



**Anatomy Team**  
**MED 439**

Revised & Approved



**MED439**  
KING SAUD UNIVERSITY

# Development of the Spinal Cord & Vertebral Column

CNS Block

Contact us:  
[Anatomy439@gmail.com](mailto:Anatomy439@gmail.com)

Don't forget to check the [Editing File](#)

Color index:

Content  
Male slides  
Female slides  
Important  
Doctors notes

Extra information, explanation

# Objectives

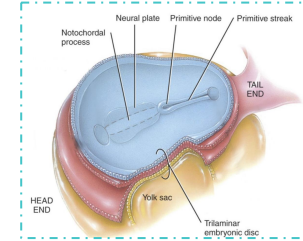
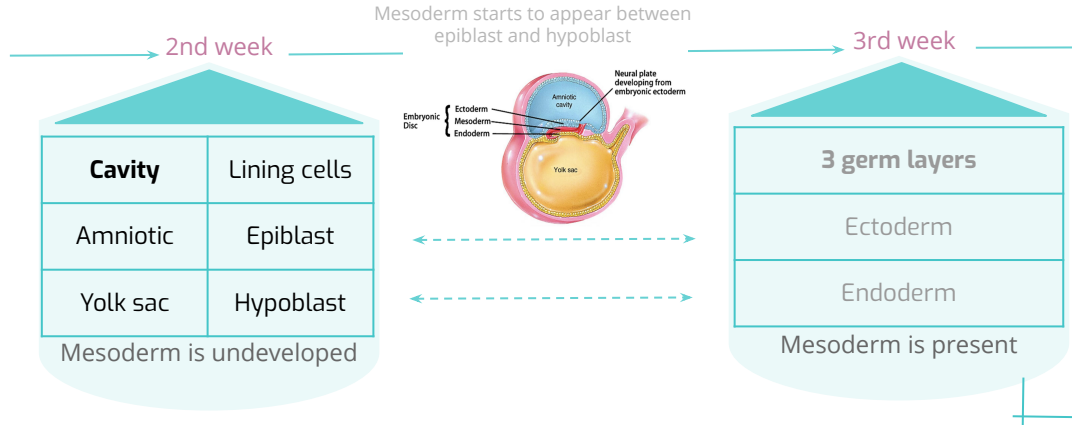
At the end of the lecture, students should be able to:

- 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

# Introduction



## Embryo

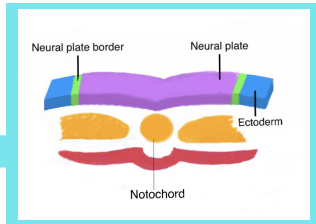


Also these structure will present in the Amniotic surface:

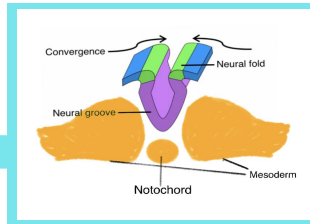
- Primitive node
- Primitive streak
- Notochord
- Intra embryonic mesoderm

# Development of neural tube

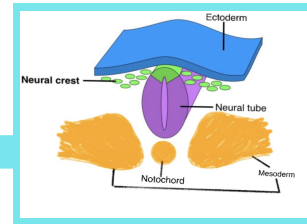
It is a derivative of the ectoderm  
Gives rise to the brain and the spinal cord



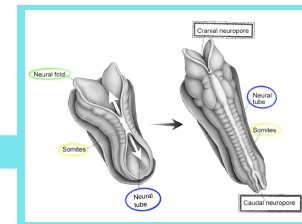
Ectodermal cells **above** "dorsal" to \*notochord thickens to form "**neural plate**".



A longitudinal groove develops in the neural plate "**neural groove**"  
Neural plate folds to form "**neural groove**".



The margins of the neural plate (neural folds) approach to each other and fuse to form the **neural tube**. Then Neural tube separates from the overlying ectoderm.

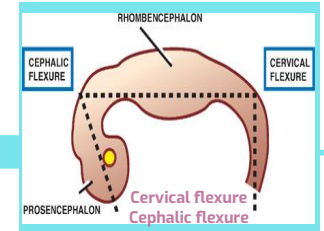


Closer of the neural tube begins in the future neck region (**4th somite**), then proceeds **cranially and caudally**.  
The most cranial and caudal ends of the tubes still open as

- Anterior neuropores
- Posterior neuropores
- Anterior (cranial) neuropores → will close at day 25 → lamina terminalis
- Posterior (caudal) neuropores → will close at day 27

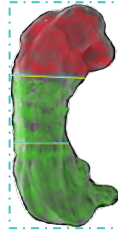
The lumen of the tube will give:

- 1- ventricles of the brain
- 2- central canal of spinal cord.



Notochord stimulates the formation of:  
Neural tube & vertebral column.

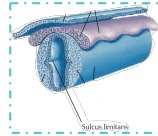
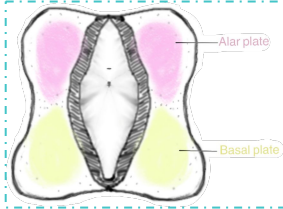
# Development of spinal cord



01

Neural tube cells "neuroepithelial" arranged in 3 layers:

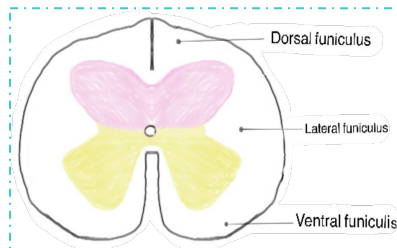
- 1- **Inner ventricular zone** of undifferentiated cells
- 2- **Middle mantle zone** of cell bodies of neurons (further grey matter)
- 3- **Outer marginal zone** of nerve fibers or axons of neurons (further white matter)



03

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

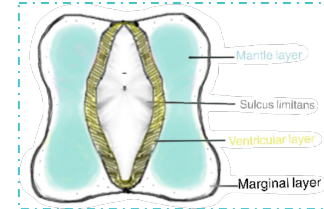
- 1- **Dorsal median septum**
- 2- **Ventral median fissure**
- 3- Narrowing of the lumen of the neural tube to form small central canal.



05

Neural tube differentiates into 2 regions:  
Upper  $\frac{1}{3}$  → **brain** region.  
Lower  $\frac{2}{3}$  → **spinal cord** region.

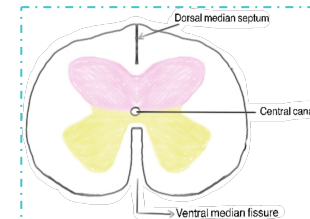
02



Neurons of mantle layer (future grey matter) differentiate into 2 areas separated by **sulcus limitans** (a **longitudinal groove**) into :

- 1- **Dorsal alar plate** (future dorsal horn): containing sensory neurons.
- 2- **Ventral basal plate** (future ventral horn): containing motor neurons

04



Marginal layer (future white matter) increases in size due to addition of ascending, descending, intersegmental nerve fibers. It divides into: **dorsal, ventral, lateral funiculi**. (**White column**)  
**Myelination** of nerve fibers starts at **4th month** and continues during **1st postnatal period**.

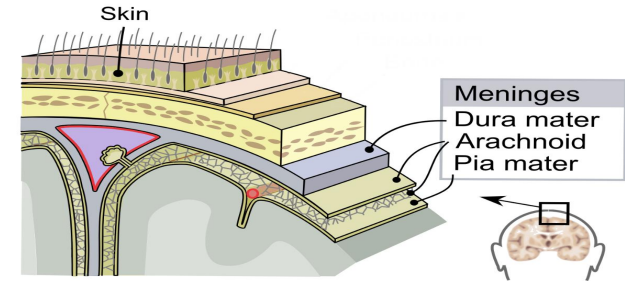
Motor fibers myelinated before sensory fibers.

So after nerve injury, both motor and sensory axons have the ability to regenerate and are given a proper pathway.

# Meninges

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

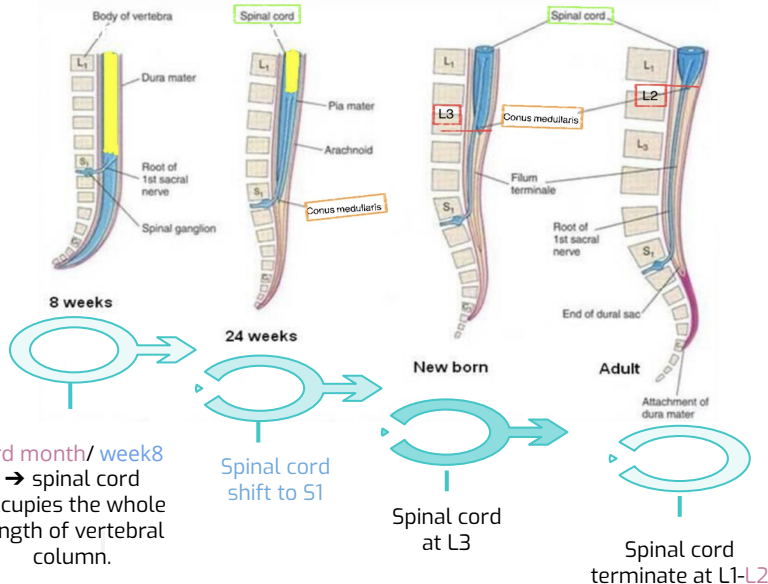
- Outer thick **dura mater**: MESODERMAL in origin
- Middle **arachnoid mater**: Ectodermal in origin
- Inner thin **pia mater**: ECTODERMAL in origin.
- **Subarachnoid cavity** appears between arachnoid & pia matters, filled with CSF.



# Positional changes of spinal cord

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

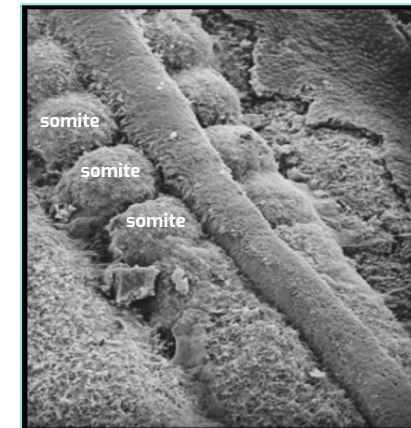
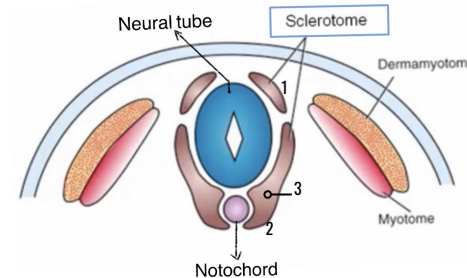
As a result of the faster growth of vertebral column, the caudal end of the spinal cord (conus medullaris) shift gradually to a higher level (spinal cord become shorter than vertebral column).



# Vertebral development Males slides

Paraxial mesoderm → somite → **sclerotome**  
(part that gives vertebrae and ribs)

- 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)



# Intraembryonic mesoderm

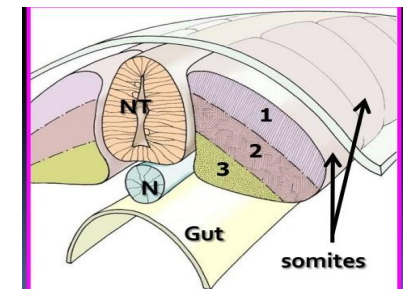
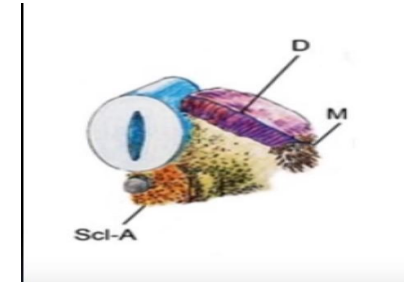
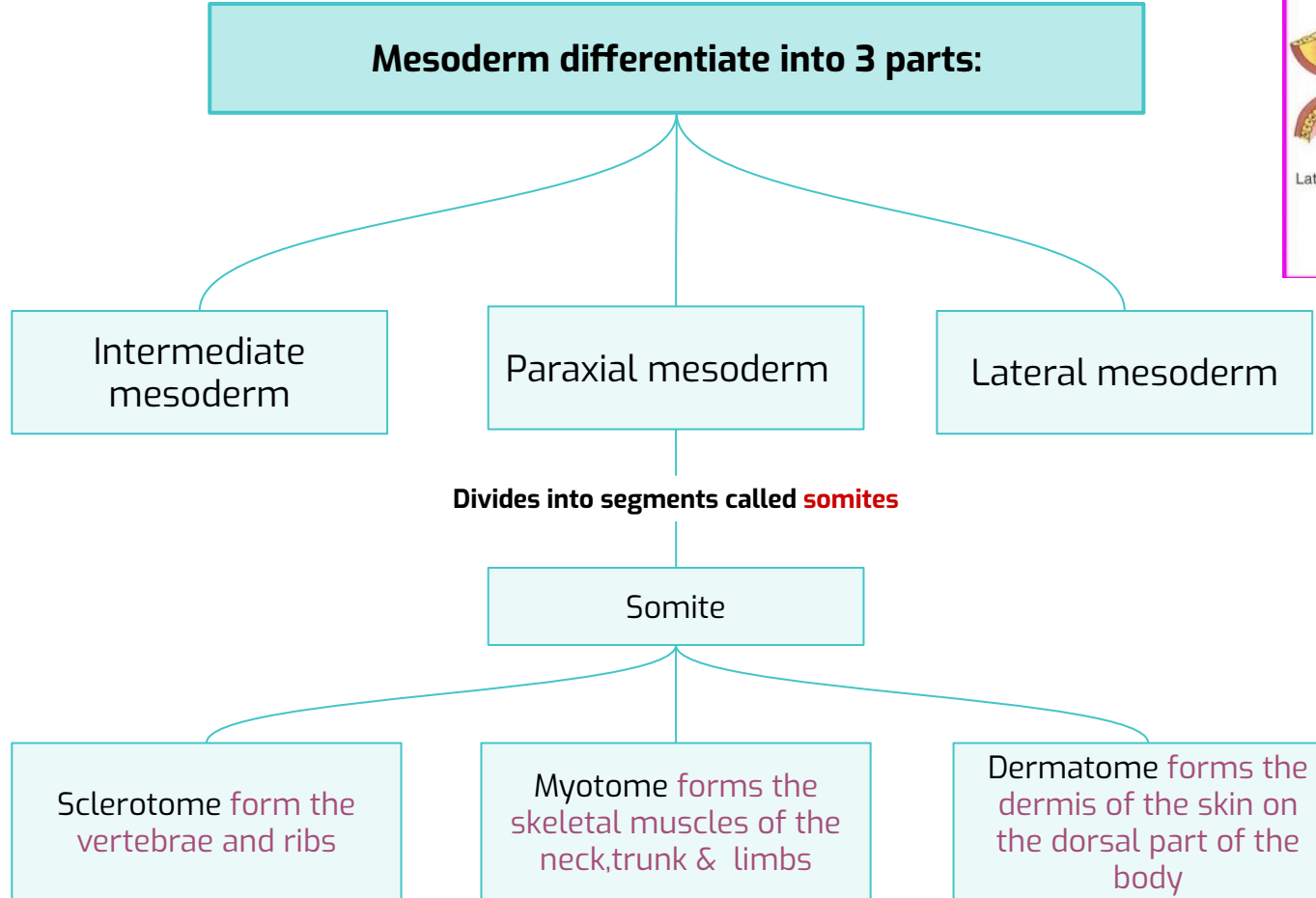
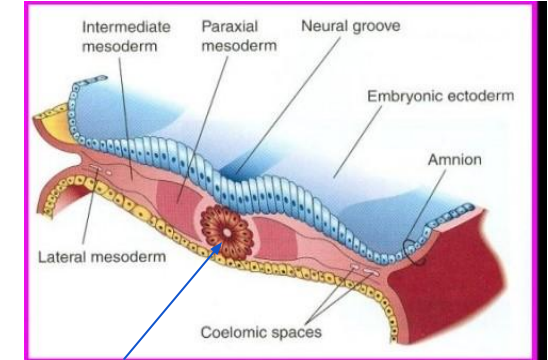
## Introduction:

The mesoderm is located between ectoderm and endoderm except in the central axis of embryo where notochord is found.

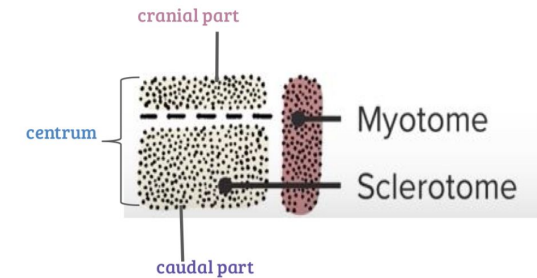
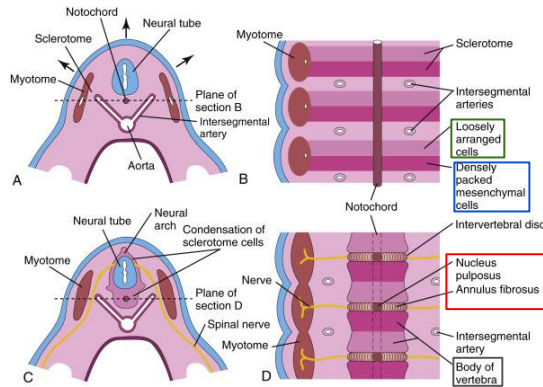
**The first sign** of specialization of mesoderm is appearance of **notochord**.

Three collections of the mesoderm appear lateral to the notochord

- Somites
- Intermediate mesoderm
- Double sheets of lateral plate mesoderm



# Formation of body of vertebrae



The vertebral column develops from the ventromedial parts (sclerotomes) of the somites

At week 4, each sclerotome is formed of:  
 1-A cranial part of loosely arranged cells  
 2-A caudal part of densely packed cells

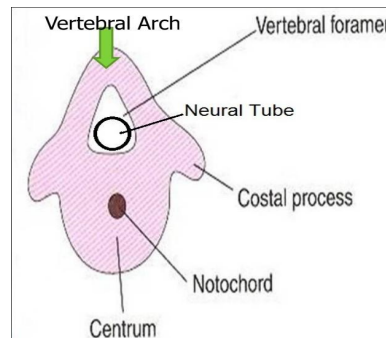
The caudal part of each sclerotome/somite fuses with the cranial part of succeeding sclerotome/somite to form the centrum (body primordium/ of vertebra)

Each centrum develops from 2 adjacent sclerotomes. Thus the bodies of the vertebrae are intersegmental in origin. The fused sclerotomes grow: (A) dorsally around neural tube and form the vertebral (neural) arch. (B) ventrolaterally to form costal processes that give rise to ribs in thoracic region

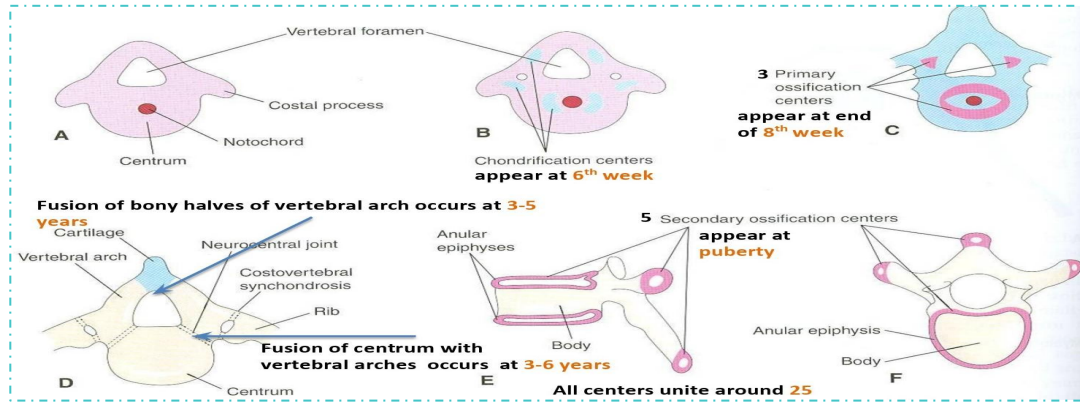
**Fate of notochord:**

- in region of the bodies of vertebrae it degenerates
- between bodies of vertebrae forms the intervertebral discs (nucleus pulposus)

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



# Vertebral development



At 6th week:  
Chondrification  
centers appear

At end of 8th week:  
**3 primary**  
ossification centers  
appear

Fusion of **bony halves** of  
vertebral arch occurs at **3-5**  
**years**.  
Fusion of **centrum** with  
vertebral arches occurs at **3-6**  
**years**.

At puberty:  
**5 secondary**  
ossification  
centers appear

All centers  
unite  
around **25**  
**years**

# Curvatures of vertebral column

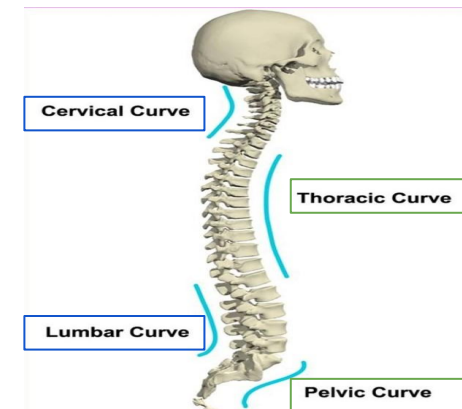
## Primary curves(concave anterior):

Thoracic and pelvic (or sacral): develop **prenatally**

## Secondary curves(convex anterior):

Develop **postnatally**

- 1- **Cervical** (concave posteriorly): as a result of lifting the head
- 2- **Lumbar** (concave posteriorly): as a result of walking ,help support trunk,upper body.





# Spina bifida

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

**Incidence:** 0.04-0.15%

**Sex:** More frequent in **females**

**Types:**

**1- Spina bifida occulta(20%)**

**2- Spina bifida cystica(80%).**

## Spina bifida occulta

The closed type

Only one vertebra is affected

**No clinical symptoms**

**Usually doesn't involve underlying neural tissue**

Skin overlying it is intact, sometimes covered by a tuft of hair



## Spina bifida cystica

The open type. **Most severe and complex form of spina bifida**

It usually involves serious **neurological problems**. A portion of the nerves and the spinal cord are exposed outside the body

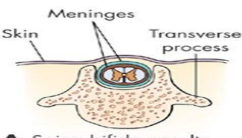
Subdivided into:

**1-Spina bifida with meningocele:** protrusion of sac containing meninges and cerebrospinal fluid

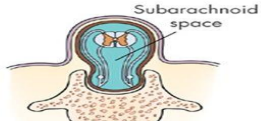
**2-spina bifida with meningomyelocele:** protrusion of sac containing meninges with spinal cord and/or nerve roots

**3-spina bifida with myeloschisis:** spinal cord is open due to failure of fusion of neural folds

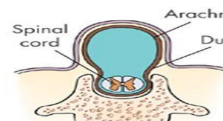
• Failure of vertebral arch bony growth and fusion  
 • Neurologic symptoms are usually absent, although problems may occur during growth owing to "tethering" of the spinal cord.  
 • Skin anomalies frequently overlie the defect, including a hairy patch, hemangioma, or dermal sinus



**A Spina bifida occulta**



**C Meningomyelocele**



**B Meningocele**



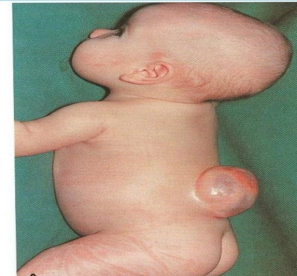
**D Rachischisis**

Myeloschisis

Meninges bulge through the defect

Neural tissue is directly exposed

**With meningomyelocele**



**With myeloschisis**



# MCQ

Q1: The neural tube is a derivative of ?

A: Endoderm

B: Ectoderm

C: Mesoderm

D: Notochord

Q2: What stimulates the development of the vertebral column?

A: Ectoderm

B: Mesoderm

C: Neural tube

D: Endoderm

Q3: The spinal cord develops from the .....of the neural tube.

A: Caudal 2/3

B: Caudal 1/3

C: Cranial 2/3

D: Cranial 1/3

Q4: Marginal layer of the spinal cord is divided into all of the following except:

A: Dorsal funiculi

B: Lateral funiculi

C: Ventral funiculi

D: Medial funiculi

Q5: The inner thin pia mater originates from:

A: Mesoderm

B: Ectoderm

C: Endoderm

D: Subarachnoid space

Q6: Somites develop from the ?

A: Paraxial mesoderm

B: Intermediate mesoderm

C: Lateral mesoderm

D: Medial mesoderm

Answer key:  
1 (B) , 2 (C) , 3 (A) , 4 (D) , 5 (B) , 6 (A)

# MCQ

**Q7: At which one of the following periods of life fusion of bony halves of vertebral arch occurs**

- |                   |                     |                     |                           |
|-------------------|---------------------|---------------------|---------------------------|
| <b>A: Puberty</b> | <b>B: 3-5 years</b> | <b>C: 3-6 years</b> | <b>D: Around 25 years</b> |
|-------------------|---------------------|---------------------|---------------------------|

**Q8: What is the correct sequence of vertebral development?**

- |  |  |  |  |
|--|--|--|--|
| <b>A: Mesenchymal, primary ossification, fusion, chondrification, secondary ossification</b> | <b>B: Mesenchymal, chondrification, primary ossification, fusion, secondary ossification</b> | <b>C: Mesenchymal, fusion, primary ossification, chondrification, secondary ossification</b> | <b>D: Fusion, Mesenchymal, primary ossification, chondrification, secondary ossification</b> |
|--|--|--|--|

**Q9: Secondary vertebral column curves are:**

- |                                |                                 |                                 |                                 |
|--------------------------------|---------------------------------|---------------------------------|---------------------------------|
| <b>A: Cervical &amp; sacra</b> | <b>B: Lumbar &amp; thoracic</b> | <b>C: Thoracic &amp; pelvic</b> | <b>D: Lumbar &amp; cervical</b> |
|--------------------------------|---------------------------------|---------------------------------|---------------------------------|

**Q10: Spina Bifida is most common in:**

- |                   |                 |                    |                   |
|-------------------|-----------------|--------------------|-------------------|
| <b>A: Females</b> | <b>B: Males</b> | <b>C: Children</b> | <b>D: Elderly</b> |
|-------------------|-----------------|--------------------|-------------------|

**Q11: Which type of spina bifida is caused by profusion of sac containing meninges & cerebrospinal fluid?**

- |  |  |   |                                |
|--|--|---|--------------------------------|
| <b>A: Spina bifida with meningomyelocele</b> | <b>B: Spina bifida with myeloschisis</b> | <b>C: Spina bifida with meningocele</b> | <b>D: Spina bifida occulta</b> |
|--|--|---|--------------------------------|

**Q12: Which part of the somite forms the dermis of the skin on the dorsal part of the body?**

- |                      |                   |                     |                             |
|----------------------|-------------------|---------------------|-----------------------------|
| <b>A: Sclerotome</b> | <b>B: Myotome</b> | <b>C: Dermatome</b> | <b>D: None of the above</b> |
|----------------------|-------------------|---------------------|-----------------------------|

Answer key:  
7(B) . 8(B) . 9(D) . 10(A) . 11(C) . 12(C)

# SAQ

**Q1: What separates the ventral basal plate from the dorsal alar plate?**

**Q2: What are the 2 types of spina bifida?**

**Q3: Which type of spina bifida occurs do to failure of development of neural folds?**

**Q4: What is the subarachnoid space?**

## Answers

**1 : A longitudinal groove ( sulcus limitans )**

**2 : Spina bifida occulta & Spina bifida cystica.**

**3 : Spina bifida with myeloschisis**

**4: Is a cavity that appears between the arachnoid & pia mater. It becomes filled with cerebrospinal fluid (CSF)**

## Team leaders

Rayan jabaan  
Abeer Awwad

## A special thanks to Mohamed Alquhidan

### Reviser

Abdulaziz Alkraida

### Organizer

Abdulaziz Alghuligah

### Note taker

Asma Alamri

## Team Members



- Alaa Assulmi
- Albandari Alanazi
- Aljoud Algazlan
- Afnan Almohsen
- Arwa Alqahtani
- Aseel Alshehri
- Asma Alamri
- Bodoor Almubarak
- Deemah Alotaibi
- Fatimah Saad
- Ghada Alabdi
- Ghaida Alassiry
- Joud Alnujaidi
- May Barakah
- Norah Alasheikh
- Nouf Alsubaie
- Raghad Alasiri
- Raghad Soaeed
- Renad Alosaimi
- Sara Alharbi
- Sarah Almuqati
- Sarah Alqahtani
- Shaden Alsaiedan
- Shahad Almezel
- Shayma Alghanoum
- Sumo Alzeer



- Abdullah Alburikan
- Abdullah Aldosari
- Abdulaziz Alghuligah
- Abdulaziz Alkraida
- Abdulaziz Alomairy
- Abdulaziz Alrabiah
- Abdulaziz Alsuhaim
- Abdulrahman Almugren
- Ahmed Alkhayatt
- Bader Alrayes
- Basel Fakeeha
- Fahad Alajmi
- Faisal Alotaibi
- Fayez Altabbaa
- Feras Alqaidi
- Hadi Alhemsy
- Hesham Alsqabi
- Mohammed Aldehaim
- Mohamed Alquhidan
- Mohammed Beyari
- Mubarak Alanazi
- Musab Alamri
- Nawaf Alghamdi
- Osama Alharbi
- Raed Alnutaifi
- Saad Aldohaim
- Saleh Algarni



Done by