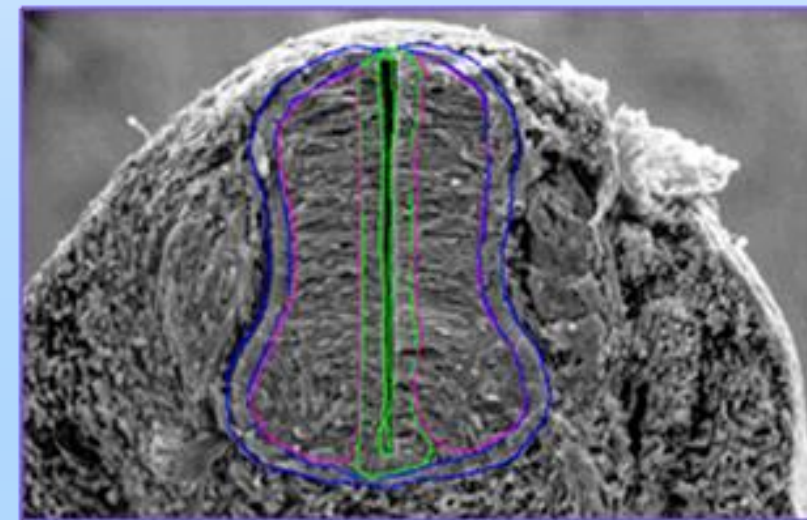
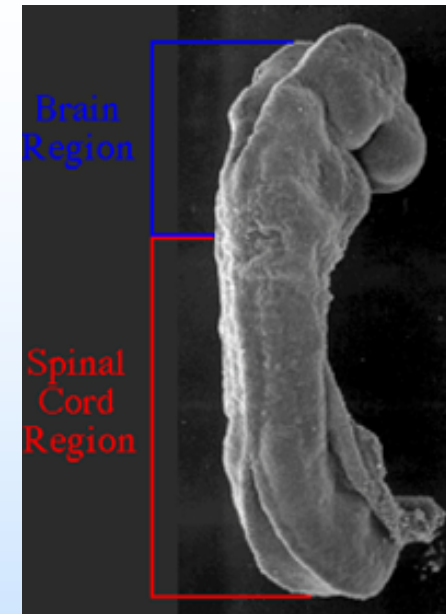
An inner **ventricular zone** of undifferentiated cells

2

A **middle mantle zone** of cell bodies of neurons (**future grey matter**)

3

An outer **marginal zone** of nerve fibers or axons of neurons (**future white matter**)



MANTLE LAYER OF SPINAL CORD

A dorsal **alar plate** (future dorsal horn)

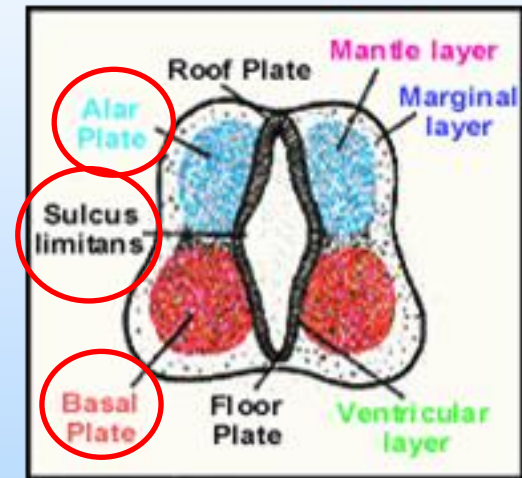
containing sensory neurons

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

A ventral **basal plate** (future ventral horn)

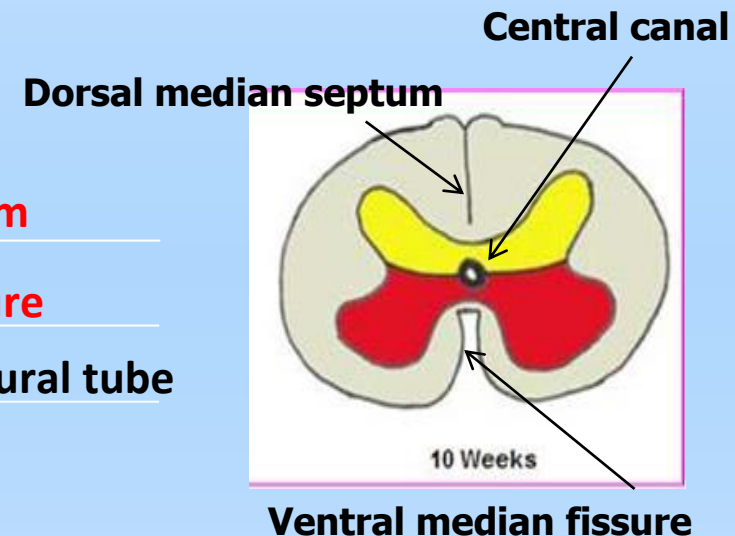
containing motor neurons

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



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

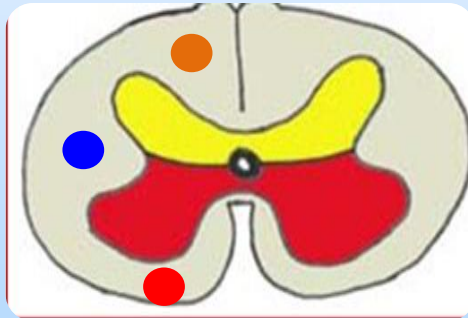
1. Formation of **dorsal median septum**
2. Formation of **ventral median fissure**
3. Narrowing of the lumen of the neural tube to form a small **central canal**



MARGINAL LAYER OF SPINAL CORD

The marginal layer (future white matter) increases in **size**. **WHY?** due to **addition of ascending, descending & intersegmental nerve fibers**.

It is divided into: **dorsal**, **lateral** and **ventral** funiculi.



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

Note : **Motor** fibers myelinate before **sensory** fibers.

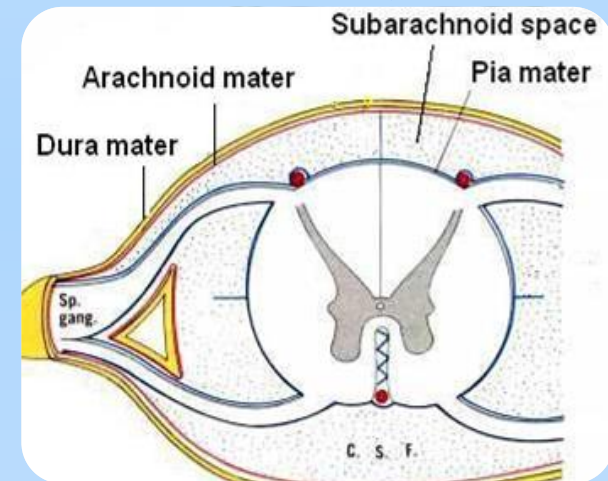
MENINGES

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

#Outer thick **dura mater: MESODERMAL** in origin.

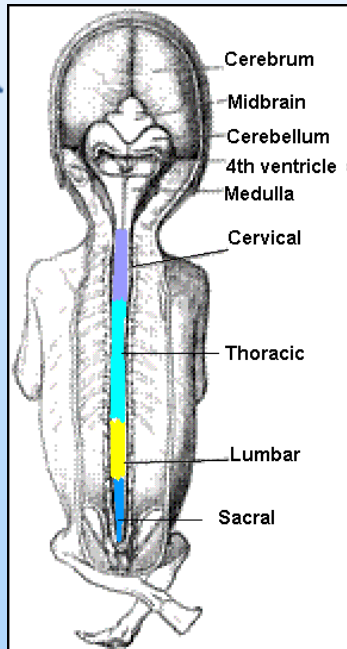
#Middle **arachnoid mater** & Inner thin **pia mater** are **ECTODERMAL** in origin.

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

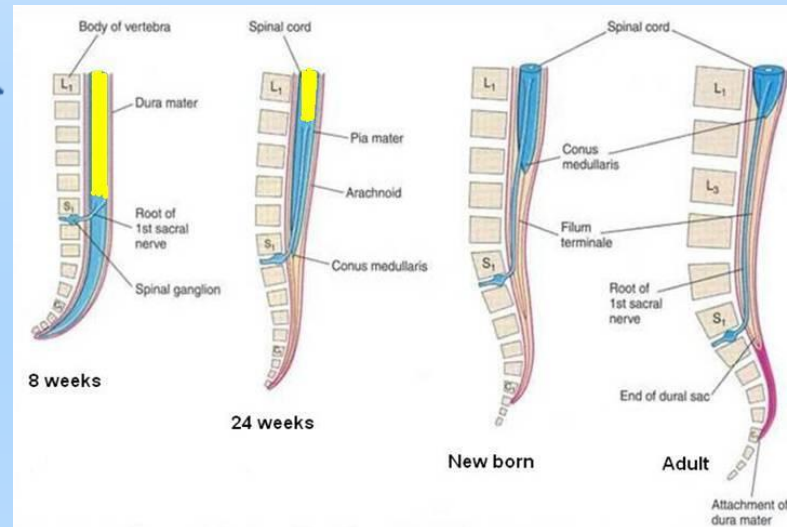


POSITIONAL CHANGES OF SPINAL CORD

At the beginning, 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. (يبدأ بالارتفاع بشكل متدرج)

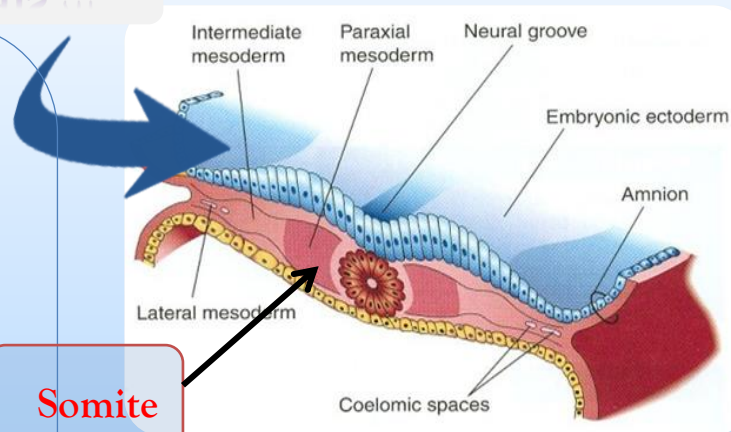


DEVELOPMENT OF THE VERTEBRAL COLUMN

The vertebral column develops from the **ventromedial parts (sclerotomes)** of the **somites**. (so, what is the somites and where does it come from ?)

DO YOU REMEMBER THIS !!!

in the last year we studied the 3 germ layers (ectoderm, endoderm and mesoderm) the mesoderm differentiates into three parts paraxial, Intermediate and lateral. The paraxial part divides into many segments called **somites**.



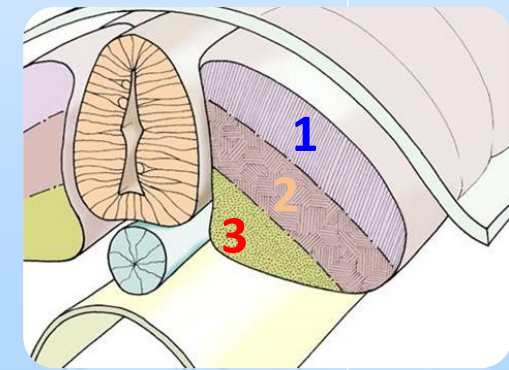
Somite

Notice that the **Intraembryonic Mesoderm** Located between **Ectoderm & Endoderm EXCEPT** in the central axis of embryo where **NOTOCHORD** is found.

SO, WHAT IS THE STRUCTURE OF SOMITE ?

each somite is divided into 3 parts :

- Dermatome
- Myotome
- Sclerotome (ventromedial)



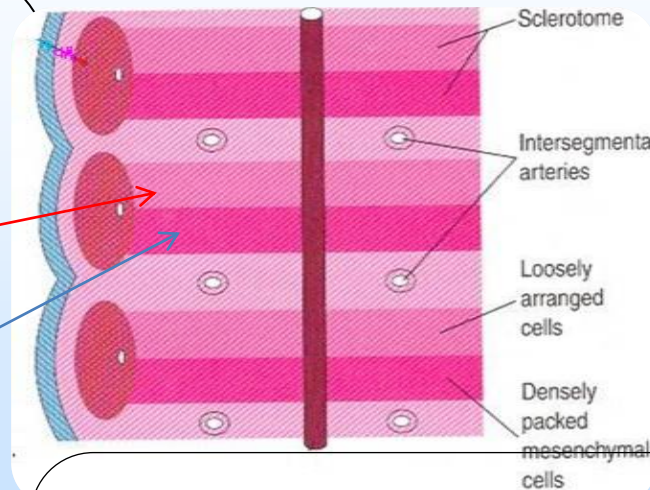
AS A RESULT, THE SOMITES DEVELOP FROM PARA-AXIAL MESODERM.

FORMATION OF BODY OF VERTEBRA

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

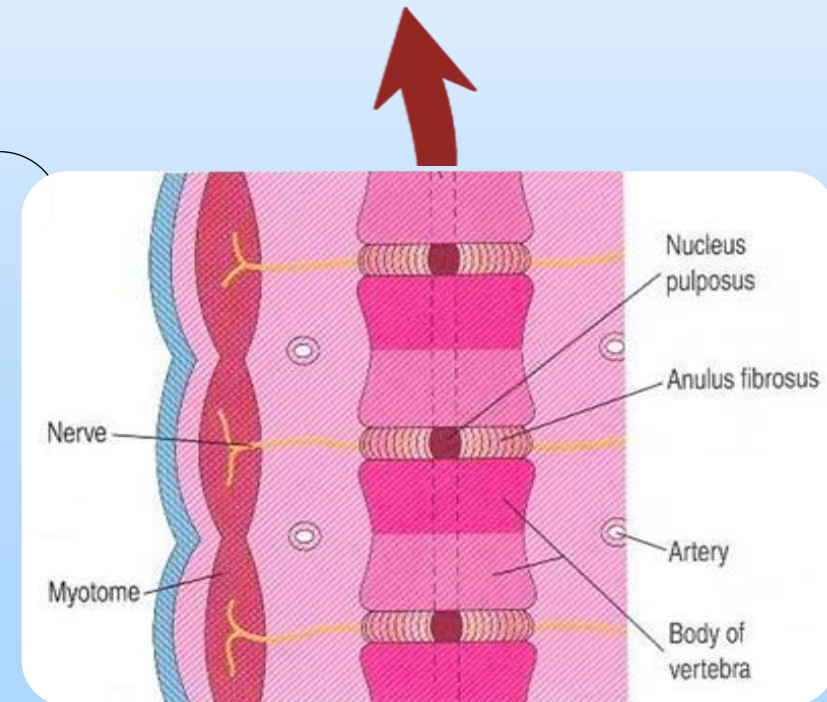
-**cranial part**, consisting of loosely arranged cells (less condensed)

-**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**.

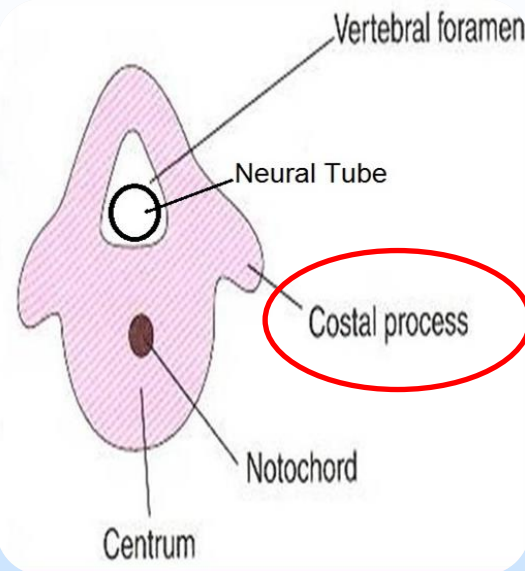
Thus each centrum develops from 2 adjacent sclerotomes



CON...

#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**



#Fusion of bony halves of vertebral arch occurs at 3-5 years (D).

and Fusion of centrum with vertebral arches occurs at 3-6 years (D).

#The secondary ossification centers appear at puberty.

#All THE CENTERS UNITE AT 25 years

SO, Ossification starts at the end of embryonic period (end of 8th week)

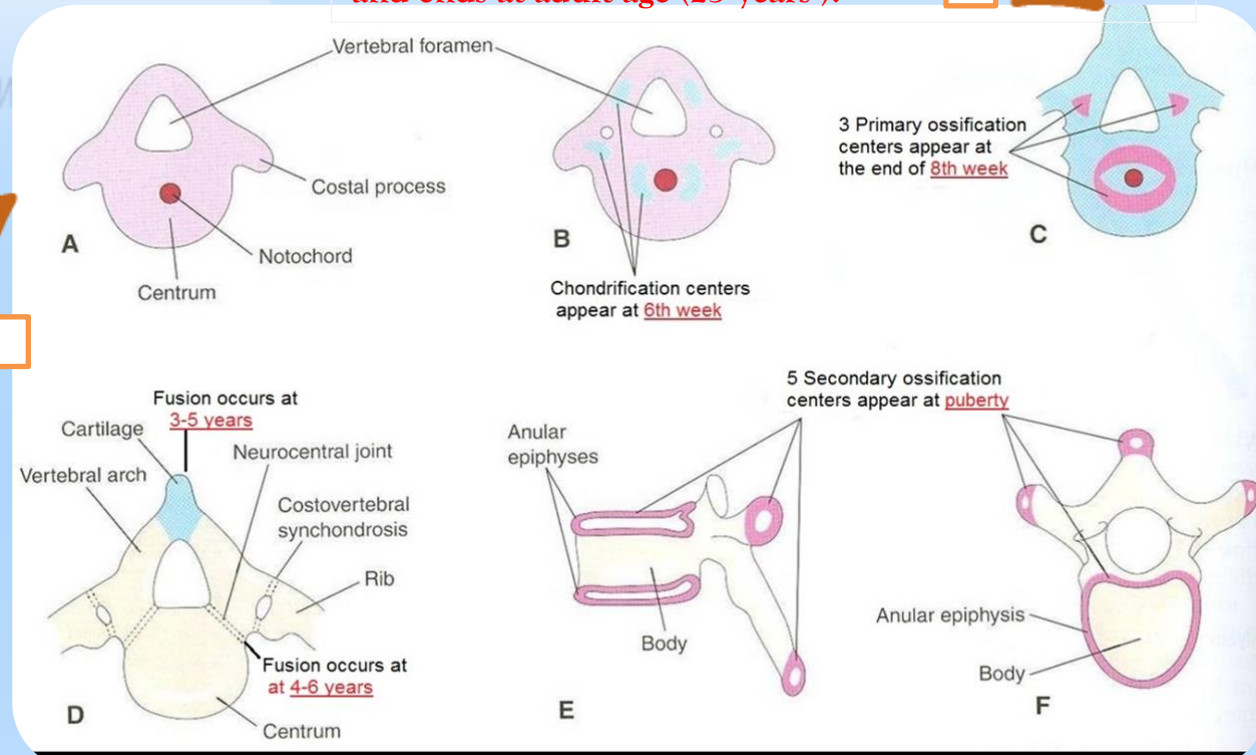
and ends at adult age (25 years).



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

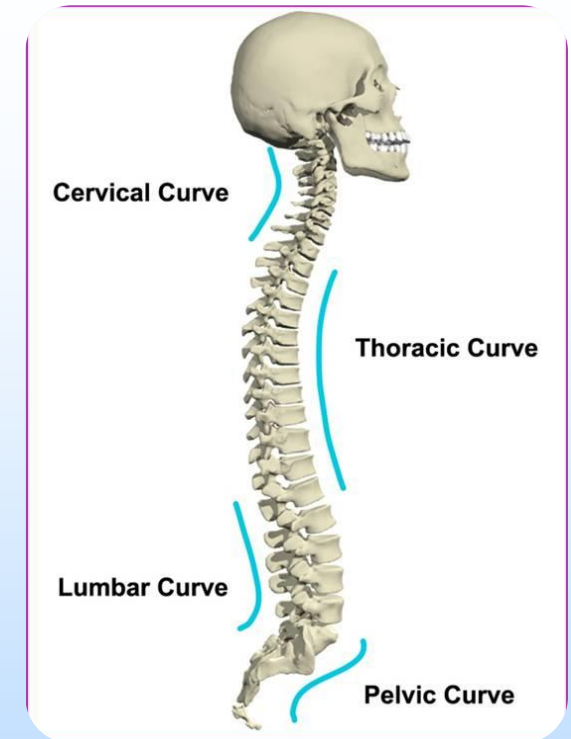
#The chondrotification centers appear at 6th week. (B)

#And by the end of embryonic period (at the end of 8th week) the primary ossification centers appears .(c)



CURVATURES OF VERTEBRAL COLUMN

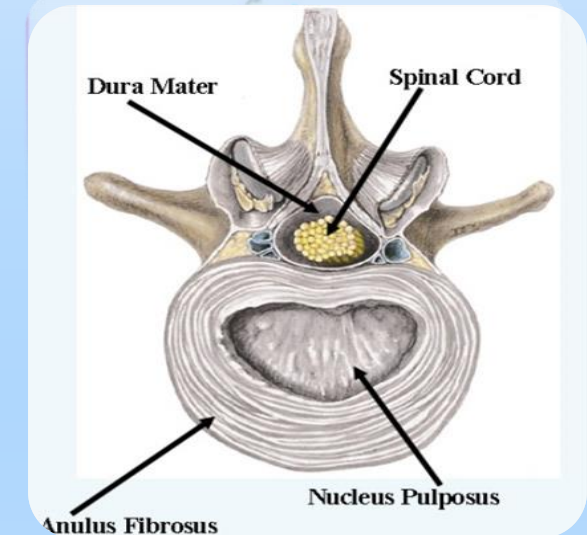
TYPE OF CURVATURE	TIME	REGIONS
Primary curvatures	prenatally	1.Thoracic 2.Pelvic or Sacral
Secondary curvatures	postnatally	1.Cervical: as a result of lifting the head. 2.Lumbar: as a result of walking.



FATE OF NOTOCHORD

#We can talk about the fate of notochord into 2 parts : the first part In the region of the bodies of vertebrae: It degenerates. but the second part 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.



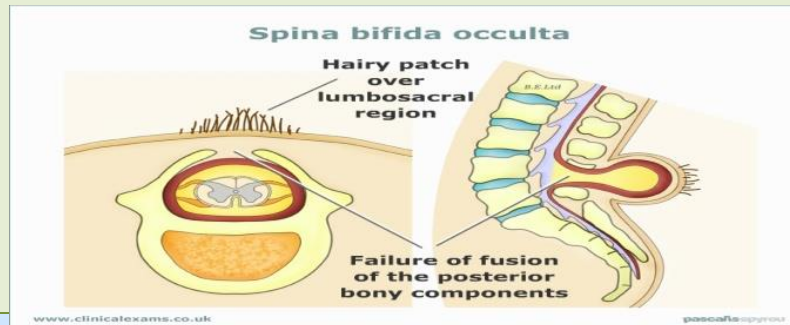
Spina Bifida

Definition: Failure of fusion of the halves of vertebral arches. It is more frequent in **females**.

Types:

1) 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



2) Spina Bifida Cystica (80%) (the opened type)

(Neurological symptoms are present)

a) Spina Bifida with Meningomyelocele
Protrusion of sac containing meninges with spinal cord and/or nerve roots.

b) Spina Bifida with Meningocele
Protrusion of sac containing meninges & cerebrospinal fluid

c) Spina Bifida with Myeloschisis

Spinal cord is open due to failure of neural folds to develop.



SUMMARY

- 1- The neural tube is derived from **ectoderm**. Which will develop to the brain and spinal cord.
- 2- It will start with **neural plate** -> **neural groove** -> **neural tube**
- 3- (**Ventricular zone** - **mental zone** - **marginal zone**) are 3 layers of cells of neural tube.
- 4- **Mental layer** -> is the future **grey matter** while **marginal zone** -> is the future **white matter**.
- 5- There are **3 membranes covering the neural tube**: (**Dura** - **archinoid** and **pia**) matter which form meninges.
- 6- The position of spinal cord gets change due to **faster growth** of vertebral column also the curvature.
- 7- The vertebral column develops from the **ventromedial parts (sclerotomes) of the somites**.
- 8- Spina Bifida is congenital anomalies affect **female** more. lead to failure fusion of halves vertebral arches and have different types.



HELPFUL YOUTUBE VIDEOS :

<http://www.youtube.com/watch?v=Cu4lQYbOzzY>

<http://www.youtube.com/watch?v=xgwfr1h7kQU>

TIMELINE FOR THE DEVELOPMENT CHANGES

TIME	CHANGES
4 th week	Each sclerotome becomes subdivided into cranial and caudal part.
6 th week	Chondrification centers appear.
End of 8 th week	<u>3 primary</u> ossification centers appear.
4 th month	Starting of myelination of nerve fibers.
During 1 st postnatal year	Continuation of the myelination of nerve fibers.
3-5 years	Fusion occurs.
At puberty	<u>5 secondary</u> ossification centers appear.
25 years	All centers unite.

QUIZ YOURSELF

<p>Q1- is a derivative of the ectoderm</p> <p>A.The Neural Tube B.Gut C.Endocrain D.Not above</p>	<p>Q4- A dorsal <u>alar plate</u> (future dorsal horn):</p> <p>A.containing motor neurons B.containing sensory neurons C.both D.not above</p>	<p>Q7 - The vertebral column develops from the</p> <p>A.ventromedial parts (sclerotomes) of the somites B.para-axial mesoderm. C.Dermatome D.Myotome</p>	<p>Q 10 - Spina bifida with meningocele : protrusion of sac containing</p> <p>A.meninges & cerebrospinal fluid B.meninges with spinal cord and/or nerve roots C.Meninges D.All</p>
<p>Q2- The spinal cord develops from the 2/3 of the neural tube</p> <p>A- cranial B- not above C- caudal</p>	<p>Q5- Proliferation and bulging of both alar & basal plates <u>result in:</u></p> <p>A.Formation of <u>dorsal median septum</u> B.Formation of <u>ventral median fissure</u> C.Narrowing of the lumen of the neural tube to form a small <u>central canal</u> D.All</p>	<p>Q8- A ventral <u>basal plate</u> (future ventral horn):</p> <p>A.containing sensory neurons B.containing motor neurons C.both D.not above</p>	<p>Q 11 - Spina bifida with meningocele: protrusion of sac containing</p> <p>A.meninges & cerebrospinal fluid B.meninges with spinal cord and/or nerve roots C.Meninges D.All</p>
<p>Q3- marginal zone of nerve fibers or axons of neurons</p> <p>A.(future white matter) B.(future grey matter) C.Both D.Not above</p>	<p>Q6- which one of These is a membrane covering the neural tube:</p> <p>A.DURA MATTER B.Middle ventral mater C.Inner thin dorsal mater D.ALL ABOVE</p>	<p>Q9- The somites develop from the</p> <p>A.ventromedial parts (sclerotomes) of the somites B.para-axial mesoderm. C.Dermatome D.Myotome</p>	<p>Ans. 1.A 2.C 3.A 4.B 5.D 6.A 7.A 8.B 9.B 10.A 11.B</p>

BEST WISHES

DONE BY :

RAWAN ALOTAIBI

SARA ALSENEIDI

AMANI ALOTAIBI

AWATIF ALANEZI

BARAAH ALQARNI

NOURA ALNAJASHI