# Spinal Cord and Vertebral Column

SCRUBS

STUDENT COLLABORATIVE RESOURCES FOR UNDERSTANDING AND BRODY SUCCESS

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Resources Used

BSOM Coursepack

# *Mission Statement*

**SCRUBS** is a student-driven initiative that aims to develop supplemental recourses for current and future cohorts that will pass through Brody. Members of **SCRUBS** participate in a variety of sub-committees working to create resources for students, by students. These resources aim to offer unique perspectives from students that have walked in the same shoes, developing resources that we wish we had been exposed to during our time in the course.

The hope is this organization will become a staple of the Brody student body, exemplifying the unique collaborative community that Brody offers. If this is a mission that aligns with your goals and you have the desire to help those that will come behind you, as well as a goal to leave your mark on Brody as a whole, we invite you to join the team!

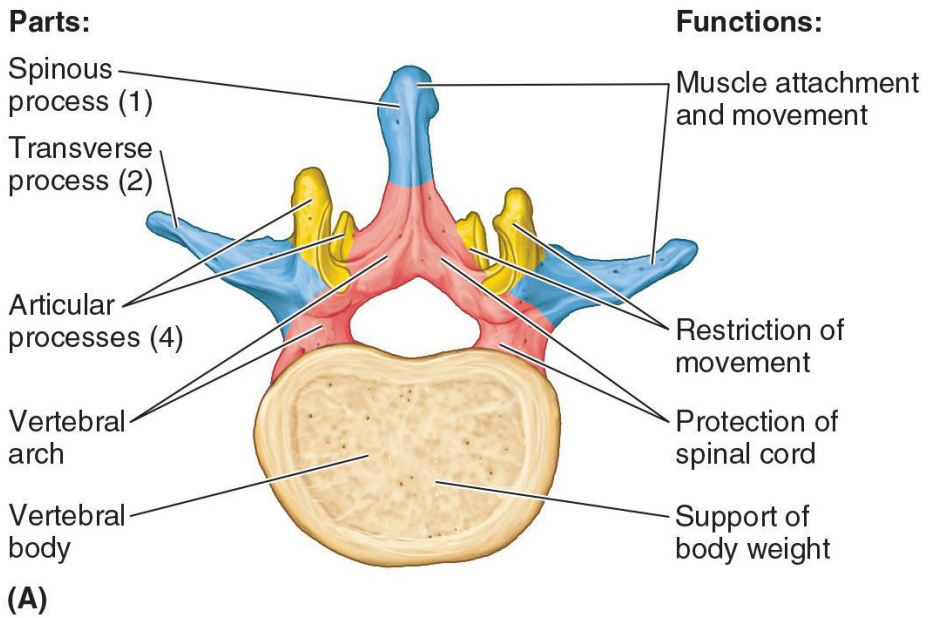
# *Disclaimer*

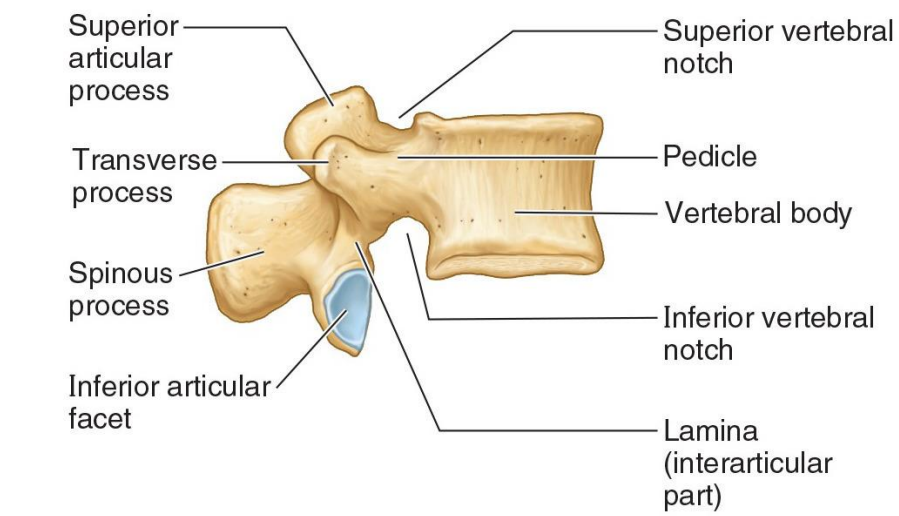
The resources that are included in this document are made by students and not the faculty. As such, there is the possibility for errors in our development, although this is mitigated via a team approach to development with multiple stages of vetting. If there is a contradiction with the coursework presented within your course, please go by the course documents. Additionally, **SCRUBS** aims to supply ***supplemental recourses***, however these are in no way replacements to the instruction of the Brody faculty. Use these recourses as a supplement, but not as your primary source for course material.

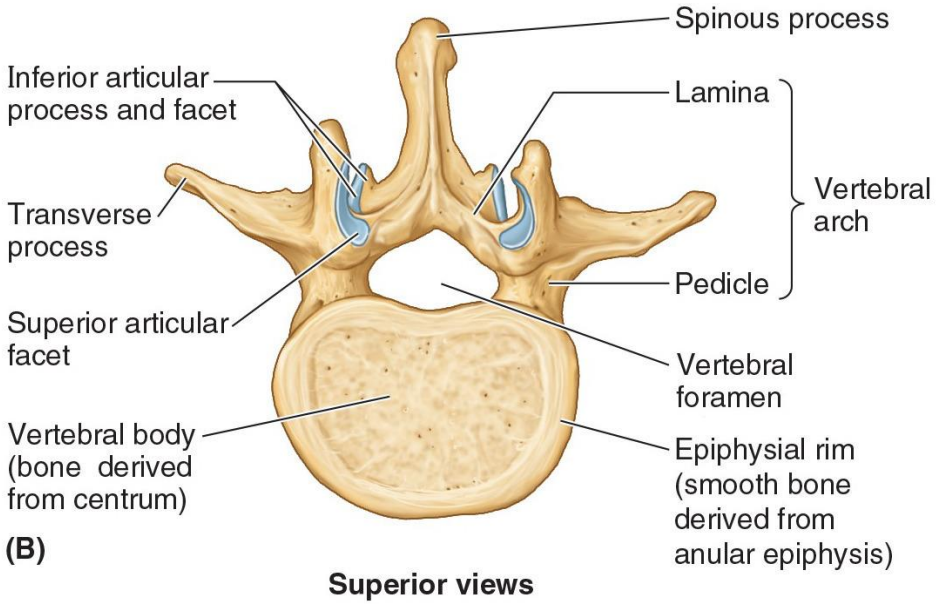
# Brief Adult Anatomy Review

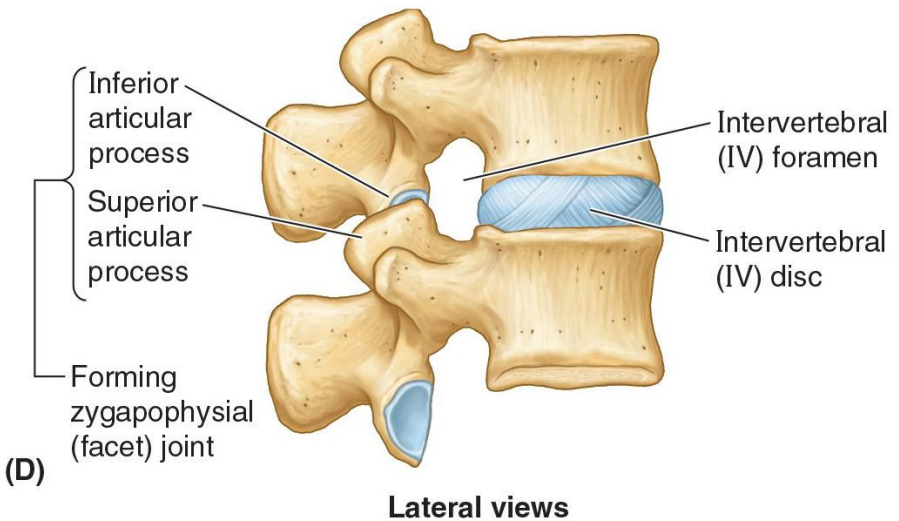
# General Vertebral Structure

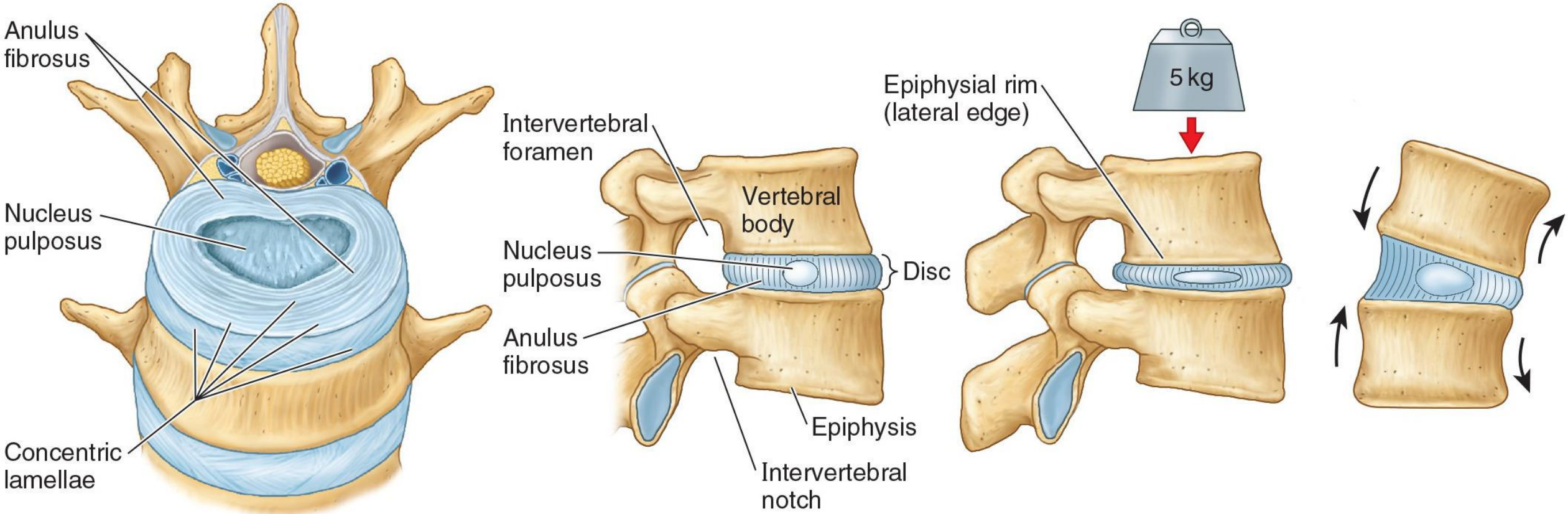
- Vertebral body
- Vertebral arch
- Transverse processes
- Spinal Process
- Articular processes (superior and inferior)



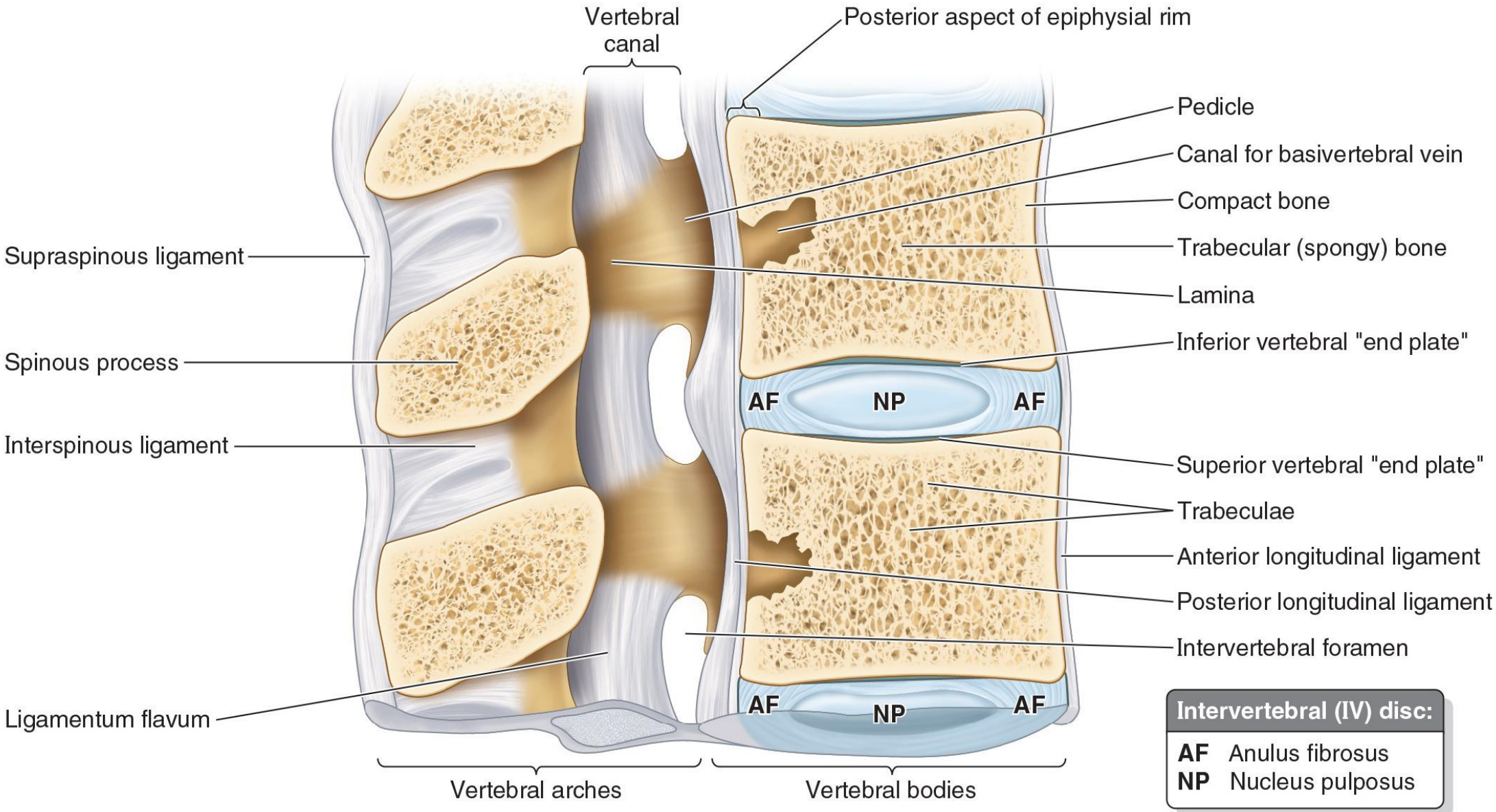



**(A) Anterosuperior view, vertebral column transversely sectioned through IV disc**

**(B) Lateral view of disc when recumbent**

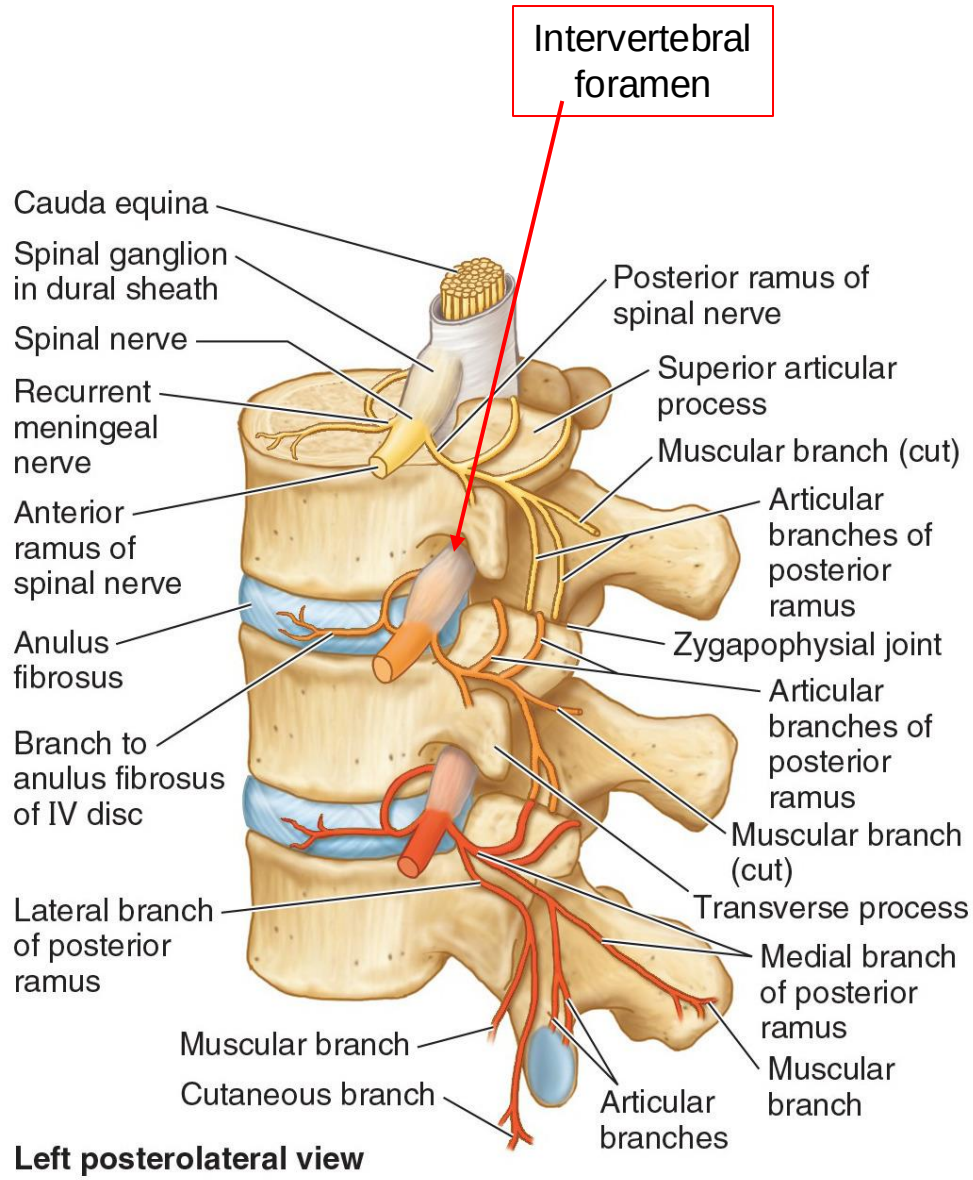
**(C) Lateral view of disc when erect (weight bearing)**

**(D) Anterior view during lateral flexion**



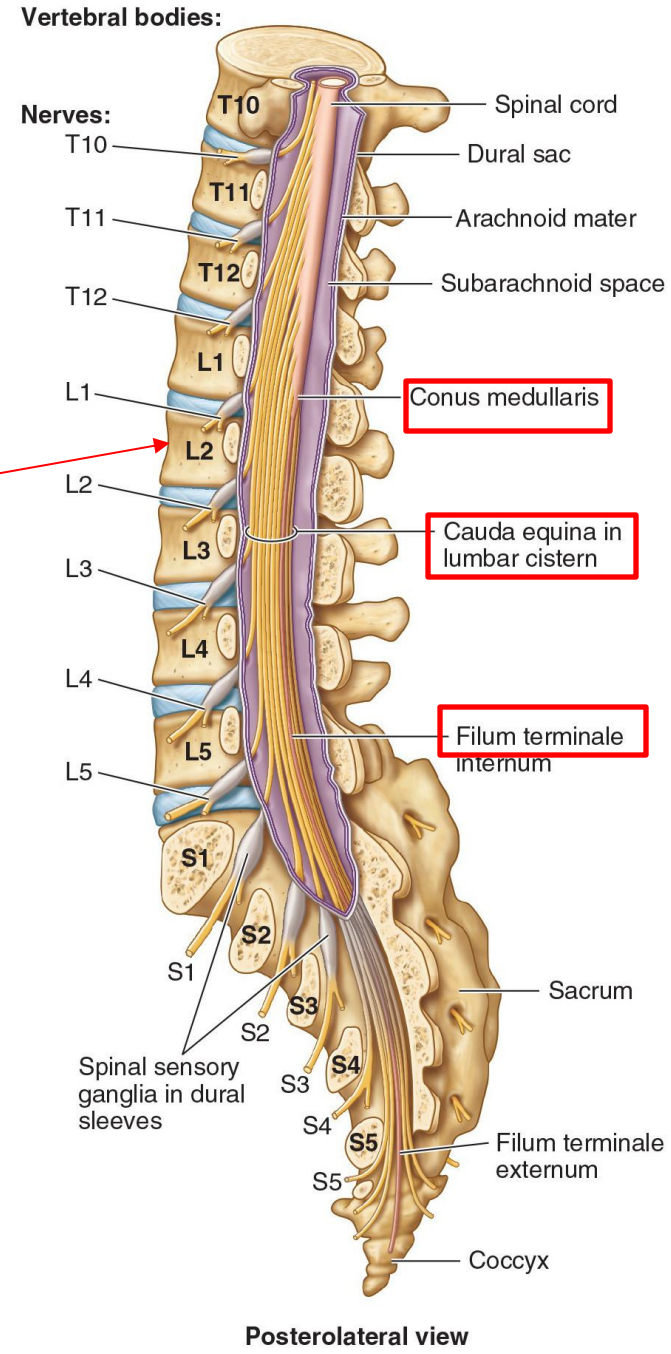

**Medial view of left halves of two adjacent hemisected vertebrae and associated IV discs**

# Spinal Cord Organization

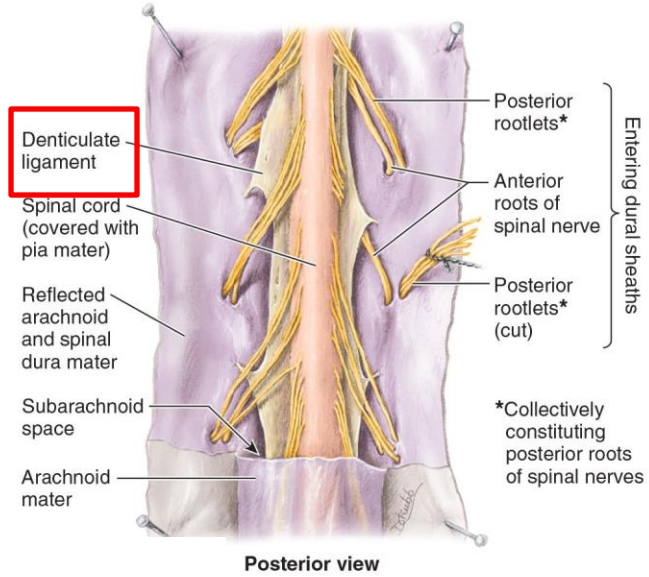


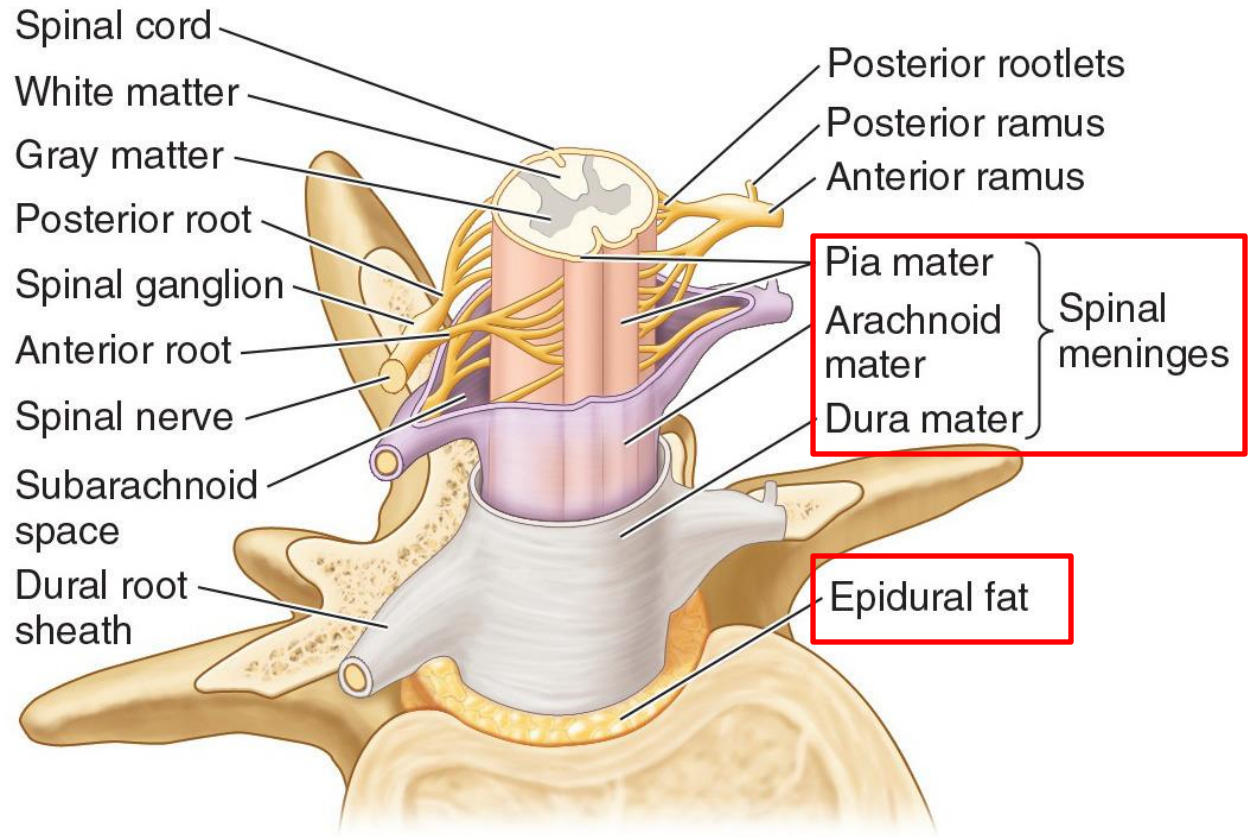


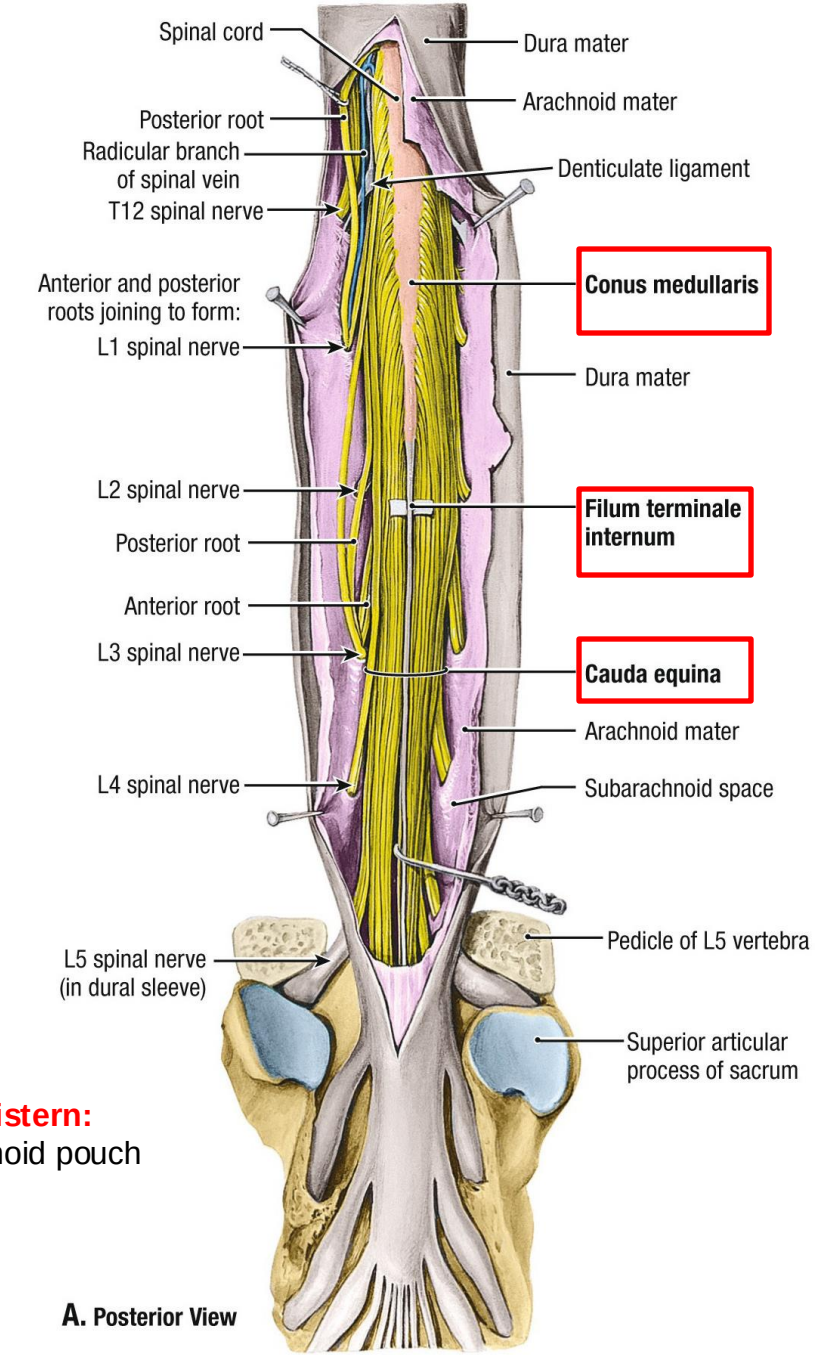

**End of spinal cord**:
Level of L2 vertebrae



# Meningeal Coverings

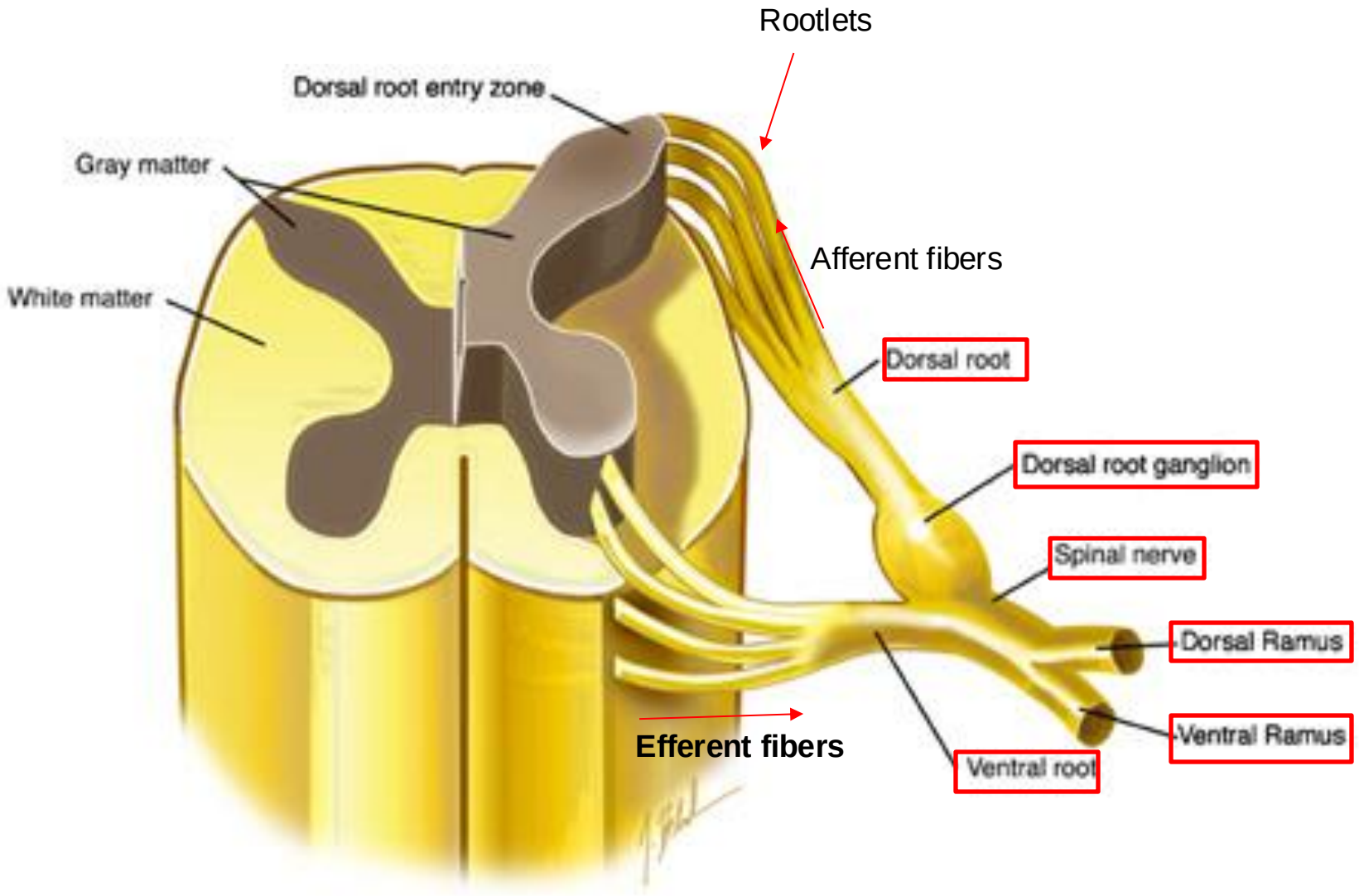


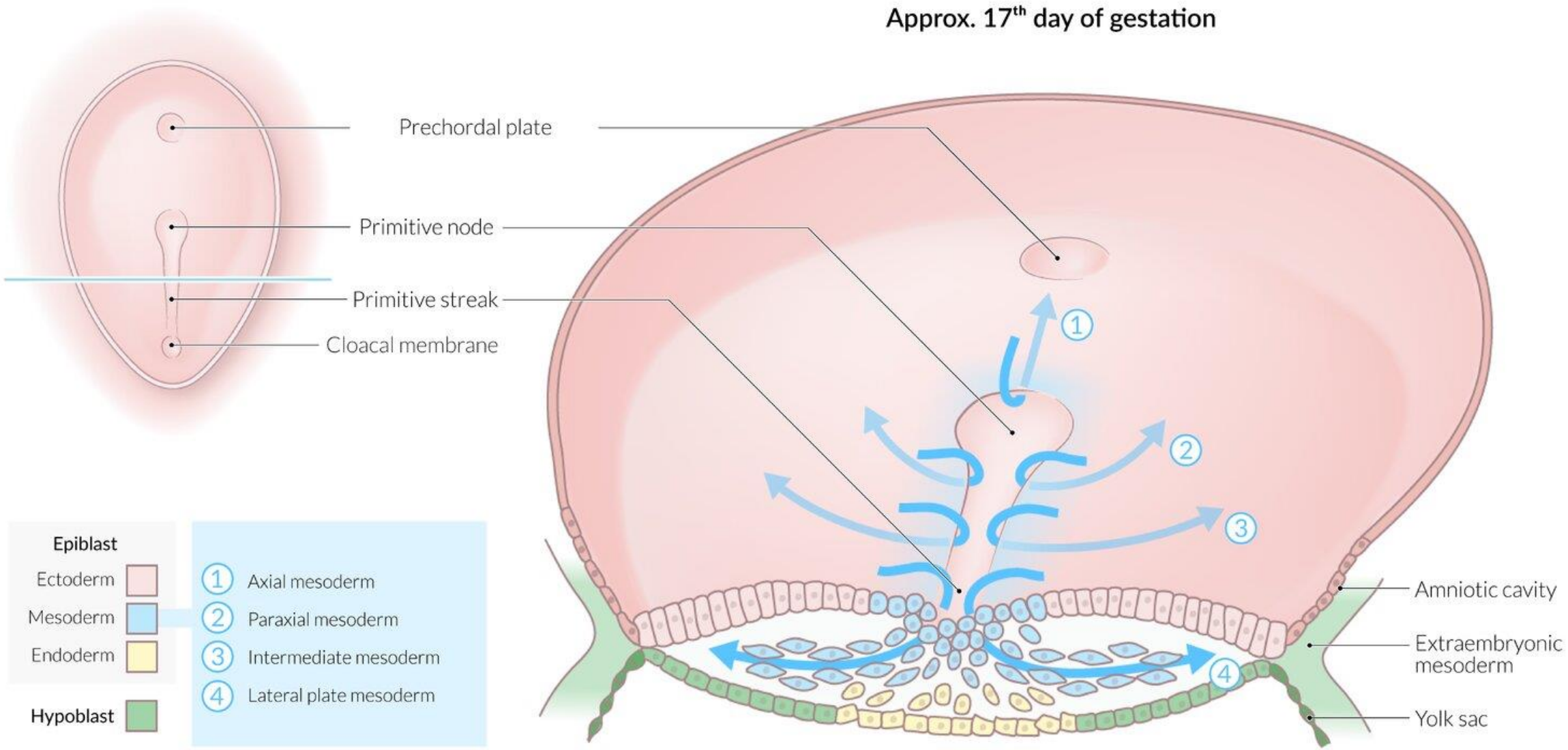

**Lumbar cistern:**
Subarachnoid pouch
btw L2-S2

# Spinal Nerve Anatomy



# Embryology

# Recall – Formation of the Trilaminar Disc

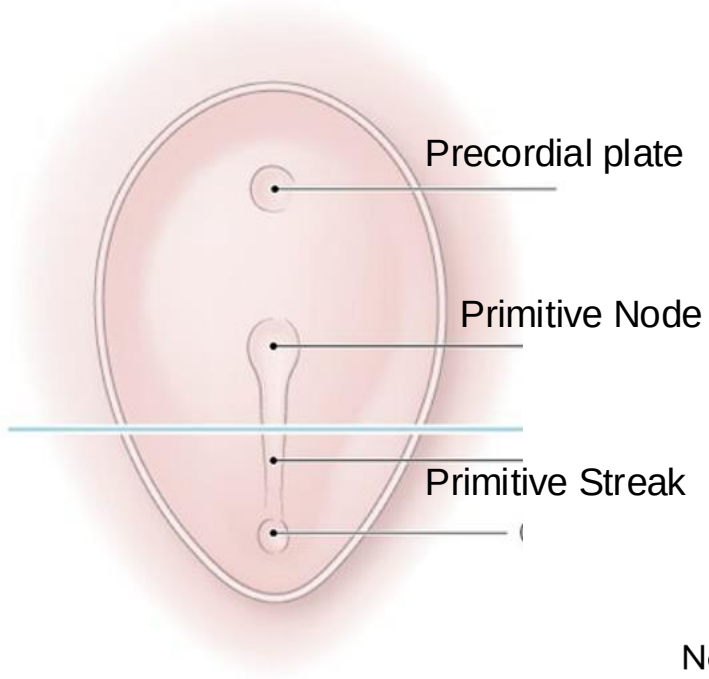


# Notochord Formation

1) Gastrulation forms the trilaminar disc
   This process creates the three germ cell layers

2) Extension towards the precordial plate
   Some of the ***mesodermal cells*** will extend cranially, between the ectoderm and endoderm layers

3) Condensation into the notochord

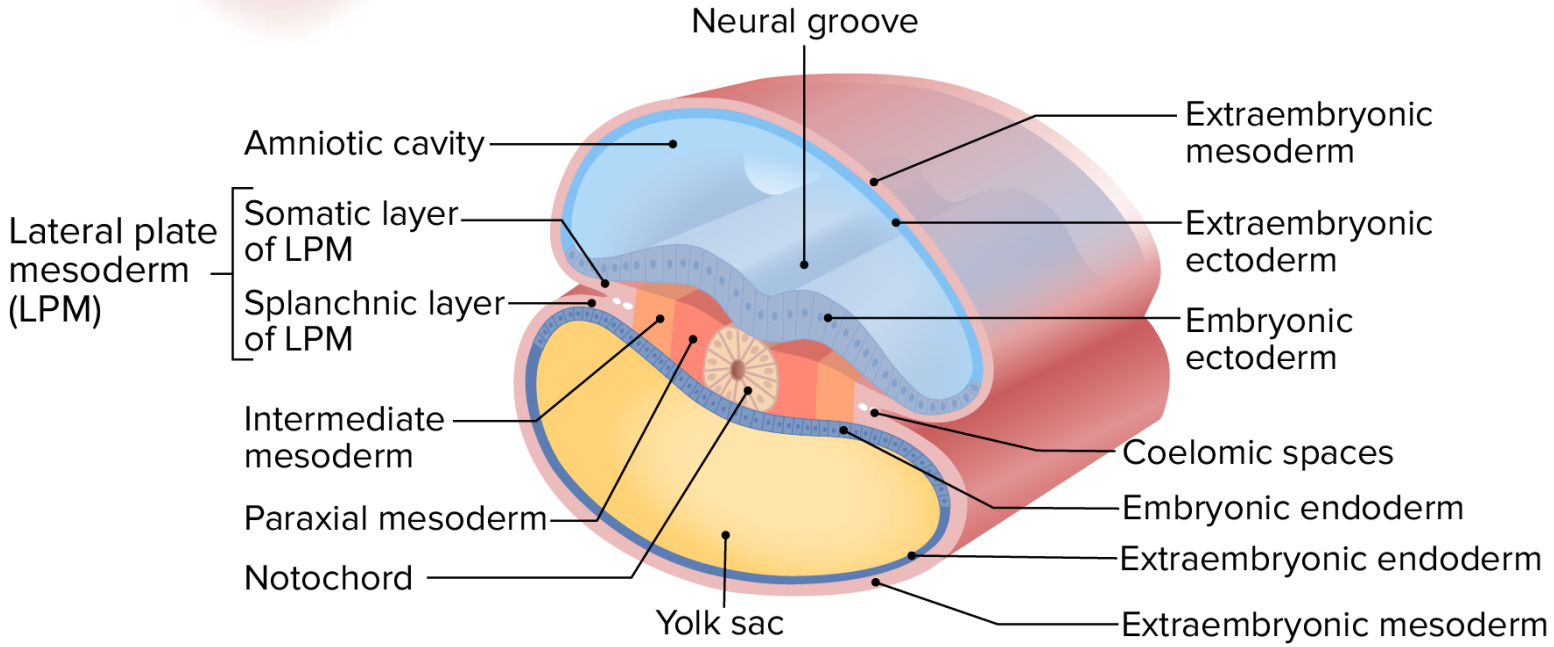



Functions of the notochord

- Rigid support for the embryo to build the **axial skeleton**
- Primary inducer of **neural tube** and **somite** development

***Somite*** *= Block like structure of mesodermal cells that form on either side of the neural tube*

***Axial skeleton*** *= Skull, vertebral column, thorax*



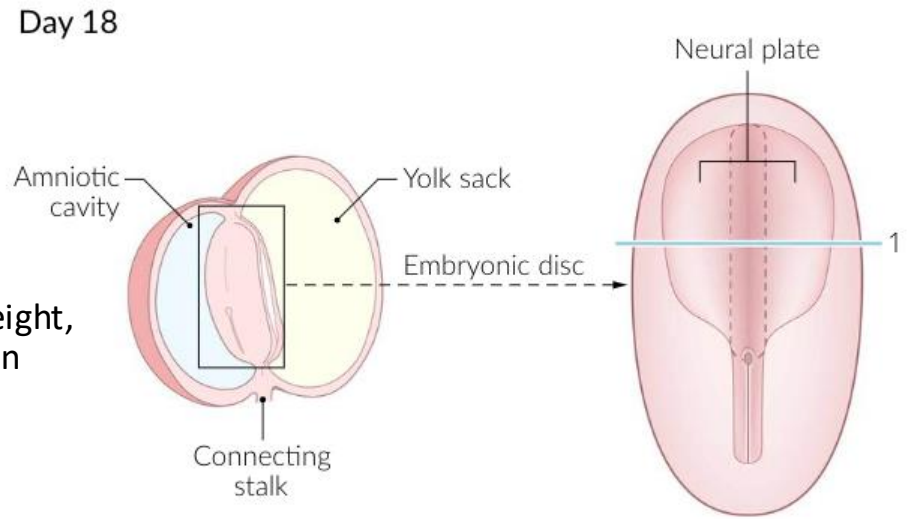
# Neurulation: Forming the Neural Tube (3rd-4th weeks)

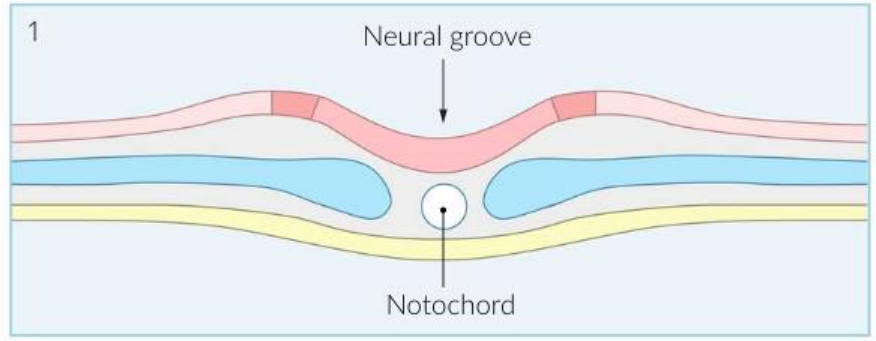
1) Notochord induction of neural plate
   - Overlying ectoderm become columnar
   - These cells are now called ***neuroectoderm***

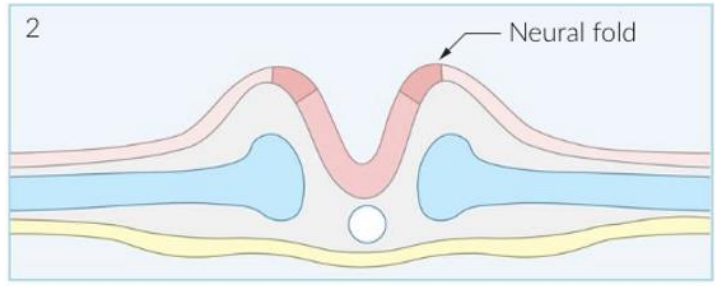
2) Neural fold and groove forms
   - The lateral cells of the neural plate increase in height, forming mounds (neural fold). The valley between these mounds is known as the neural groove

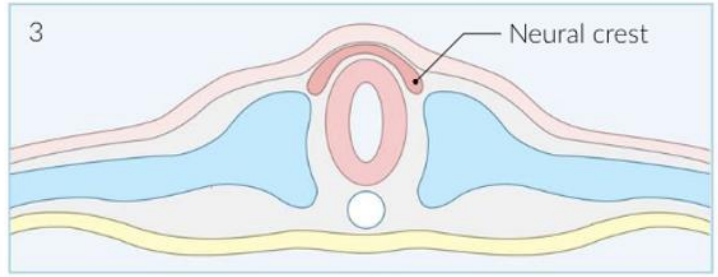
3) Neural crest fuse
   - The crests are the peaks of the neural folds
   - Fusion occurs from the center and extends cranial and caudally
   - Fusion forms the ***neural tube***

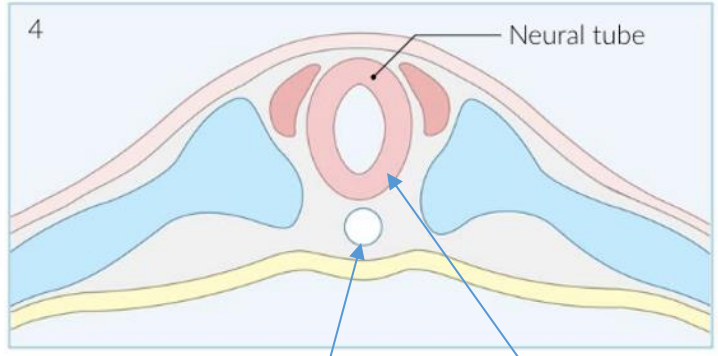
4) Cranial and Caudal neuropores close last
   - Neuroplore = openings of neural tube
   - Cranial closes approx. day 25
   - Caudal closes approx. day 27



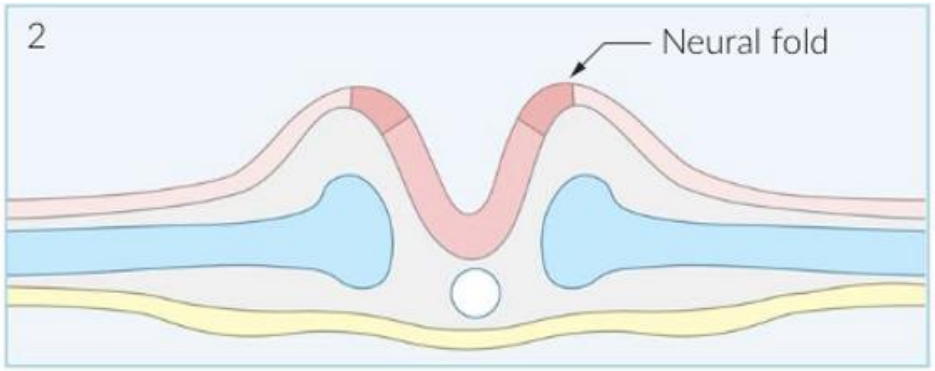



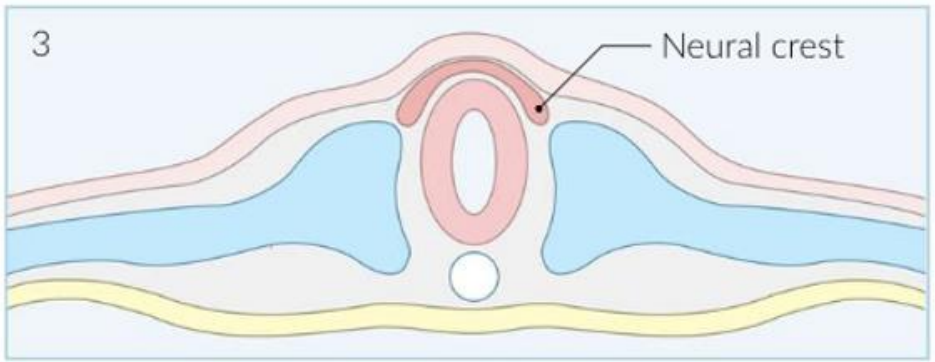

Ectoderm Mesoderm Endoderm

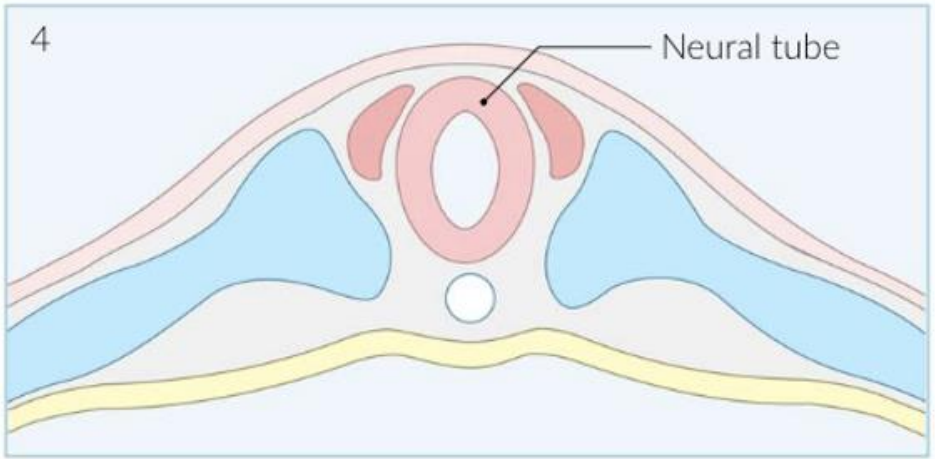
Eventual vertebral column

Eventual spinal cord body

# Neural Crest Cell Migration



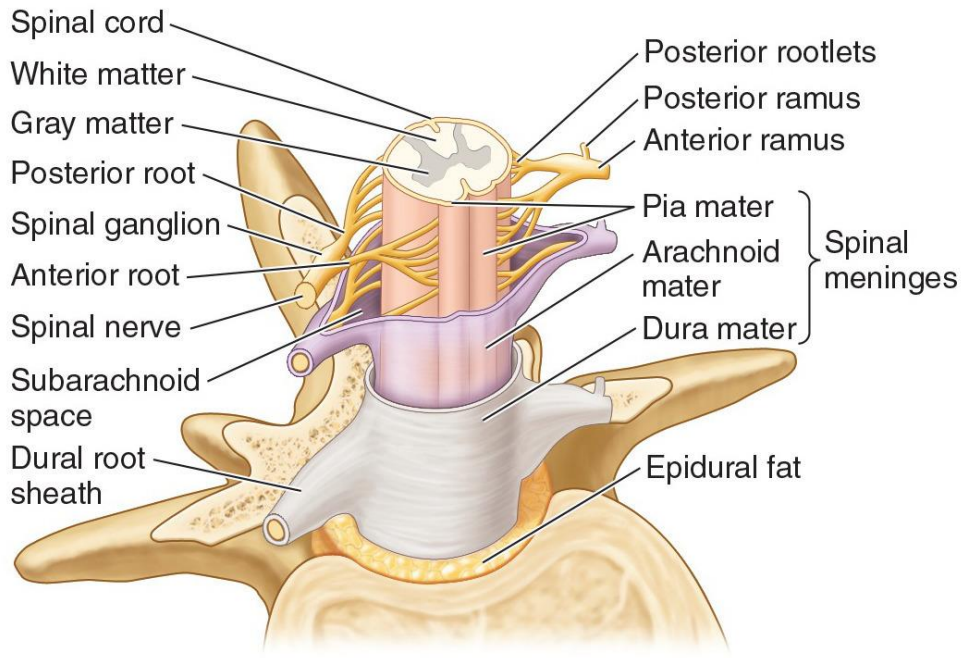



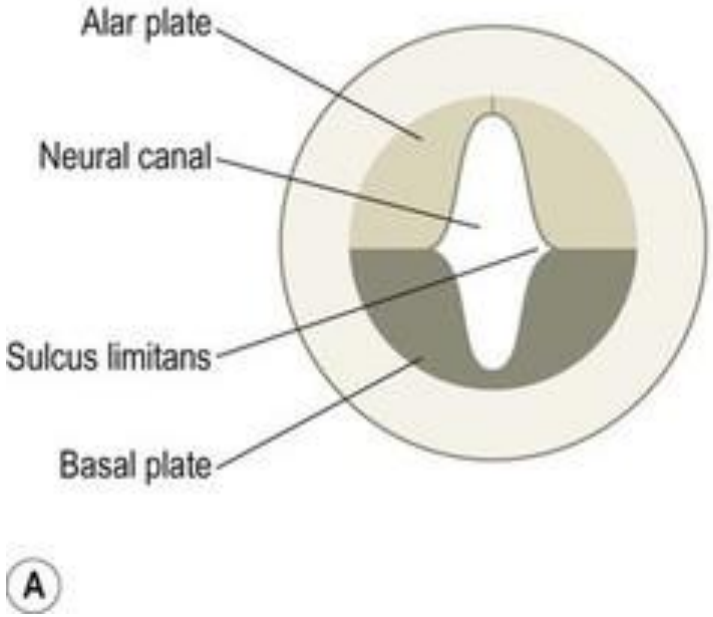

Neural crest cells migrate to a posterolateral position of the neural tube after fusion

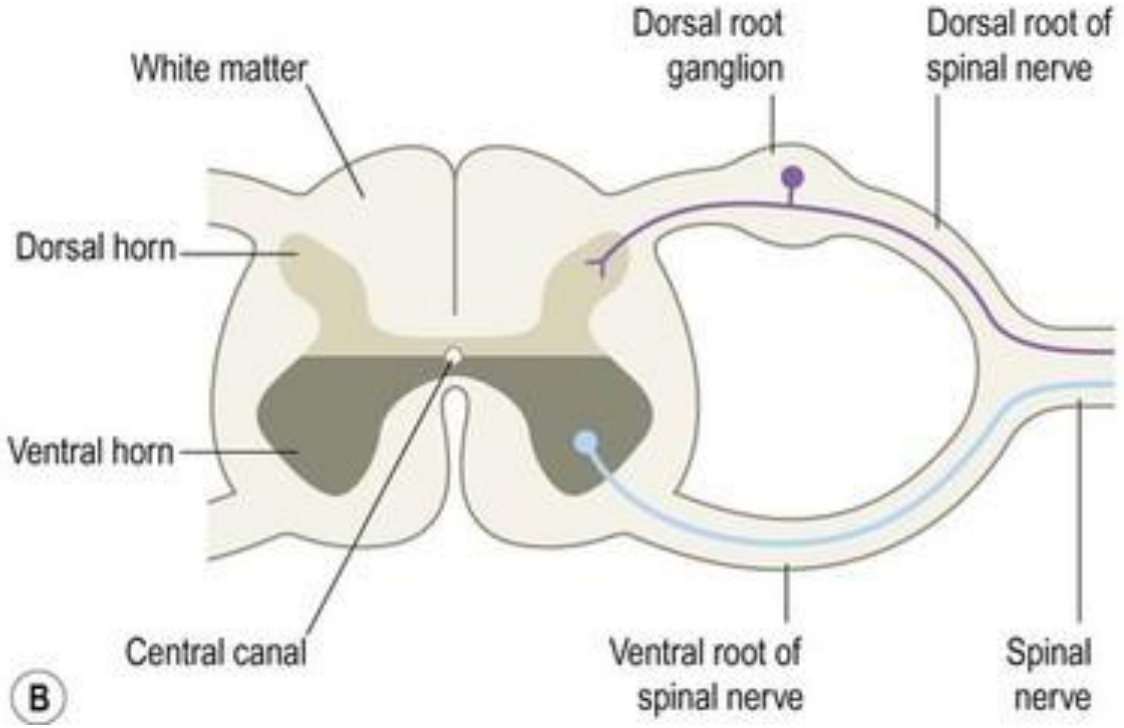
Neural crest cells derive specialized structures in the adult

- Dorsal root ganglia (located posterolateral to the spinal cord)
- All peripheral ganglia (PNS cell bodies)
- Peripheral nervous system support cells (glial cells)
- **Meningeal layers → Pia and Arachnoid**



# Spinal Cord Formation




1) Closure of the neuropores
   Usually around days 25 (cranial) – 27 (caudal)

2) Sulcus limitans forms, separating the alar and basal plates
   Alar plate = Posterior
   Basal plate = Anterior

## Functions of the alar and basal plates

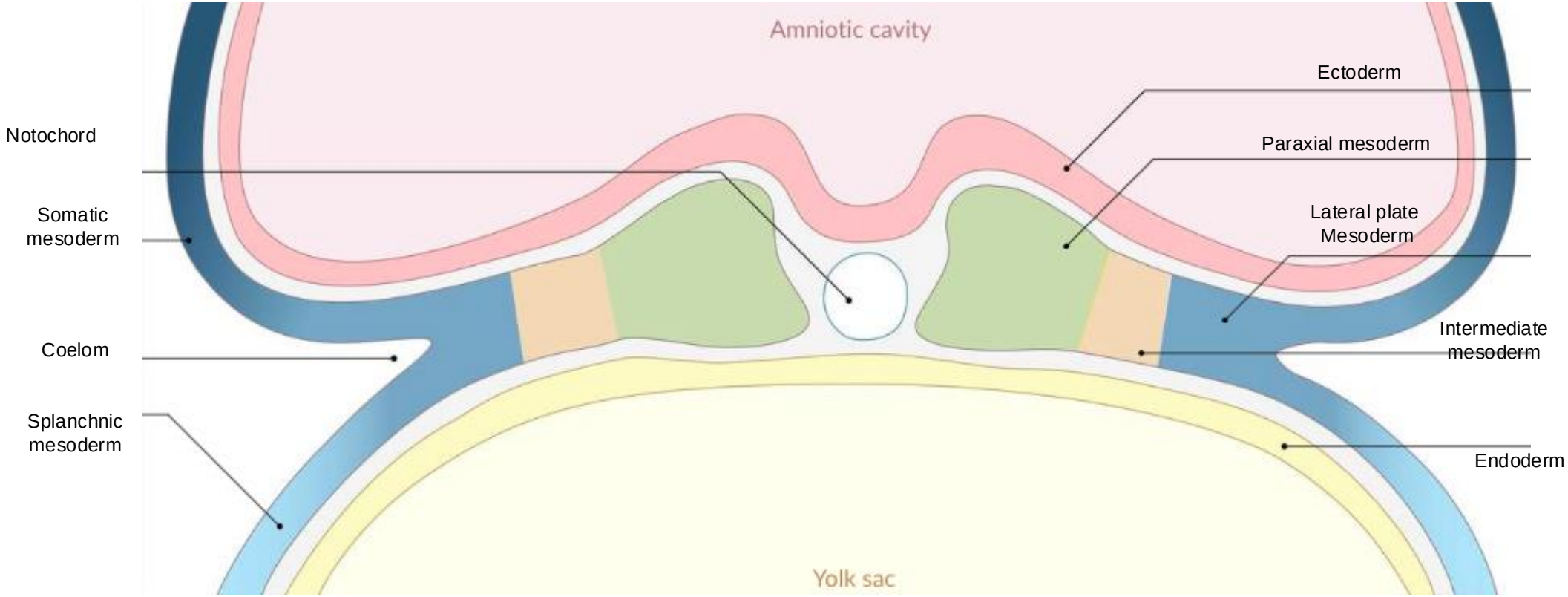
### Alar Plate

- Receive primarily sensory information
- Gives rise to the dorsal horns

### Basal Plate

- Primarily motor neurons that will exit via the ventral root
- Gives rise to the ventral horns

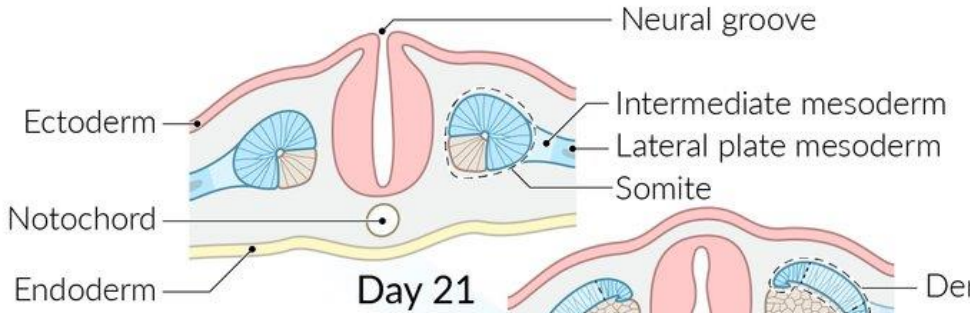
# Axial Skeleton Development



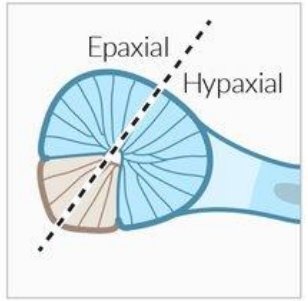

**Differentiation of mesoderm regions**

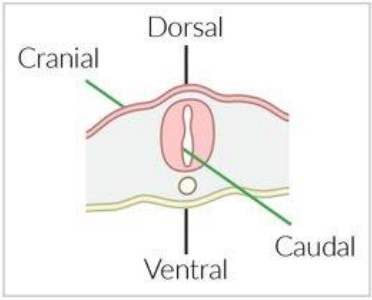
- Paraxial mesoderm
  - Will separate into paired somites
  - Receives segmental innervation/blood supply
- Intermediate mesoderm
- Lateral plate mesoderm

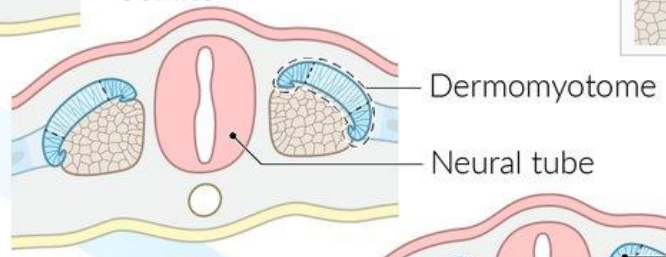
# Differentiation of Somites

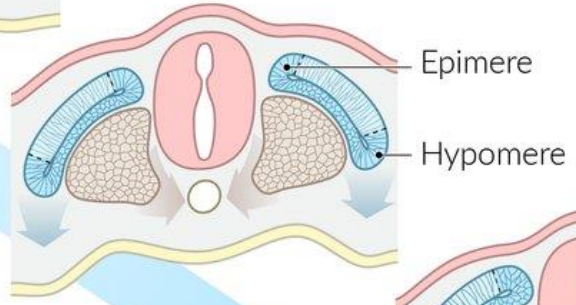


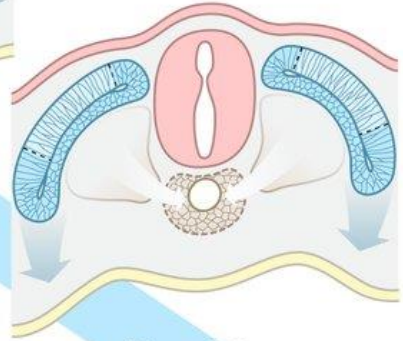


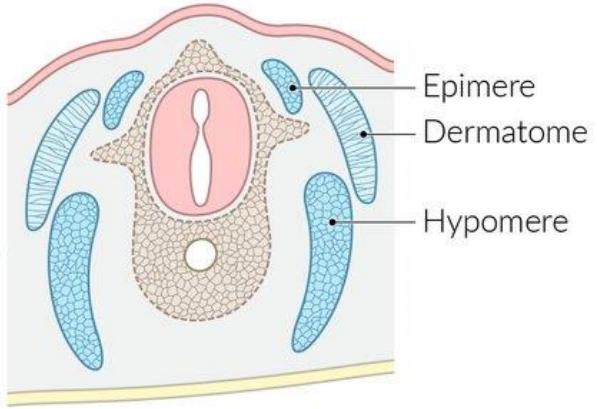


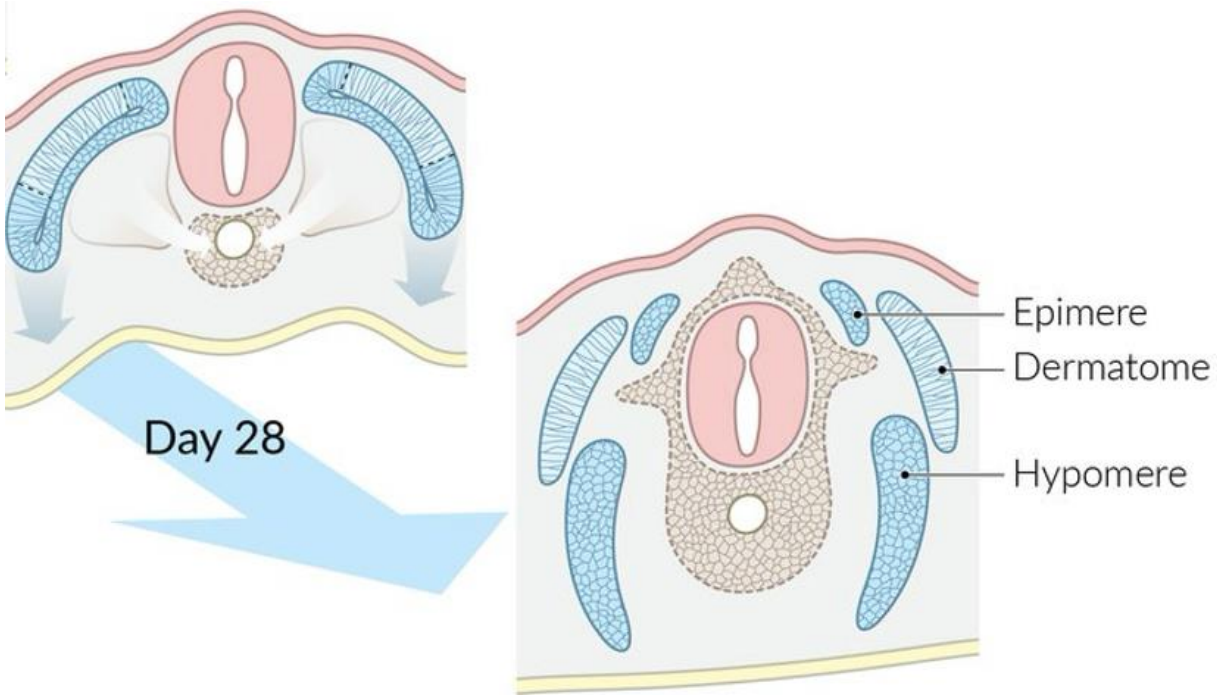

## Differentiation of somites

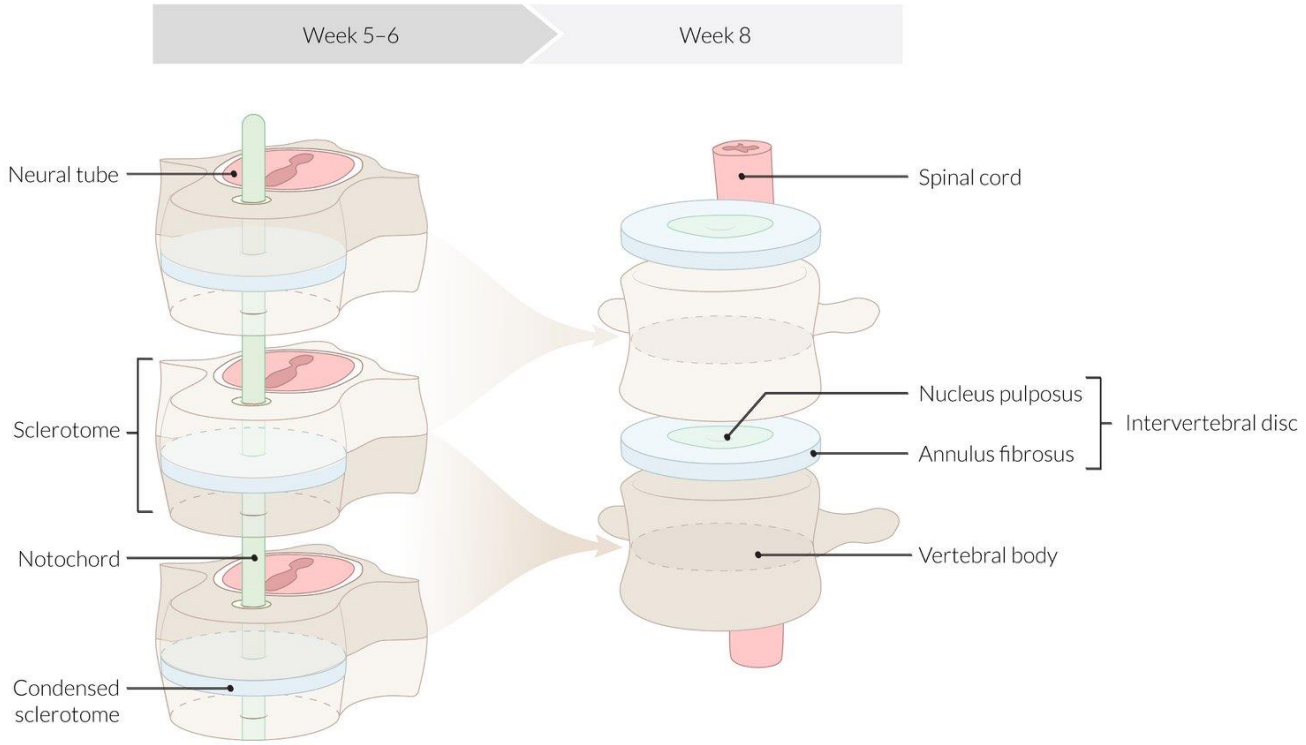
Sclerotome = Anteromedially
Dermomyotome = posterolateral

## Sclerotome and Dermomyotome give rise to axial structures

Sclerotome = Derives the spinal column and ribs
Dermomyotome = Axial musculature and associated dermis

# Vertebral Column Formation: Sclerotome Differentiation



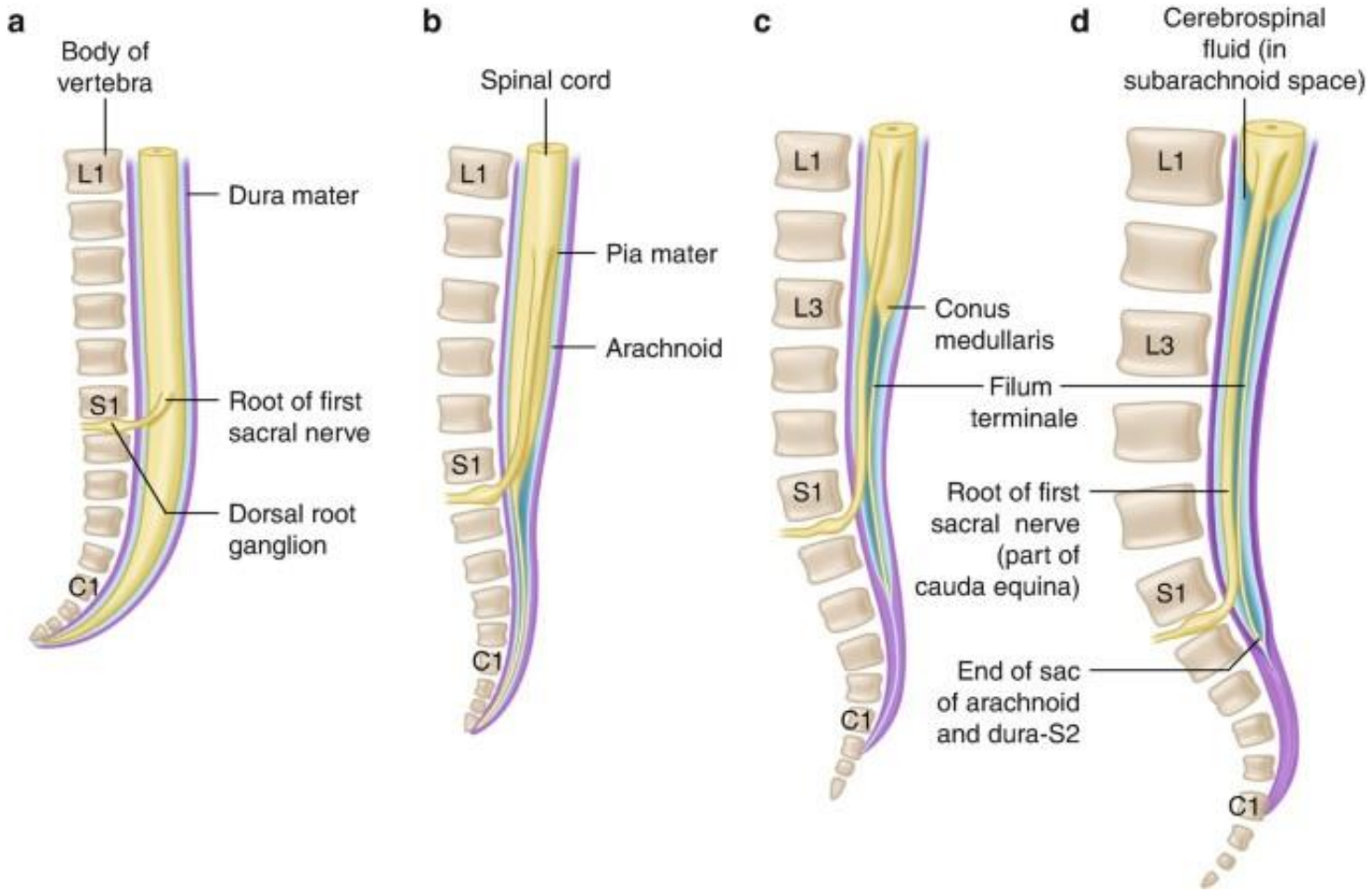

Scleroderma cells surround notochord and spinal cord

- These cells migrate initially around the notochord, referred to as the **centrum**
- **Centrum** = future vertebral bodies
- Occurs via endochondral calcification; center on each side

Mesenchyme invades to form the intervertebral discs

Notochord = nucleus pulposus
Mesenchymal cells = Annulus Fibrosus

# Positional Change of Spinal Cord




Initially in development, each spinal nerve is directly associated with the vertebral column (passing through intervertebral foramen)

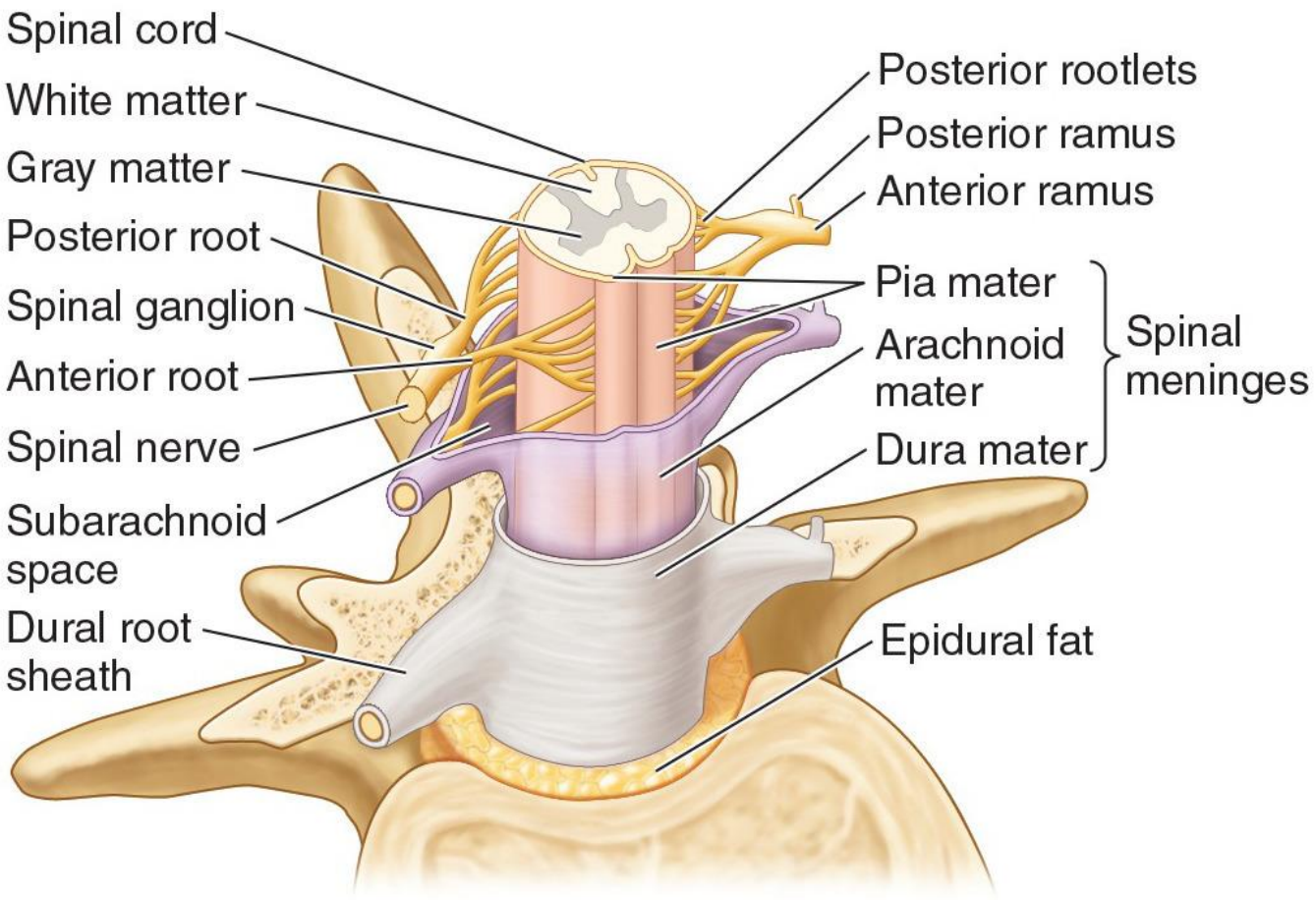
## Differential Growth of the Vertebral Column

The vertebral column/dura outpaces the spinal cord

- **Conus medullaris** begins to rise (relatively)
- In newborns, is at the level of L3
- In adults, at the level of L1/L2

Lumbar cistern, Filum Terminale, and Cauda Equina are formed

# Meningeal Development





Meninges = Coverings of the CNS
- Pia mater
- Arachnoid mater
- Dura mater

Mesenchyme surrounds the neural tube
- Forms the **primordial meninx**

Differentiation of the primordial meninx
- External mesenchyme → Dura mater
- Neural crest cells invade interior → Leptomeninges

End result:
Dura mater → Derived from mesoderm
Pia mater/arachnoid mater → Derived from N.C. cells

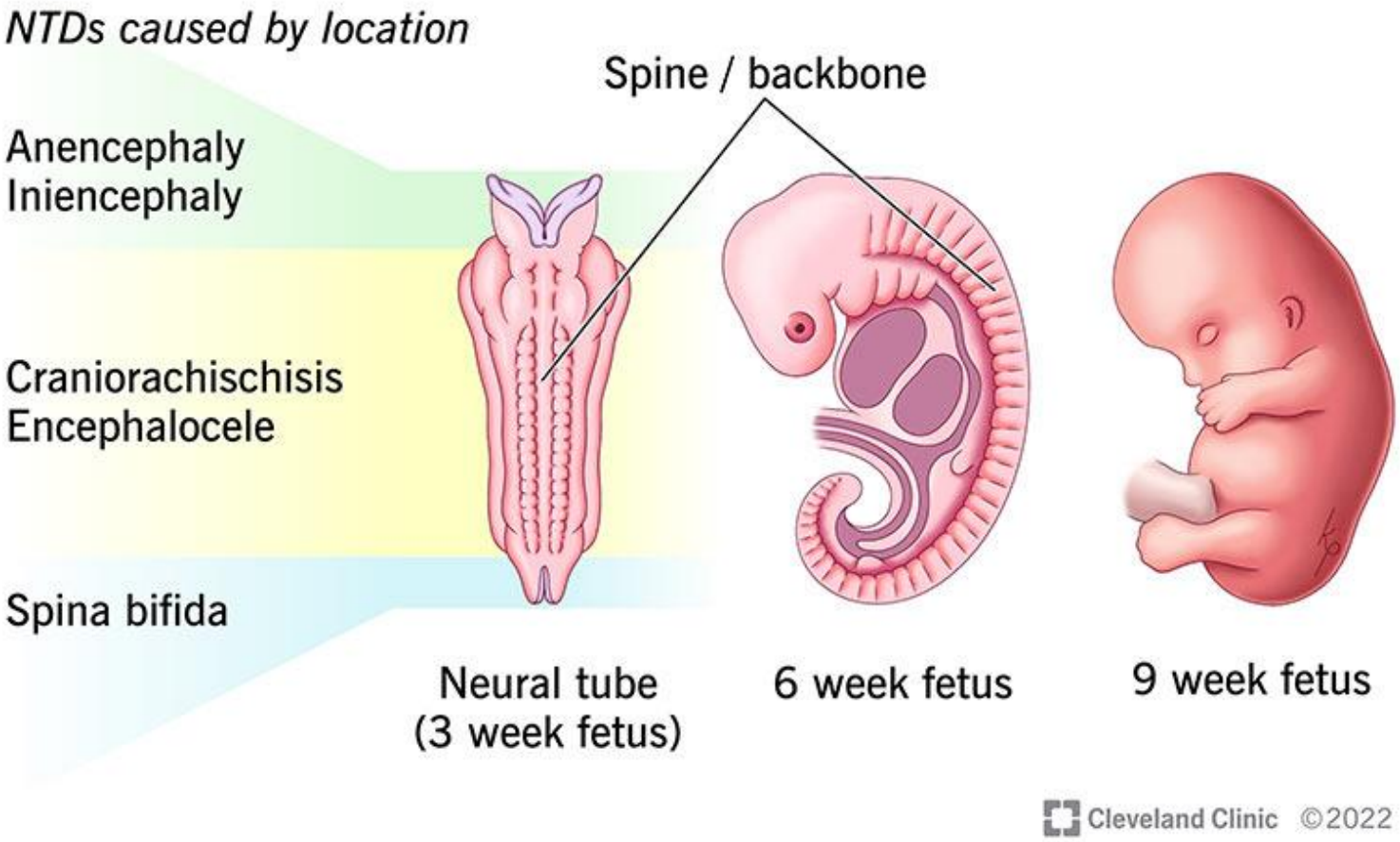
# Summary – Formation of Spinal Cord and Vertebrae

1. Notochord induction of neural plate
2. Neural fold, grooves, and crest forms
3. Neural crest fuse → Neural tube
4. NC cells migrate to the appropriate locations
5. Cranial and Caudal neuropores close
6. Spinal cord forms from basal and alar plates
7. Paraxial mesoderm forms somites
8. Somites differentiate and sclerotomes surround notochord and spinal cord
9. Segmentally forms the vertebral column and intervertebral discs
10. Primordial menix forms, NC invasion gives rise to the meninges
11. Differential growth rates of tissues

| Germ Layer | Derivative |
|---|---|
| Neural Tube (Neuroectoderm) | Brain and Spinal Cord |
| Neural Crest (Neuroectoderm) | Dorsal root ganglia, PNS glial cells, Pia Mater, Arachnoid Mater |
| Paraxial mesoderm (Somites → Dermomyotome/sclerotome) | Axial musculature and dermis of skin (dermomyotome) |
| | Vertebral column/ribs<br>Dura Mater, Annulus fibrosis (Sclerotome) |
| Notochord (Intraembryonic mesoderm) | Nucleus Pulposus |

# Clinical Anatomy

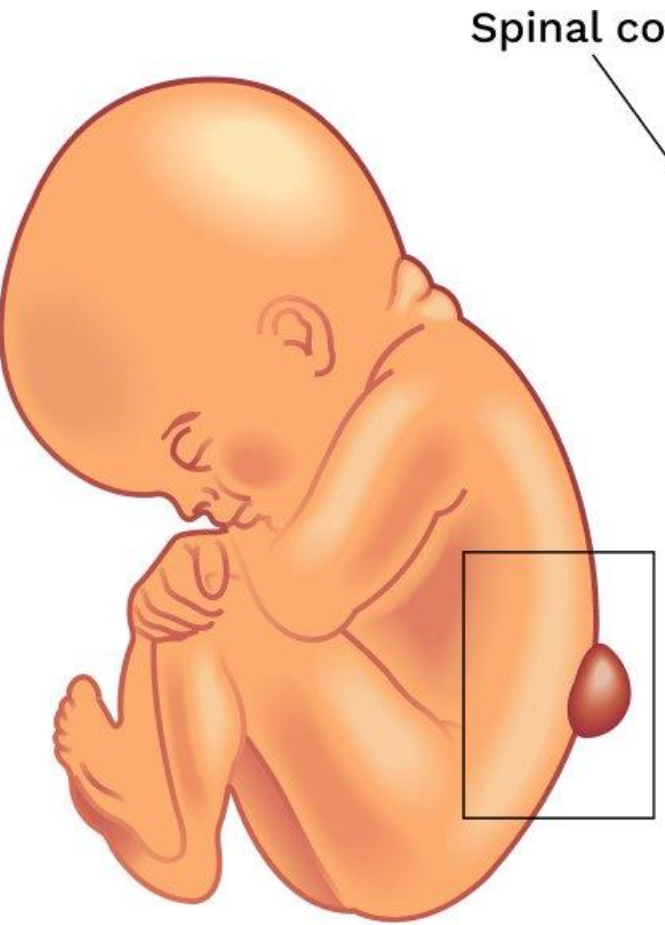
# Detecting Neural Tube Defects

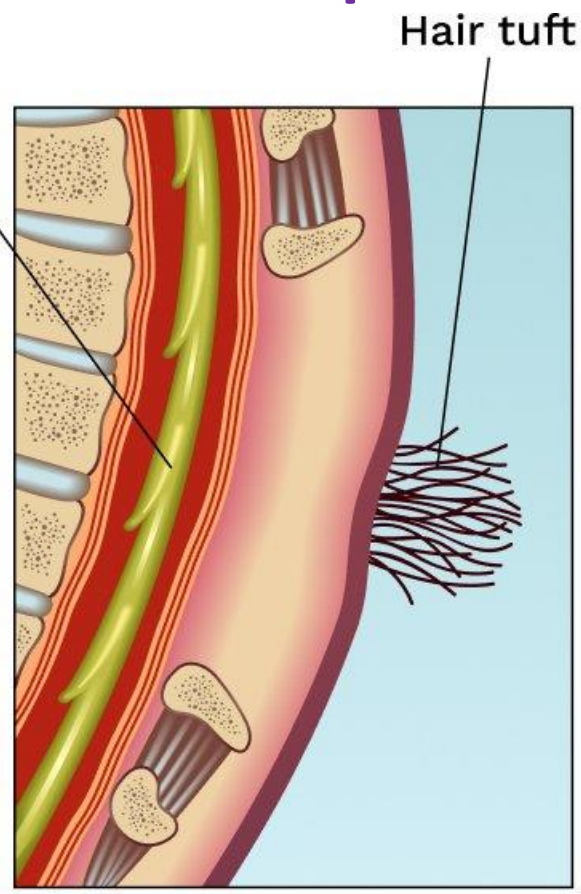



***Elevated AFP (alpha fetoprotein)***

***Most defects are due to inadequate folate***

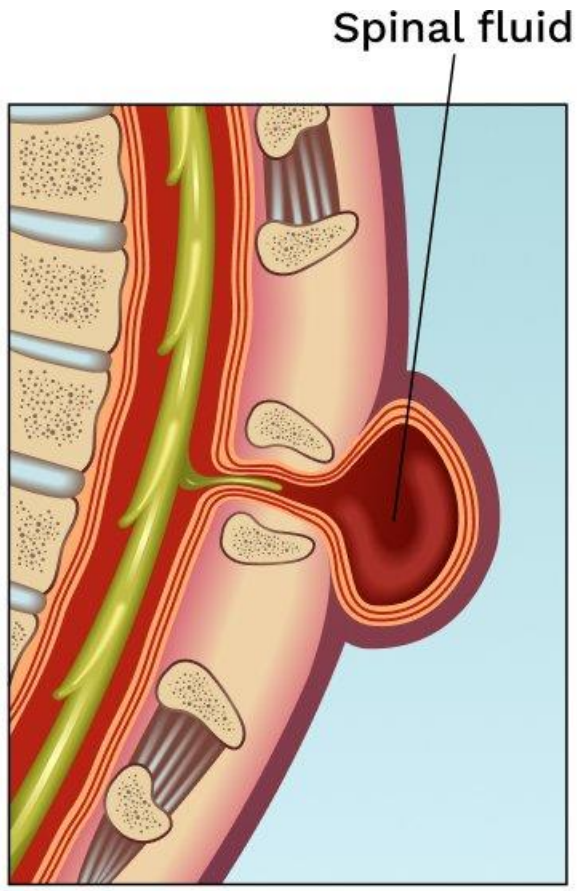
# Spina Bifida





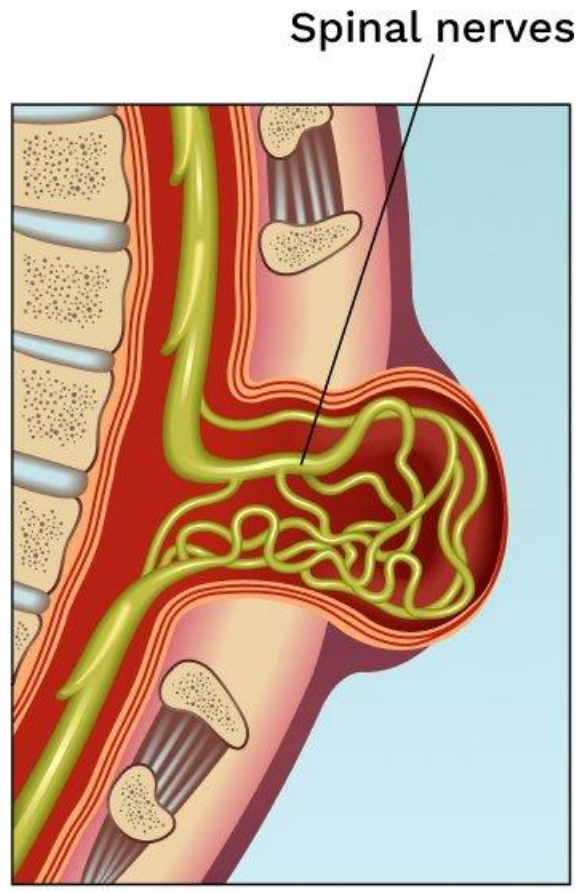

**Spina Bifida Occulta**

Defect of vertebral arch formation, no cord symptoms




**Meningocele**

Vertebral arch defect + Dura and Arachnoid protrusion




**Myelomeningocele**

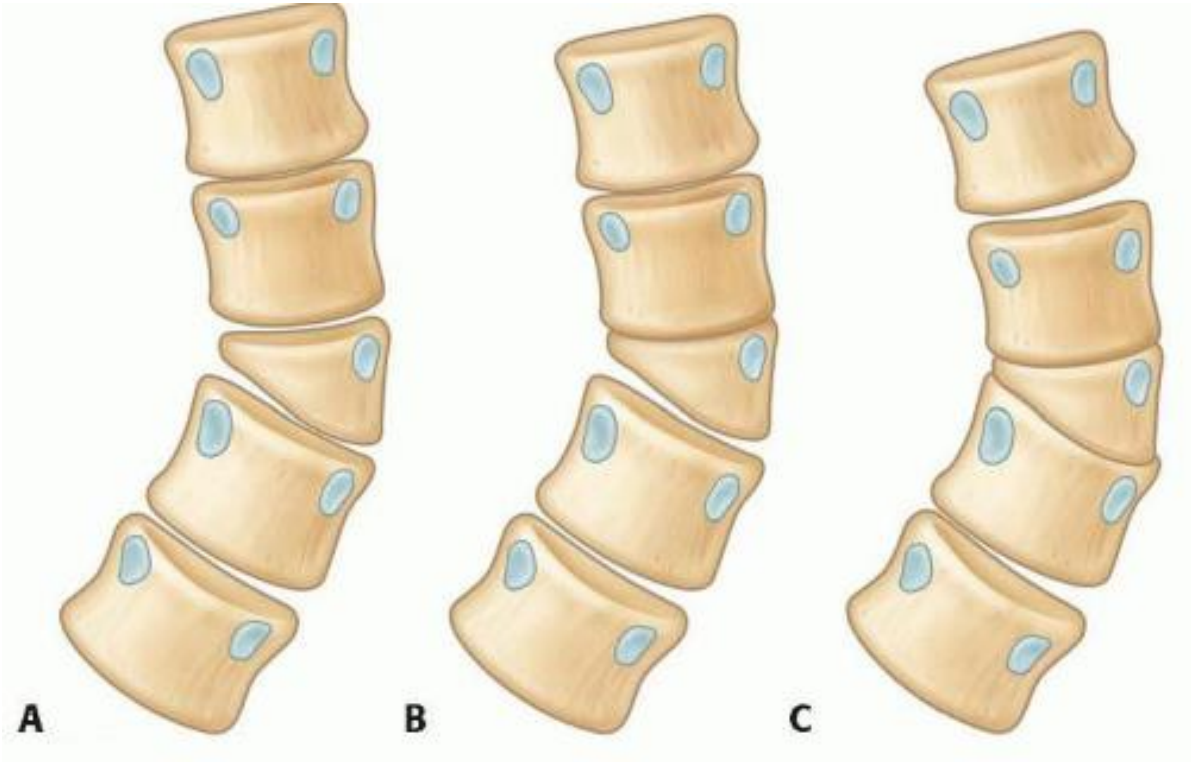
Vertebral arch defect + meninges + spinal root protrusion

Additional Terms

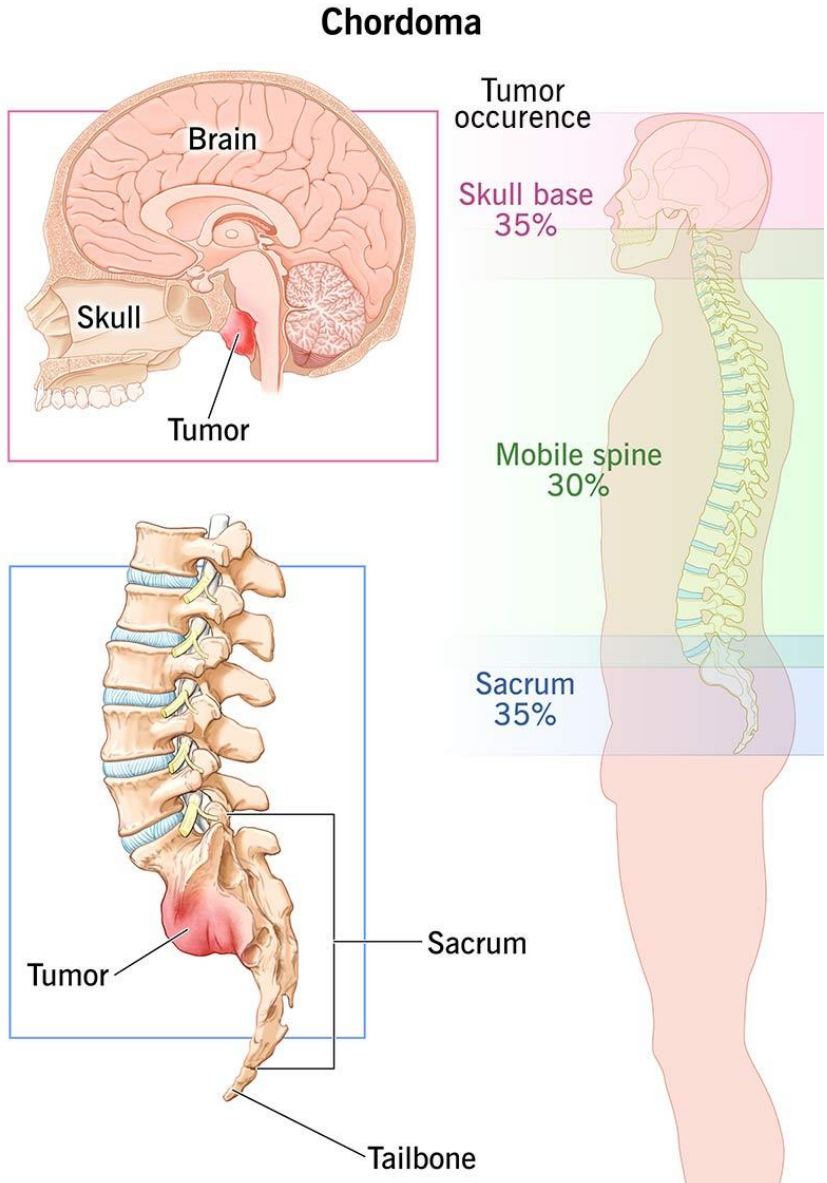
**S.B. with Myeloschisis:** Neural plate failure to close, most severe form

**Rachischisis:** Myeloschisis spanning multiple spinal segments

# Hemivertebra and Chordomas




**Hemivertebra**
Defect =One half of the chondrification center of the centrum does not occur




**Chordoma**
Tumor of the primitive notochord derivatives