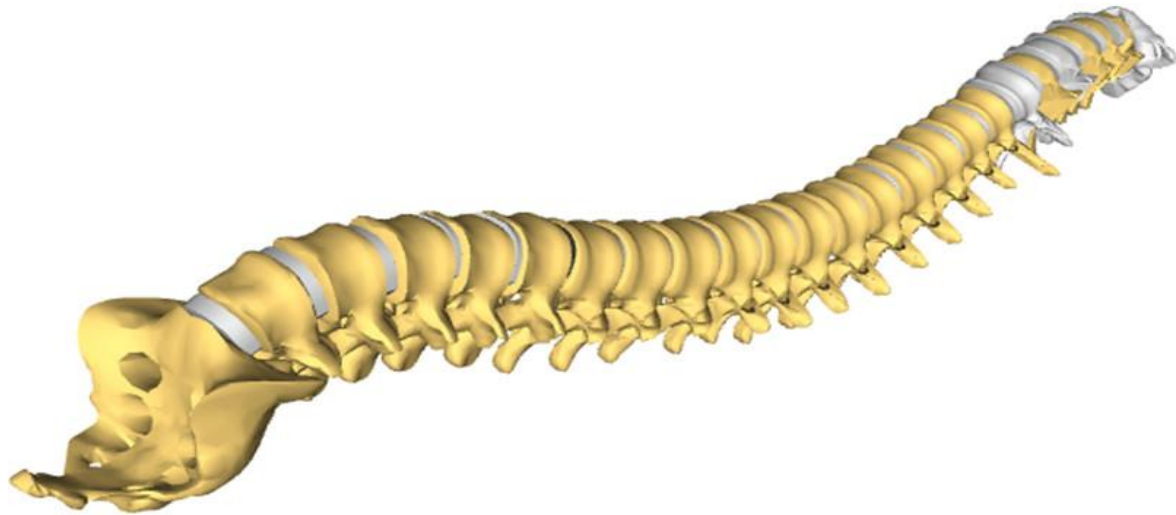
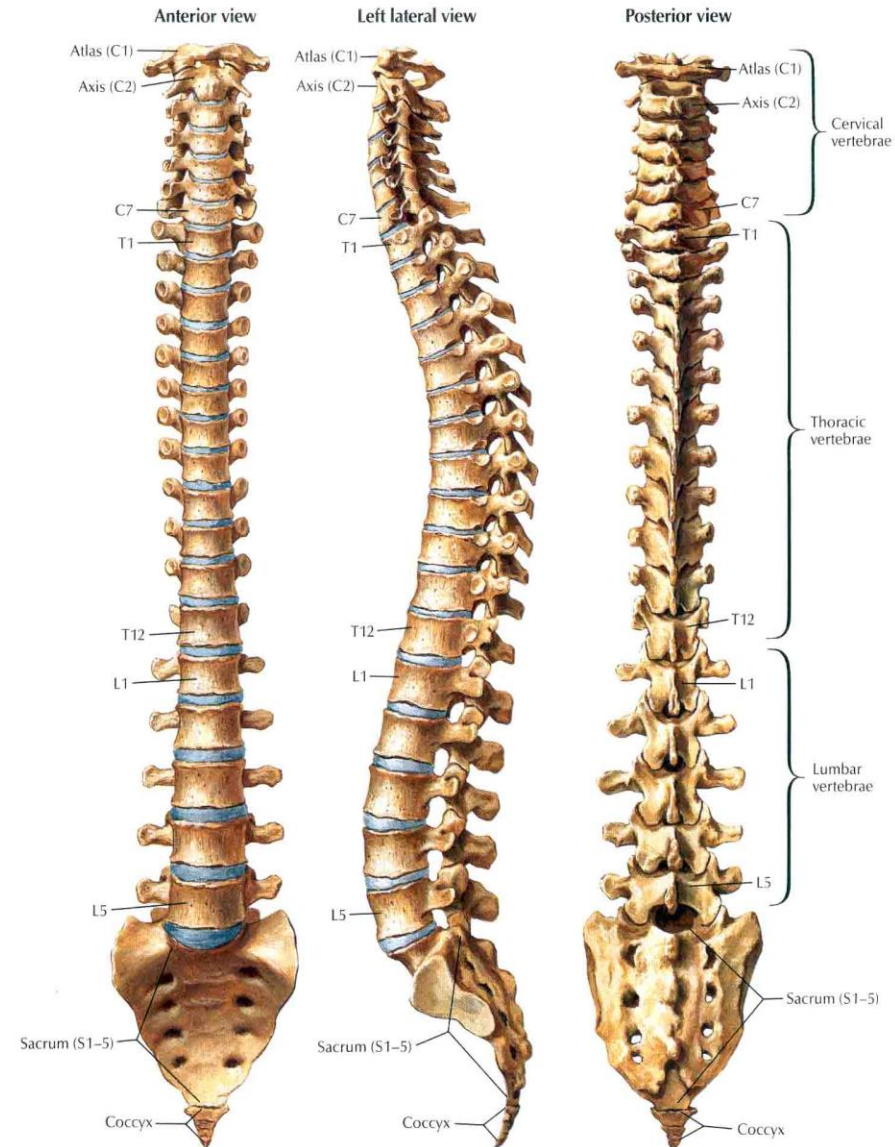


# The vertebral column

Dr.Qussay Salih AlSabbagh  
Neurosurgery department



- The vertebral column consists of 33 vertebrae (7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 3–4 coccygeal).
- These vertebrae, along with their ligaments and intervertebral discs, form the flexible, protective, and supportive vertebral column that contains the spinal cord.



# The vertebral column

- A thorough understanding of the normal relationships between these **osseous**, **discoligamentous**, and **neural elements** is essential for safe and effective surgical intervention.

# The Typical Vertebra

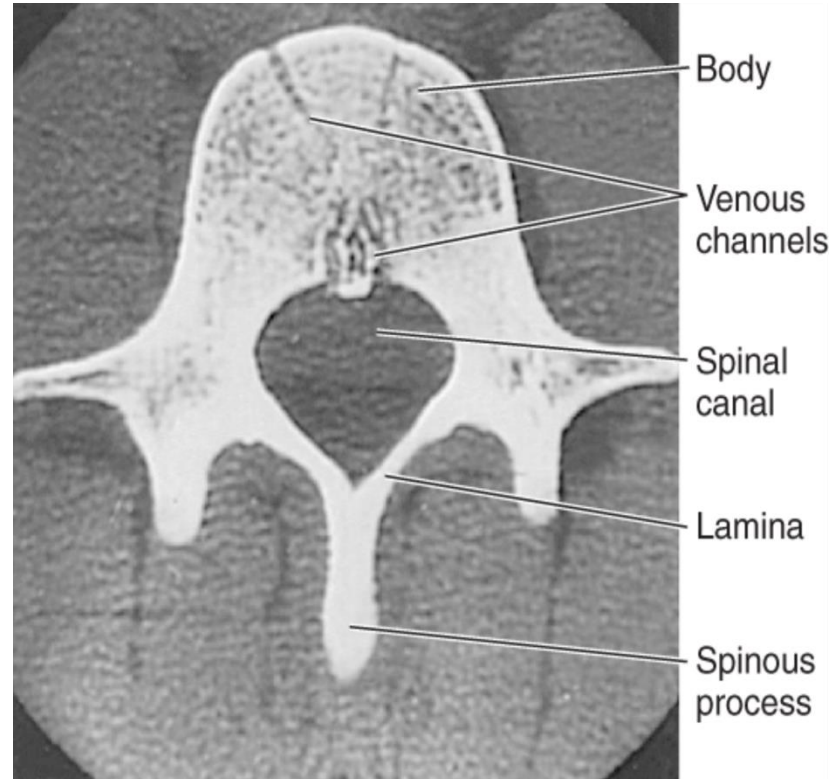
A typical vertebra consists of the followings:

**1-Body.** The anterior vertebral region that is the primary weight-bearing component of the vertebrae.

**2-Vertebral arch.** Arches posteriorly from the vertebral body and forms the vertebral foramen, which contains the spinal cord.

**3-Pedicle.** Part of the vertebral arch that joins the vertebral body to the transverse process.

**4-Transverse processes.** Extend laterally from the junction of the pedicle and lamina.



Source: Waxman SG: *Clinical Neuroanatomy: Twenty-Seventh Edition*:  
www.accessmedicine.com

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# The Typical Vertebra

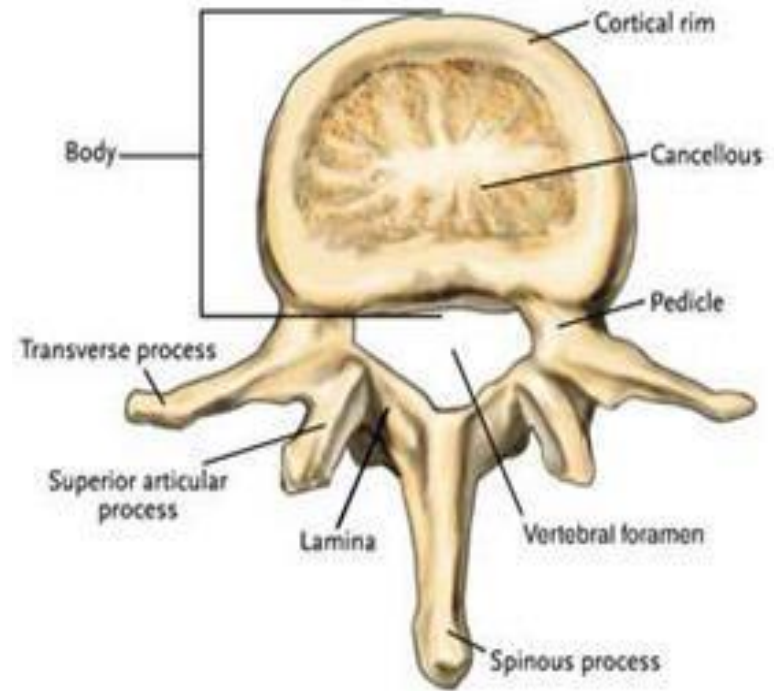
**5-Superior and inferior articular facets.** Form synovial zygapophyseal (facet) joints with the vertebrae above and below.

**6-Laminae.** The paired posterior segments of the vertebral arch that connect the transverse processes to the spinous process.

**7-Spinous processes.** The posteriorly projecting tip of the vertebral arch. These processes are easily palpated beneath the skin.

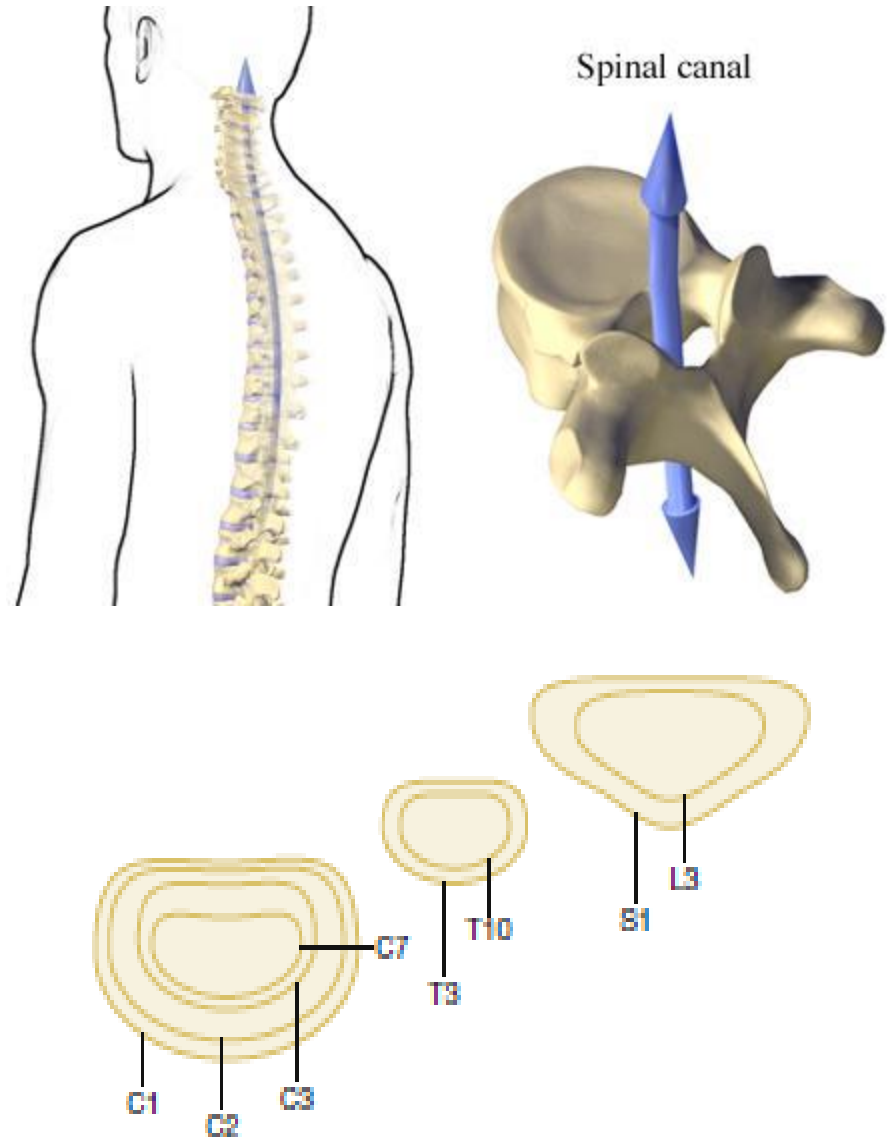
**8-Vertebral foramen.** The space in which the spinal cord, its coverings, and the rootlets of the spinal nerves lie. The series of vertebral foramina form the **vertebral canal**.

**9-Intervertebral foramina.** Bilateral foramina that form the space between pedicles of adjacent vertebrae for passage of spinal nerves.



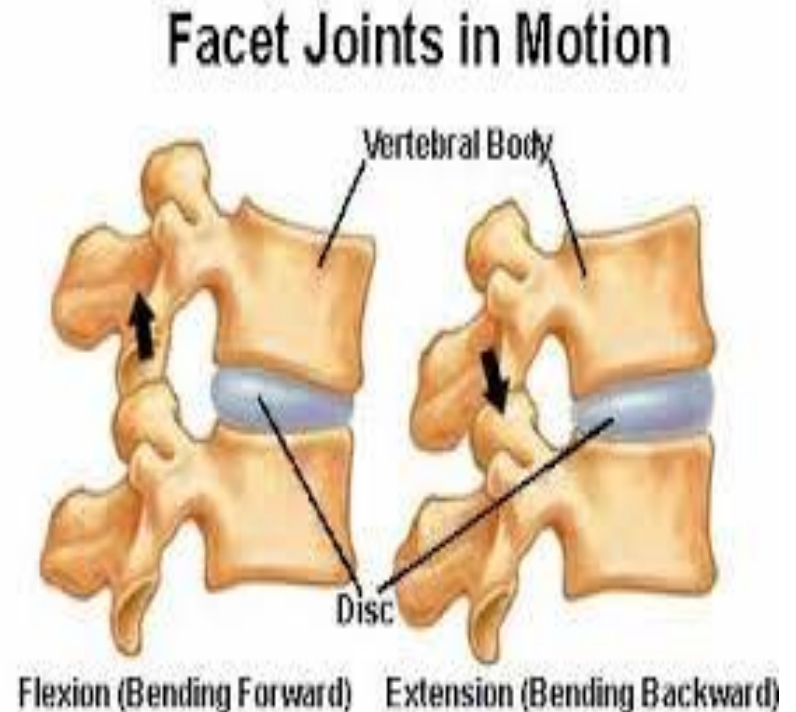
# The Spinal Canal

Spinal canal dimensions vary along the rostral-caudal axis, being greatest in the cervical region and smallest in the midthoracic region. This variation is principally due to changes in the ventral-dorsal diameter.



# The discoligamentous structures: Vertebral Articulations

- There are two types of articulations that enable the 33 vertebrae to not only provide support, protection, and absorb shock, but also to provide **flexibility**.
- These two articulations are the **intervertebral discs** and the **zygapophyseal joints**.

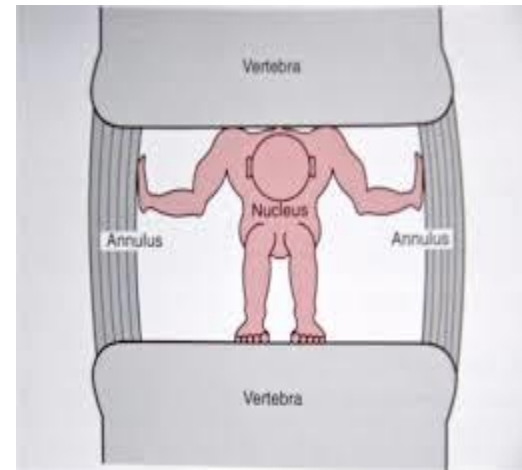
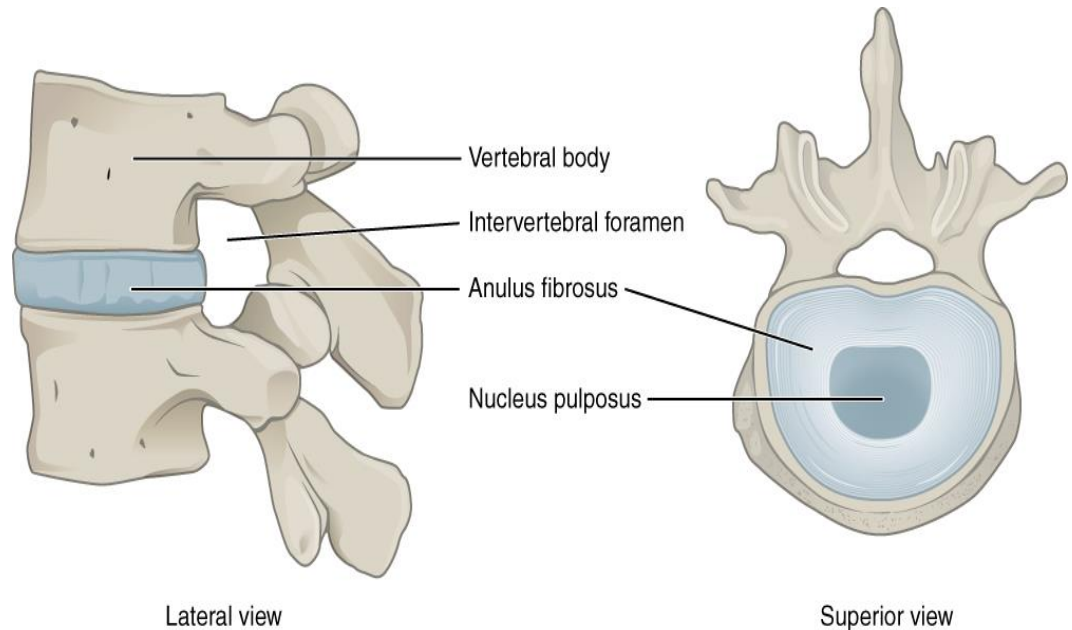




# The Intervertebral discs

The general function of the intervertebral disc is twofold:

- (1) It deforms to accommodate compressive loads, a role assumed by **the nucleus pulposus**, and
- (2) It resists tensile and torsional stresses, a role assumed by **the annulus fibrosus**

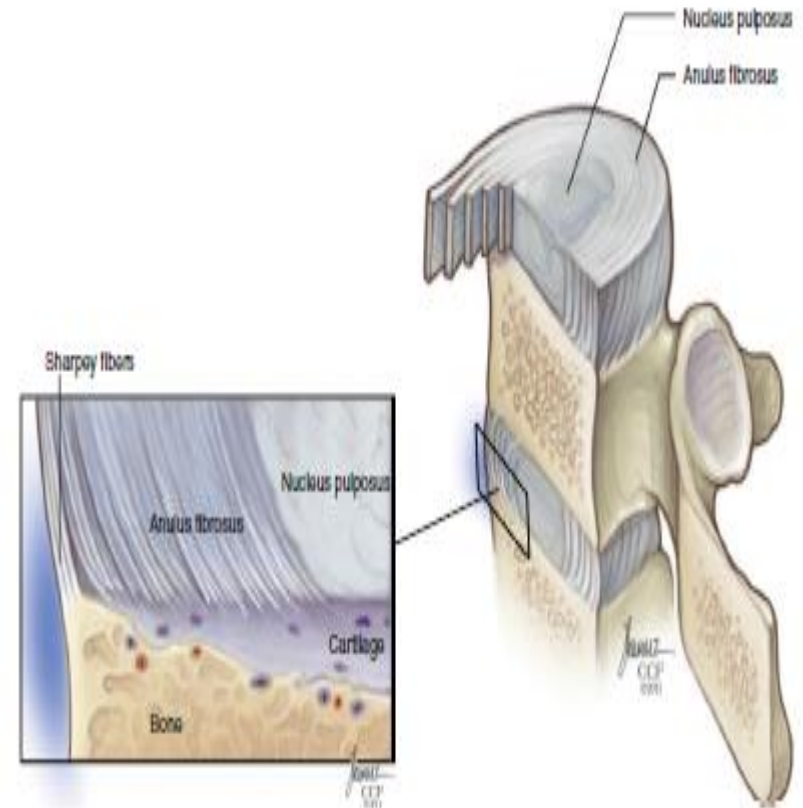




# The Intervertebral discs

At a microscopic level, the **nucleus pulposus** consists of a semifluid, gel-like substance embedded in a fine meshwork of fibrous strands. This structure results in a viscoelastic property that allows the disc to withstand and absorb axial stress.

The **anulus fibrosus** has a lamellated boundary of intersecting fibrous strands. Anular fibers known as **Sharpey fibers** penetrate the dense cortical bone that makes up the outer ring of the vertebral end plate.



- **Damage to the annulus fibrosus** may allow the softer nucleus pulposus to bulge or herniate, which may compress the segmental nerve roots. This is often referred to as a “**prolapsed or herniated disc**”.







# Level of herniation

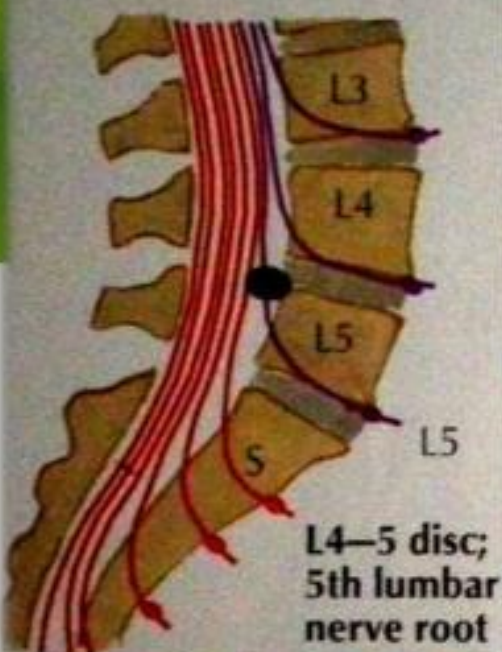
## Pain

## Numbness

## Weakness

## Atrophy

## Reflexes



Over  
sacro-  
iliac  
joint,  
hip,  
lateral  
thigh  
and leg



Lateral leg,  
first 3 toes

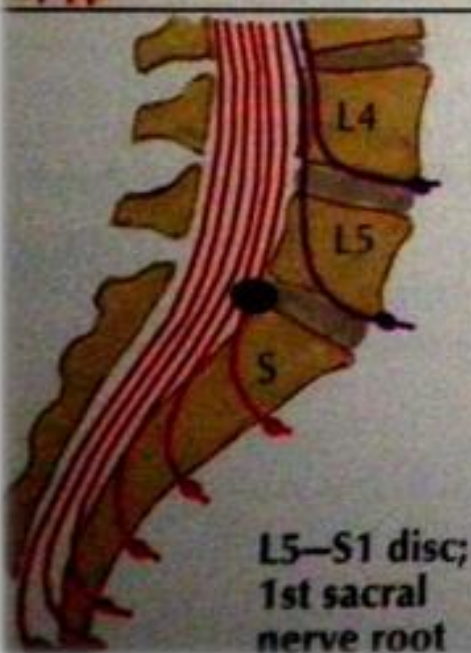


Dorsiflexion  
of great toe  
and foot;  
difficulty  
walking on  
heels; foot  
drop may  
occur

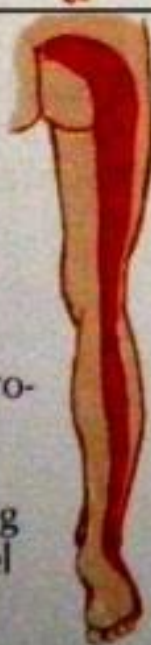


Minor

Changes  
uncommon  
in knee and  
ankle jerks,  
but internal  
hamstring  
reflex  
diminished  
or absent



Over  
sacro-  
iliac  
joint,  
hip,  
postero-  
lateral  
thigh  
and leg  
to heel



Back of  
calf, lateral  
heel, foot  
to toe



Plantar  
flexion of  
foot and  
great toe  
may be  
affected;  
difficulty  
walking on  
toes



Gastrocnemi-  
us and soleus

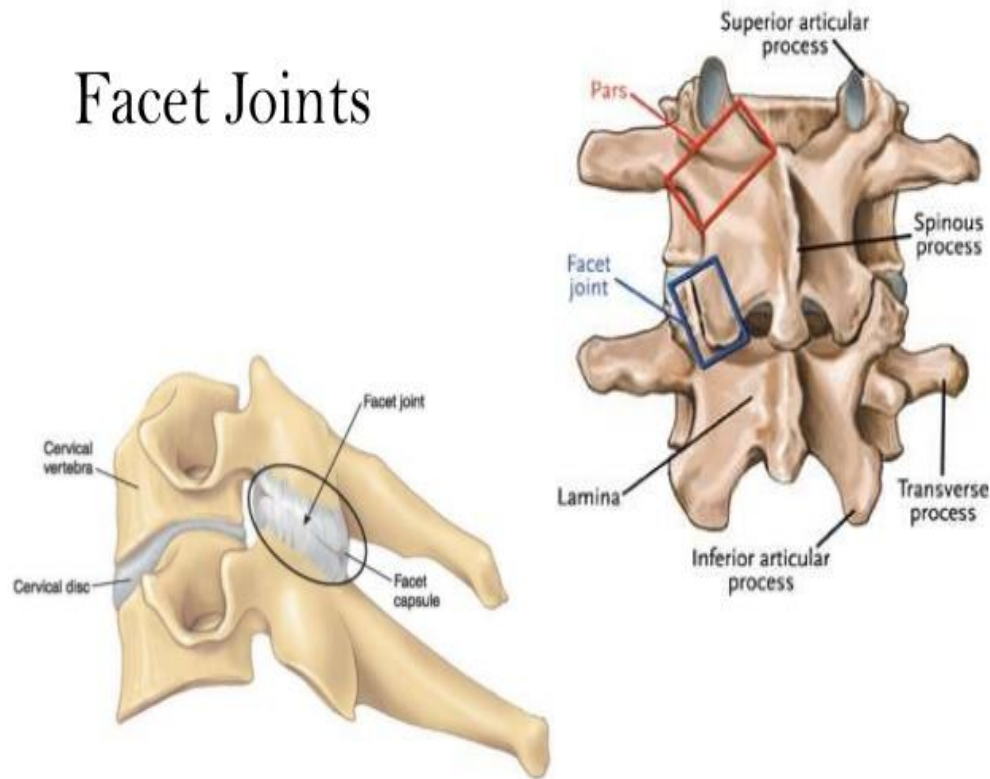


Ankle jerk  
diminished  
or absent

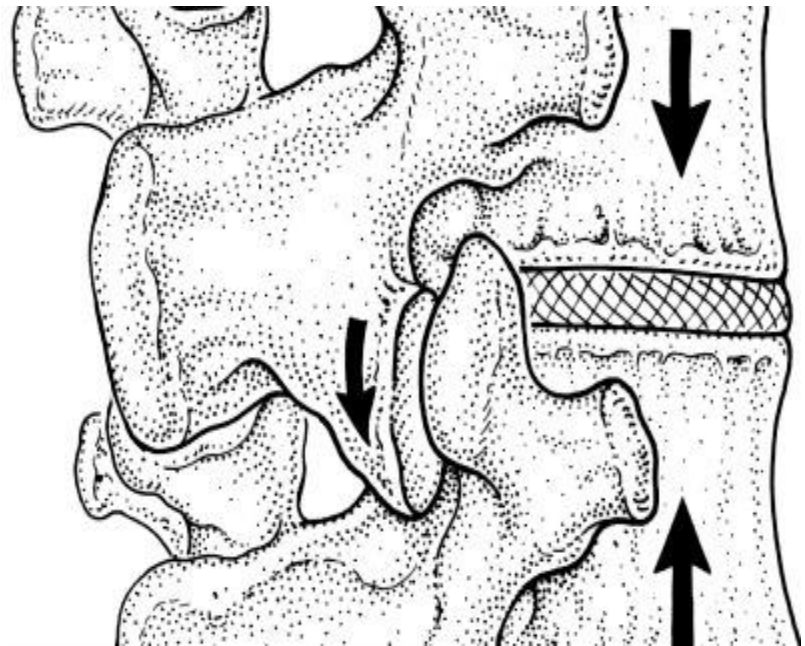
# Zygapophyseal joints(facet)

The facet joint, or zygapophyseal joint, is formed by an inferior articulating process emanating from the level above and a superior articulating process emanating from the level below.

Facet Joints



- The facet joint is a **synovial joint**, possessing a true joint capsule. Gliding articulation at the facet joint is limited by the capsular fibers, which are relatively lax in the cervical region but increase in tautness along the rostral caudal axis.





# Facet joint block for low back pain



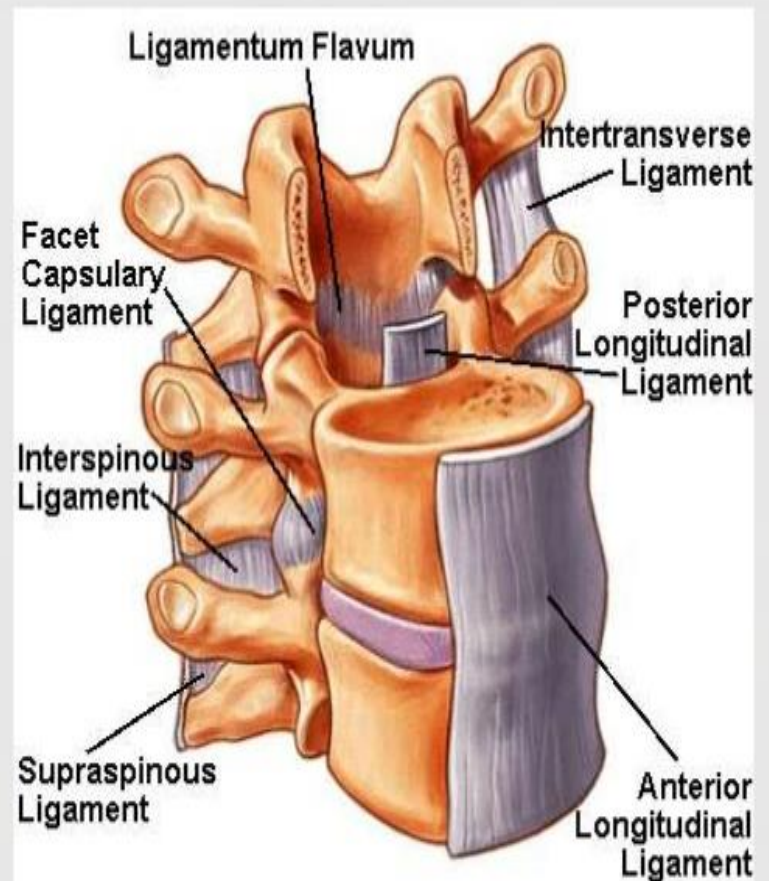


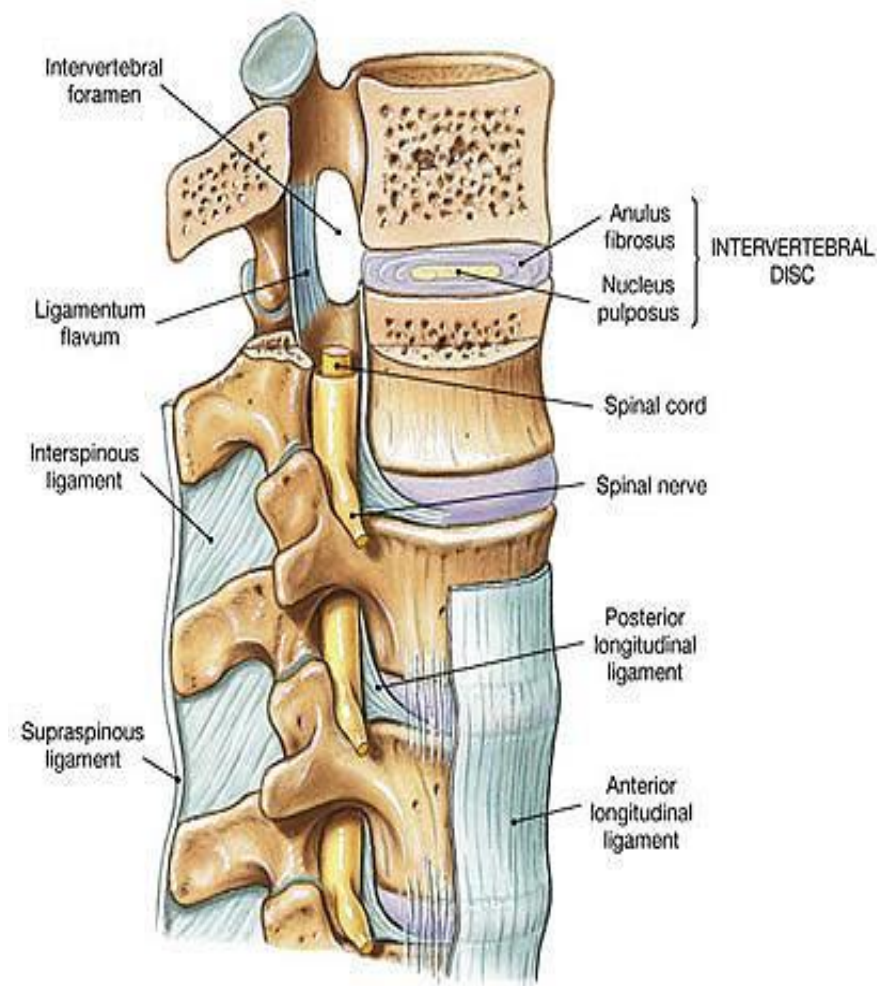
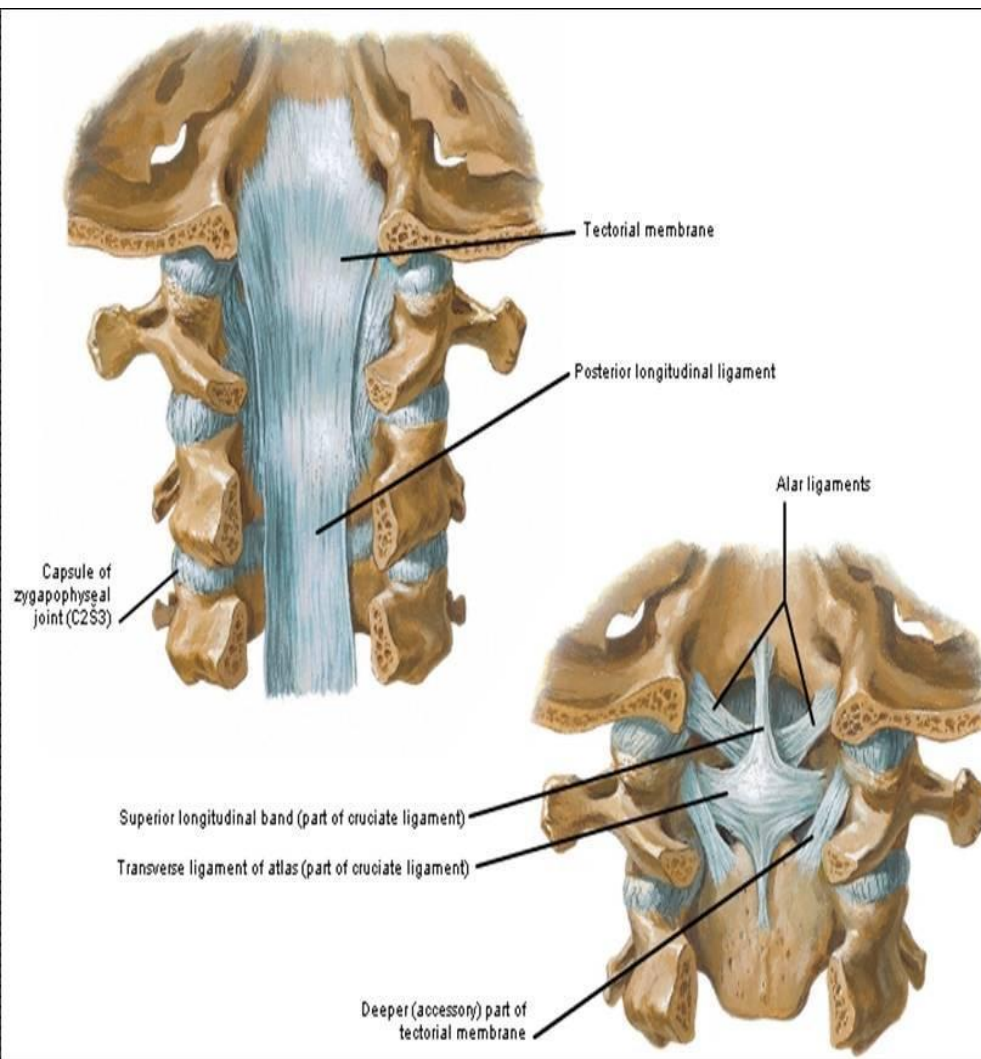
Important

# Vertebral Ligaments

- **Ligamentum flavum.**
- **Supraspinous ligament.**  
Connects the apices of the spinous processes from C7 to the sacrum.
- **Interspinous ligament.**  
Connects adjoining spinous processes.
- **Nuchal ligament.** Extends from the external occipital protuberance along the spinous processes of C1–C7.
- **Posterior longitudinal ligament.**
- **Anterior longitudinal ligament.**

## SPINAL LIGAMENTS





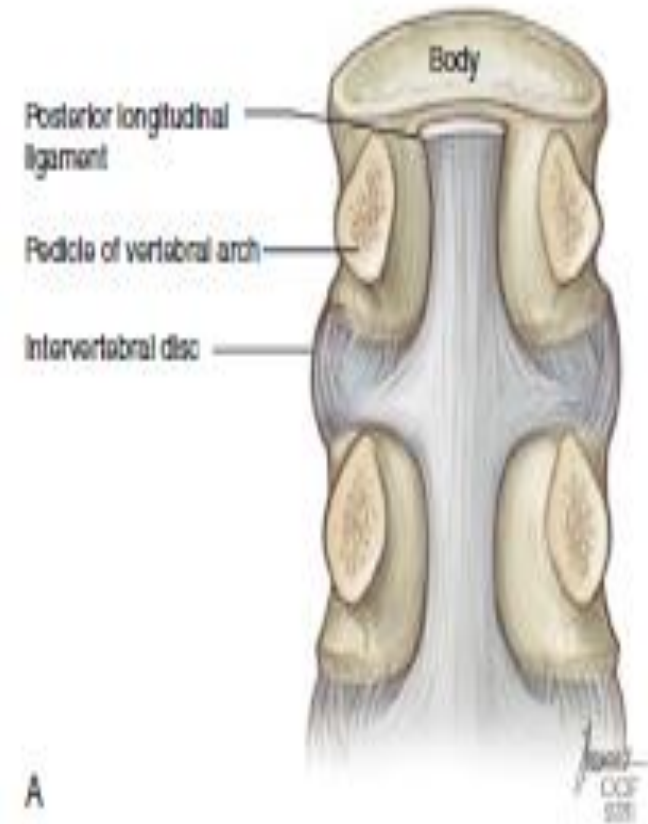
# Anterior Longitudinal Ligament

- (ALL) is a strong, broad ligament that spans the ventral surface of all the vertebral bodies.
- Its width increases along the rostral-caudal axis; at the lower lumbar levels, it encompasses almost half of the total circumference of the vertebral body.
- Because of relative strength, the ALL is an important contributor to spine stability, particularly in the lumbar spine. It resists hyperextension and, to a lesser degree, translational motion.



# Posterior Longitudinal Ligament

- (PLL) also spans the full rostral-caudal axis of the spine . It is located along the dorsal surface of the vertebral bodies, within the spinal canal .
- At the midbody level, it is relatively narrow, but it **widens considerably at the level of the disc** before narrowing again as it transitions to the level below.
- It is adherent at the level of the end plate and annulus but elevated from the concave dorsal surface of the midvertebral body.
- Although the PLL's contribution to spine stability is modest, it serves to direct disc herniations dorsolaterally, away from the central portion of the spinal canal.

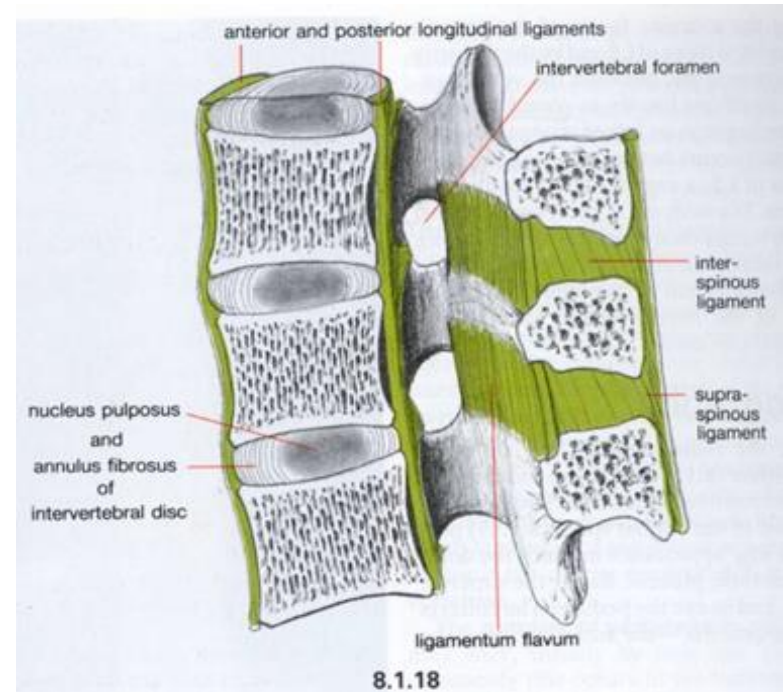




Important

# Ligamentum Flavum

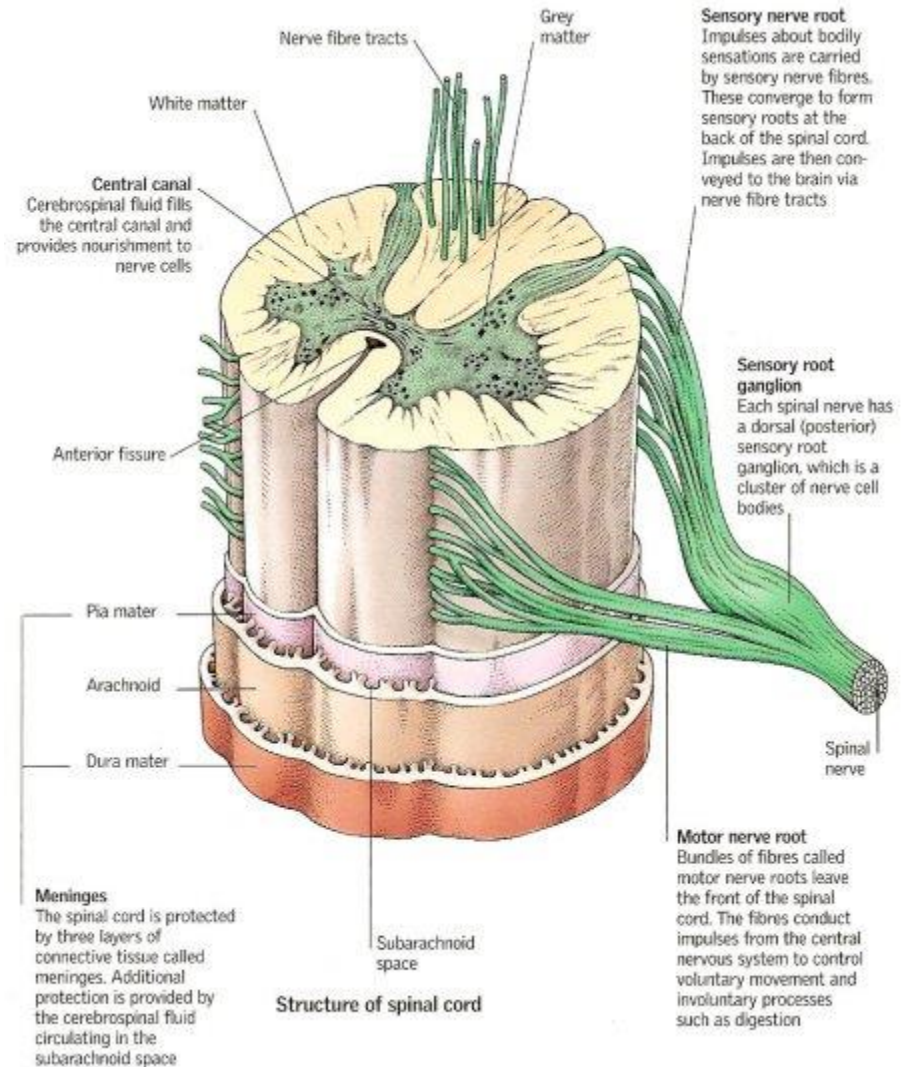
- The ligamentum flavum is a thick, yellow ligament that goes from the sacrum to C2.
- Its characteristic appearance and consistency result from a relatively increased ratio of **elastic** to collagen fibers.
- The ligamentum flavum is **discontinuous**, emanating from the rostral surface of the lamina below, spanning the interlaminar space, and inserting on the ventral surface of the lamina above
- Hypertrophy of this ligament can cause spinal canal stenosis – narrow canal in hyperextension.



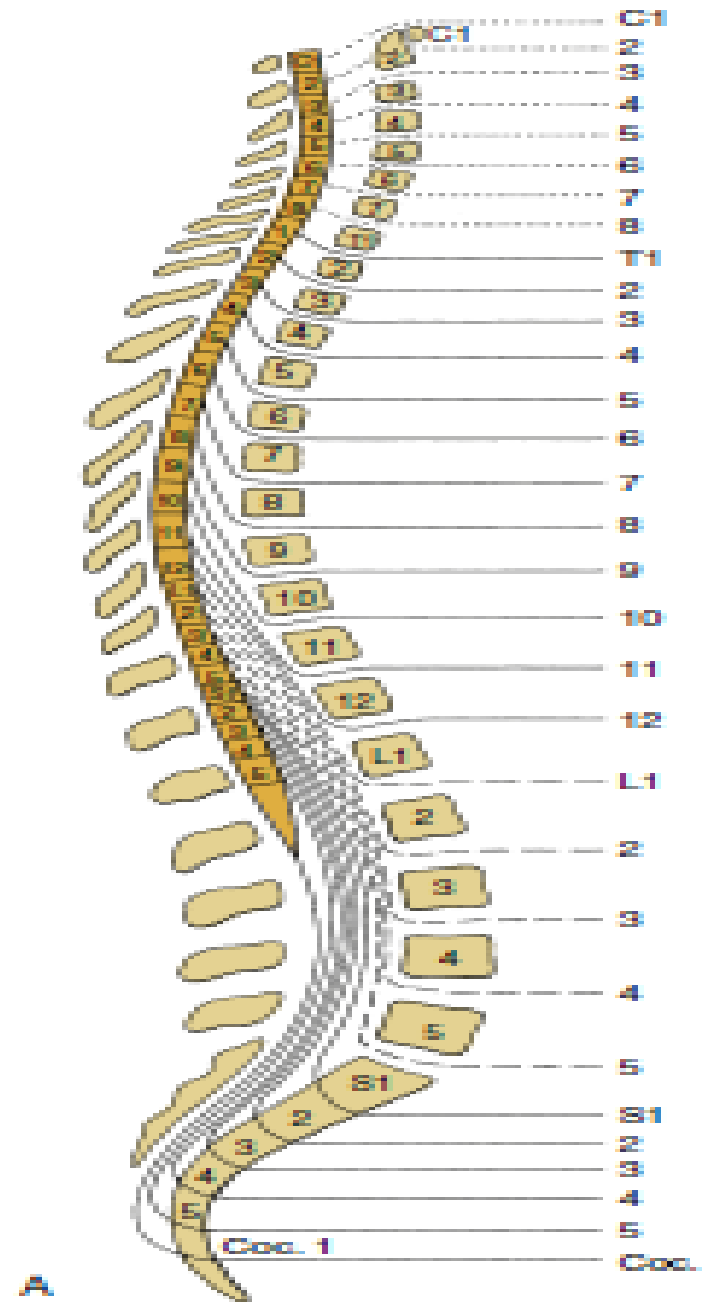
# THE NEURAL STRUCTURES

## Spinal Cord

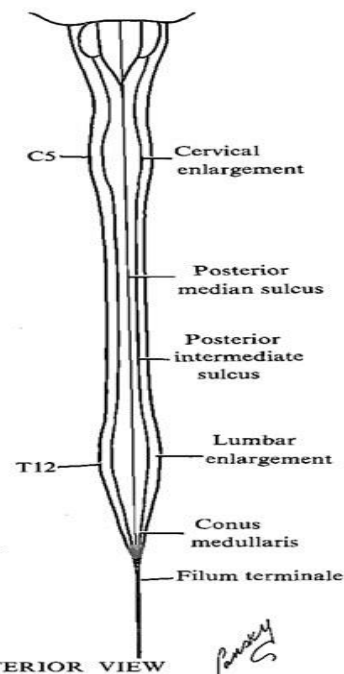
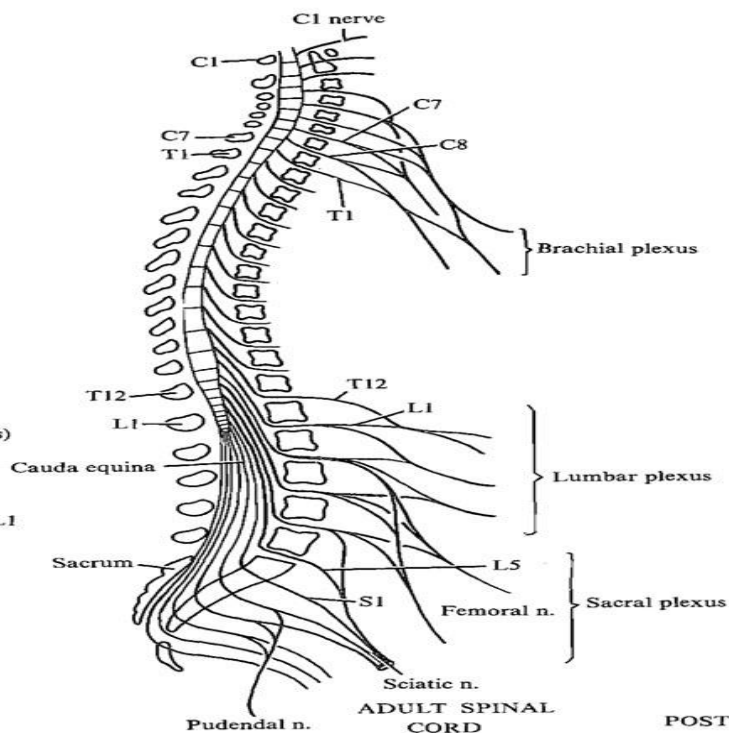
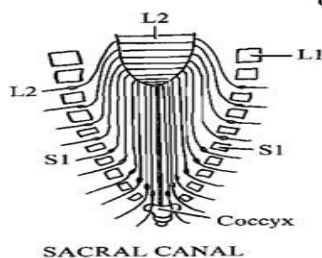
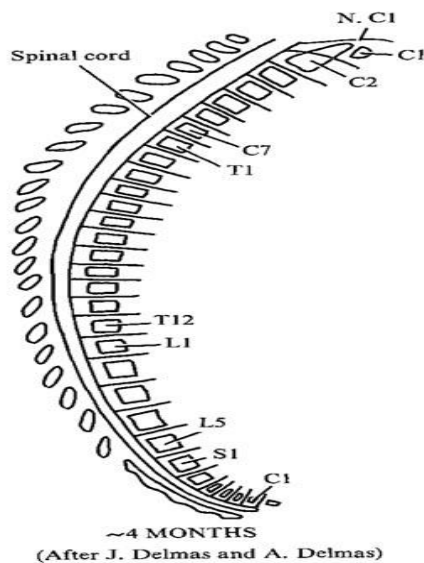
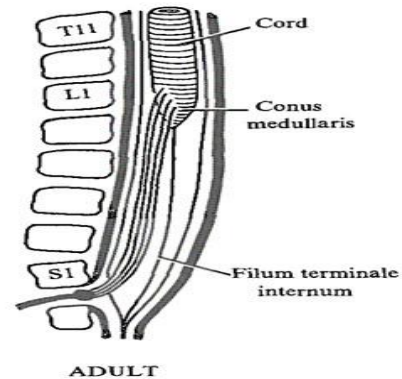
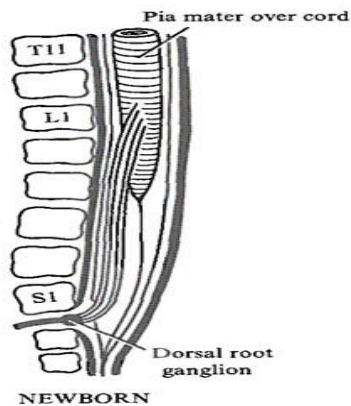
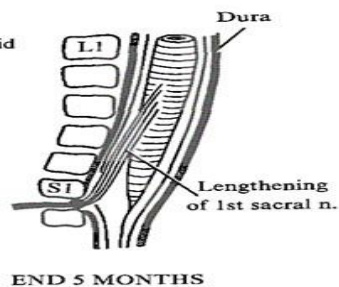
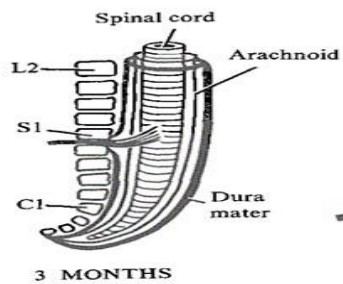
- The gray matter of the spinal cord is divided into a **ventral motor** portion and a **dorsal sensory** portion.
- Major white matter tracts are depicted in . **Somatotopy** of white matter tracts is usually such that fibers to rostral segments are positioned medial to fibers to more caudal segments.



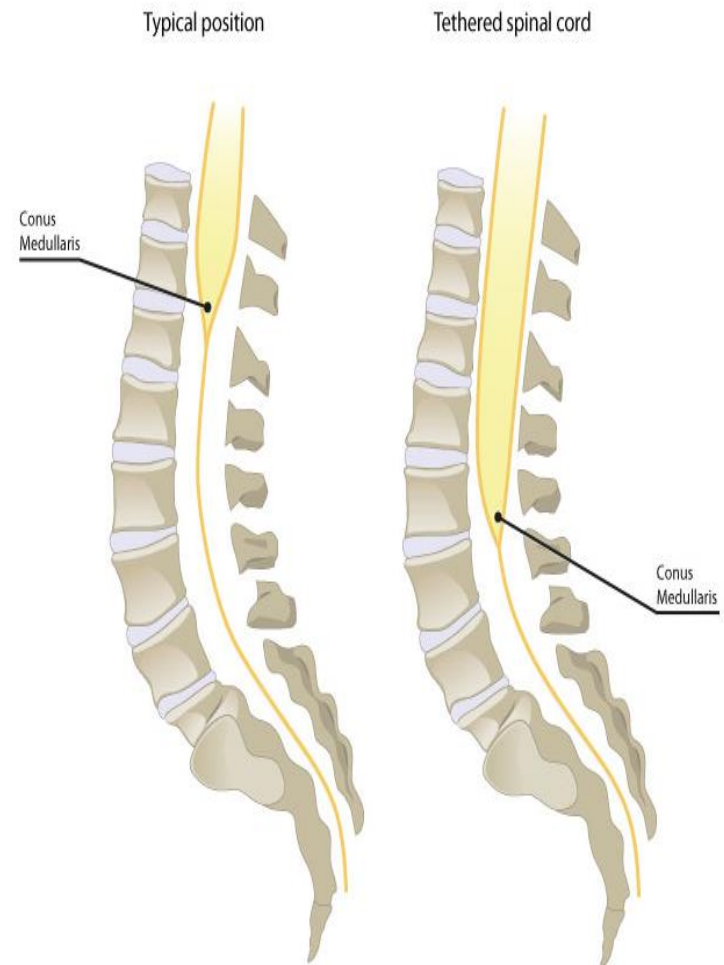
- During fetal development and childhood, the vertebral column grows **faster** than the spinal cord, resulting in ascension of the conus medullaris within the spinal canal.
- In the normal adult, the **conus typically terminates at L1**, though it may occupy positions ranging from T11-12 to the upper vertebral body of L3.







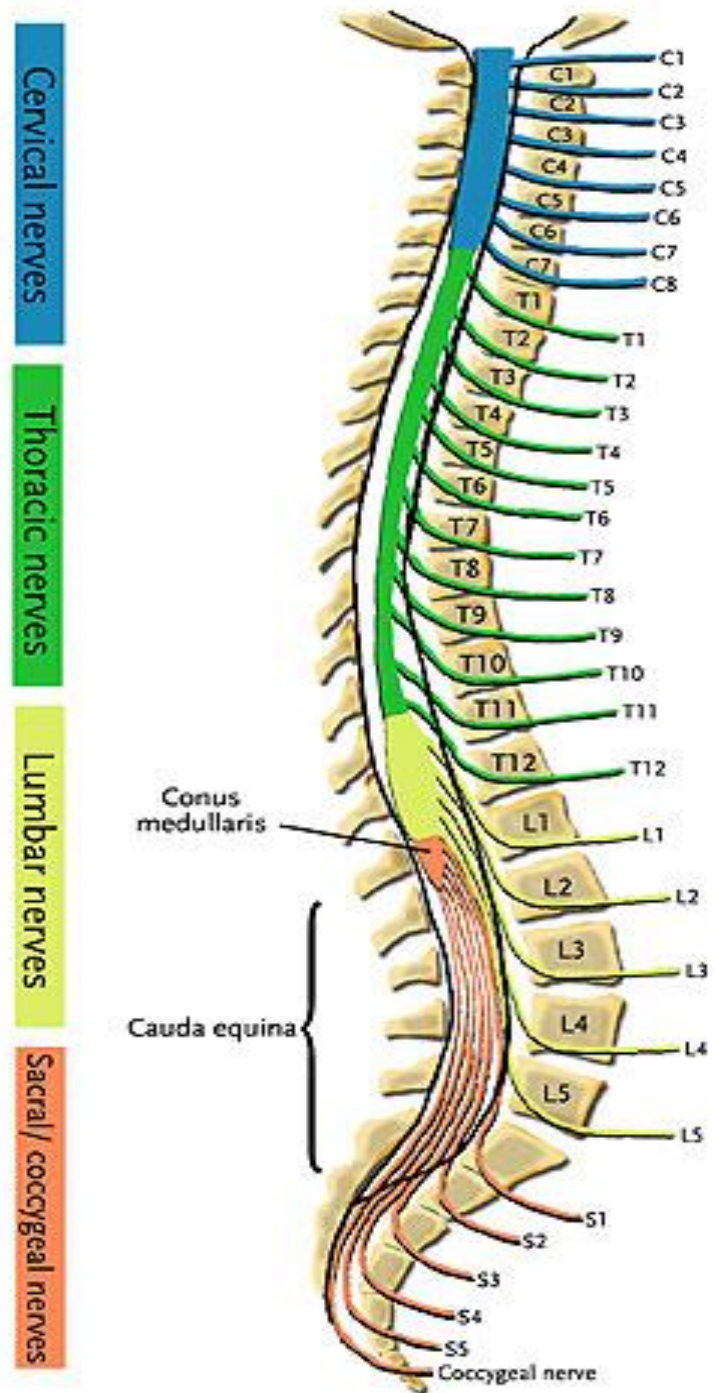
- **Tethered spinal cord syndrome** is a neurological disorder caused by tissue attachments that limit the movement of the spinal cord within the spinal column, resulting in low lying conus medullaris.





There is a discordance between **spinal level** (the level defined by spinal rootlets' origin) and **vertebral level** (the level of the neural foramen).

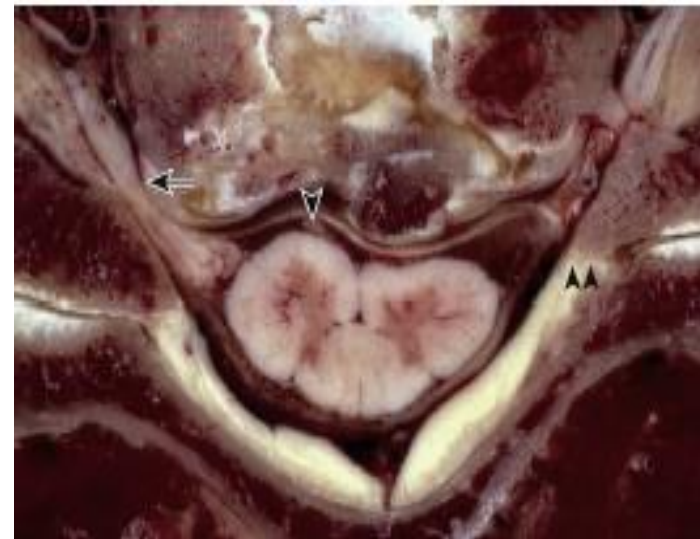
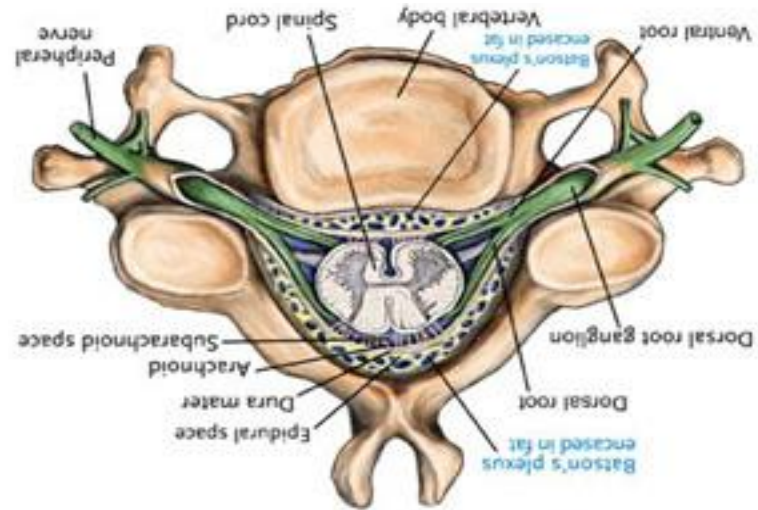
A fracture-dislocation in the upper and midthoracic spine will typically cause cord injury at the level of injury or one level below. A fracture-dislocation in the lower thoracic spine would be expected to cause cord injury two or more levels caudal to the bony injury.





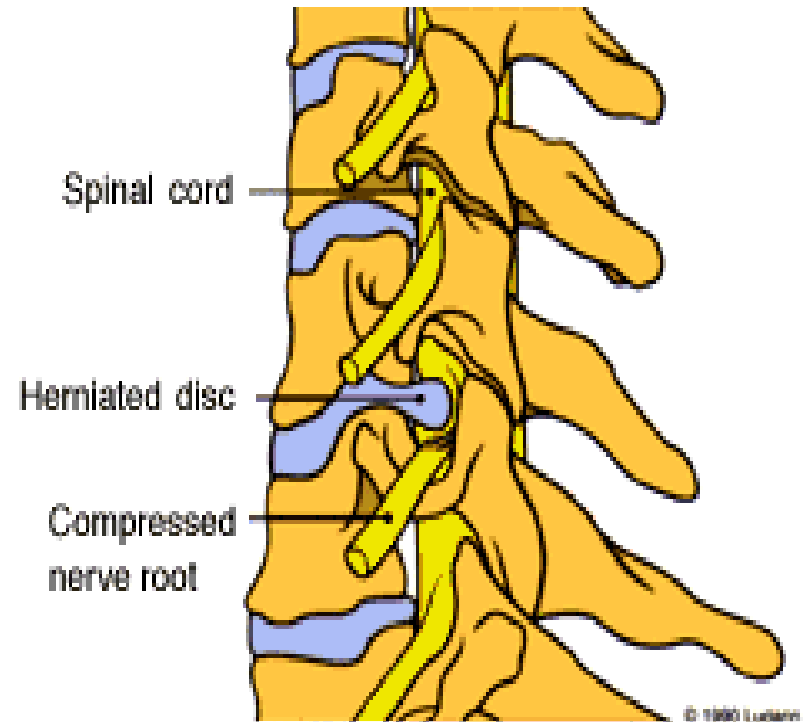
# Intradural nerve roots

- The spinal nerves represent the union of ventral and dorsal roots that arise independently from the spinal cord . Each root, in turn, represents the union of numerous rootlets that arise from the anterolateral sulcus (for the ventral root) and posterolateral sulcus (for the dorsal root).



# The cervical roots

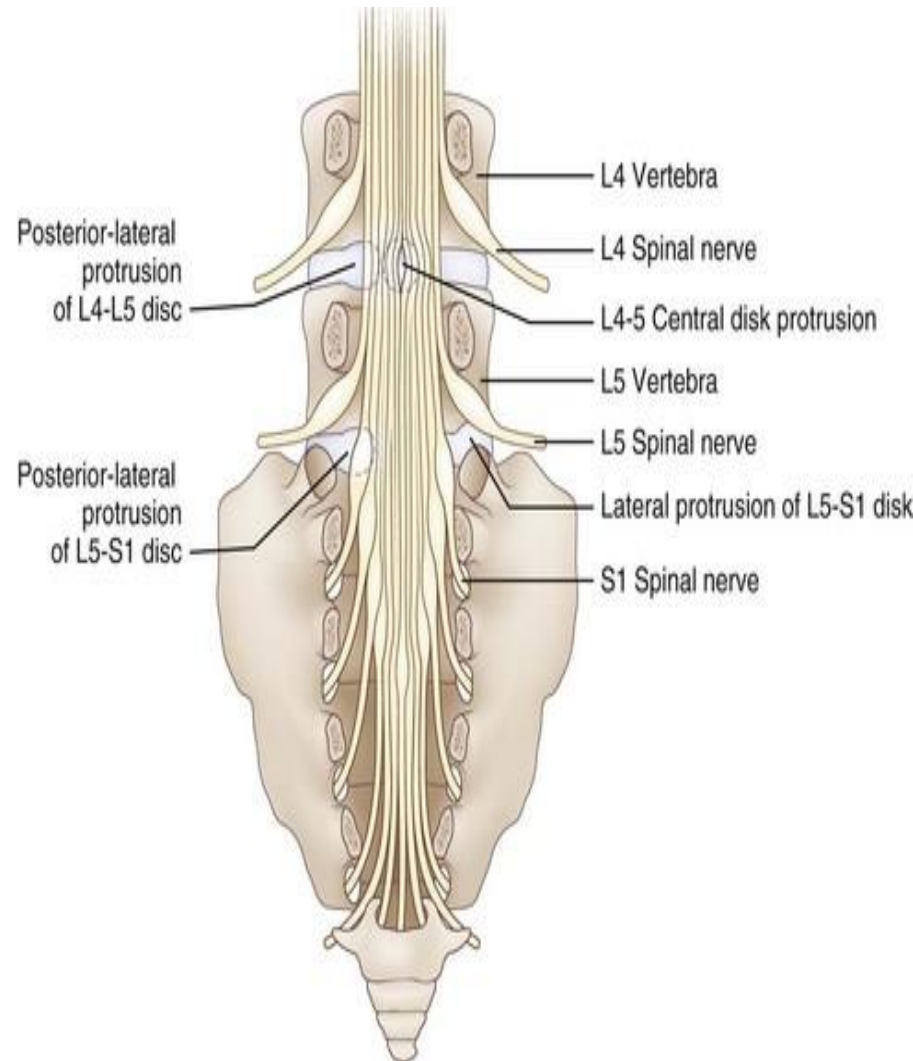
- The ventral and dorsal roots both traverse the intervertebral neural foramen **above their same-numbered pedicle** (i.e., the C5 nerve roots exit in the C4-5 neural foramen, above the C5 pedicle). The C8 pedicle exits the C7-T1 intervertebral foramen.
- The first cervical root does not have a dorsal root ganglion and consequently does not have a corresponding sensory dermatome.



**Figure 2** *Herniated cervical disc pressing on nerve root and spinal cord*

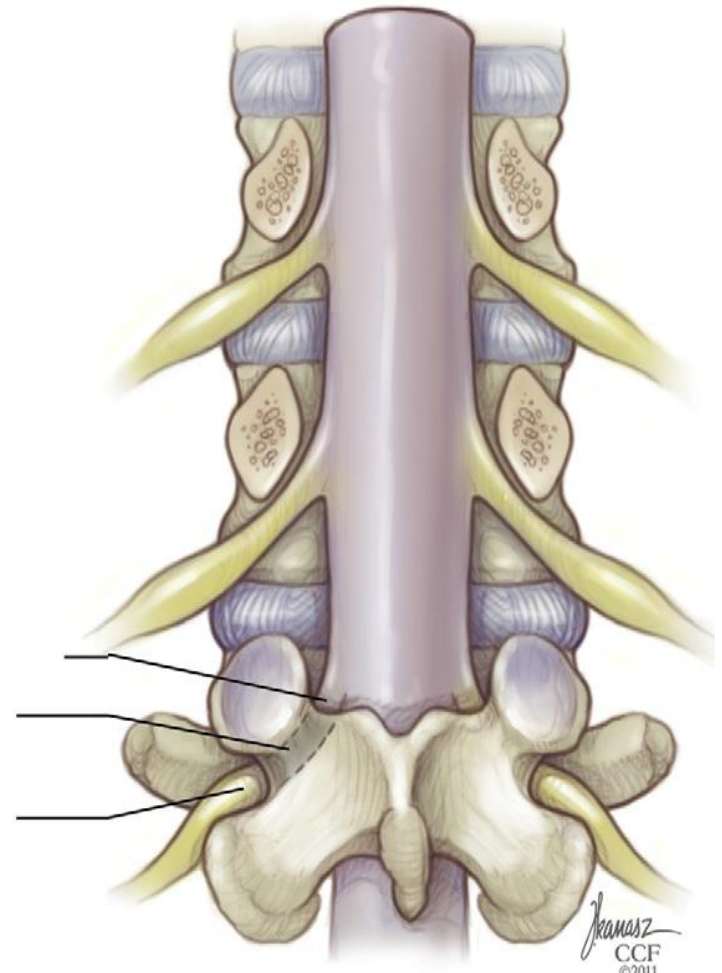
# The Cauda Equina

- The descending intradural roots of the cauda equina possess a rough **somatotopy** that may be of practical use during intradural procedures.
- Sacral roots tend to occupy a more central position within the canal (having emanated from the tip of the conus), while lower lumbar roots are located in a paramedian position and upper lumbar roots are located most laterally.



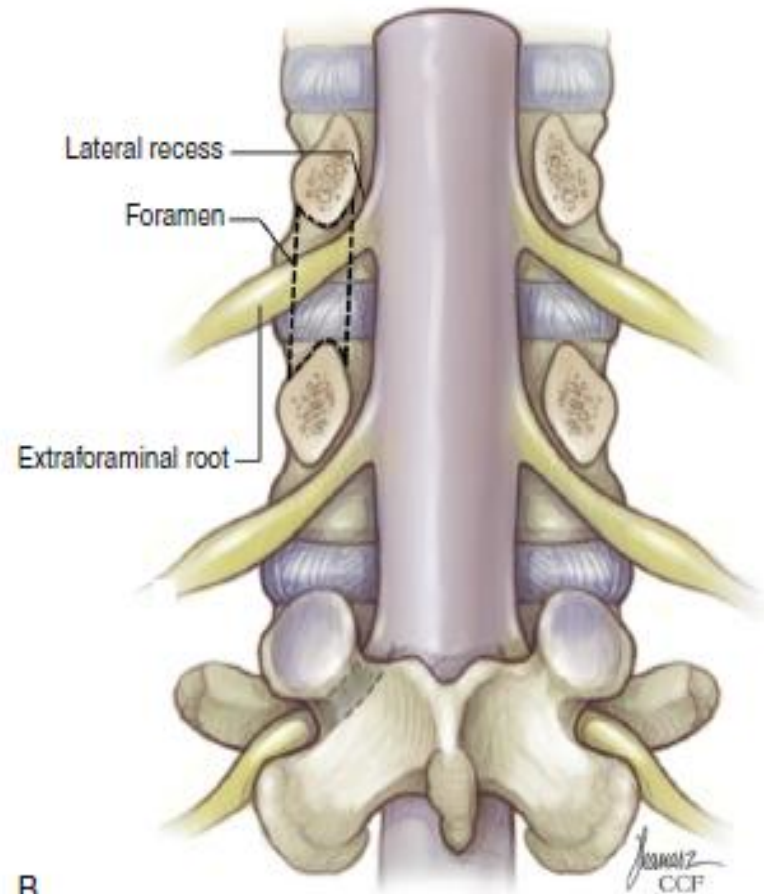


- At the lateral border of the thecal sac, each root becomes ensheathed in dura.
- In the lumbar spine, the root angles **obliquely** downward to pass below the like-numbered pedicle; in so doing, it crosses the plane of the intervertebral disc. In the cervical spine, by contrast, the nerve takes a relatively **horizontal** course to its corresponding foramen (above the like-numbered pedicle).

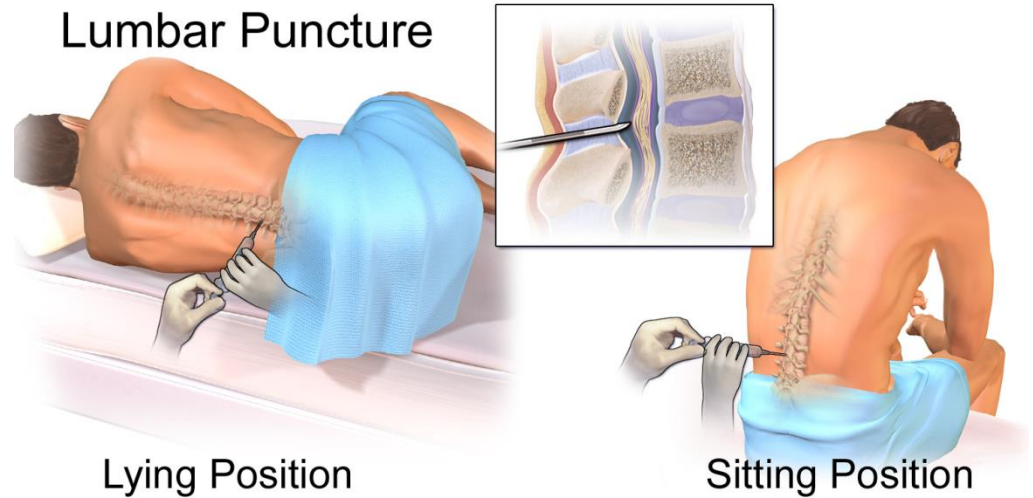
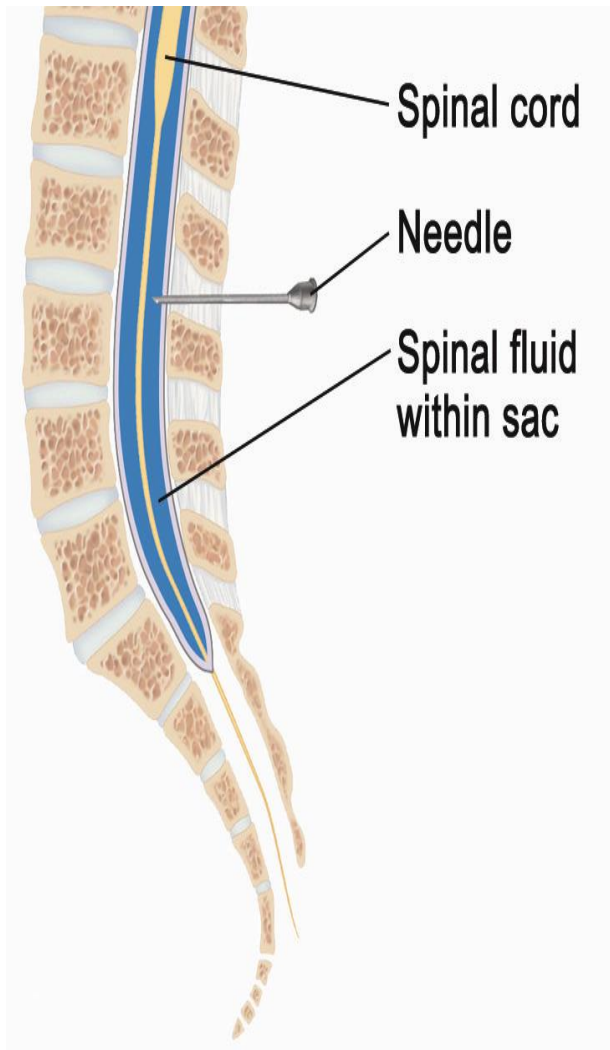


# The lateral recess& neural foramen

- Before entering the neural foramen, a nerve root traverses the **lateral recess**: is a space defined medially by the edge of the thecal sac and laterally by the medial pedicular plane at the level of the midvertebral and lower vertebral body .
- **The neural foramen** is a space defined rostrally by the pedicle, caudally by the pedicle, ventrally by the inferior portion of the vertebral body and the intervertebral disc, and dorsally by the superior articular process of the level below, with its capsular covering .

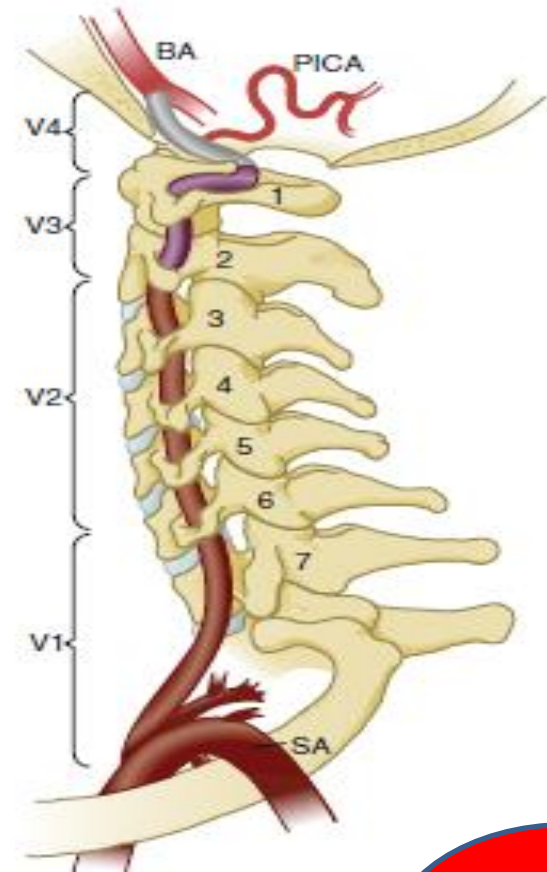


# Lumbar puncture



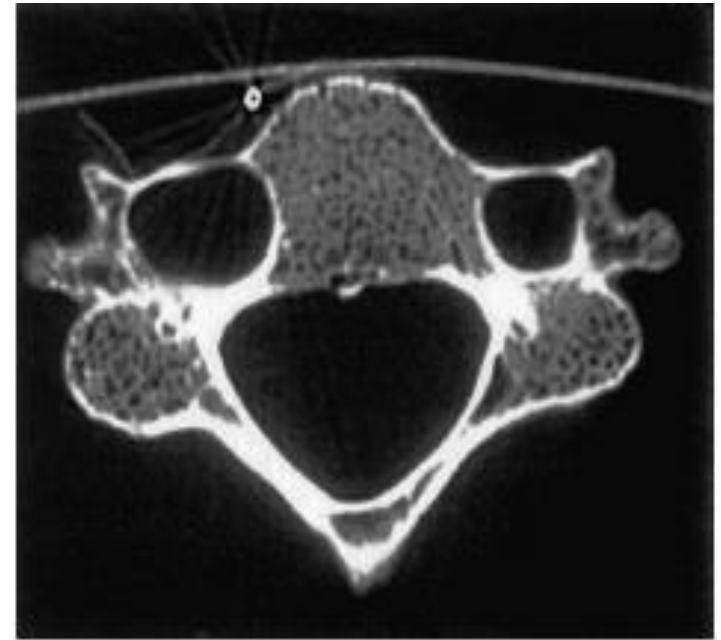
# Vascular Anatomy- Vertebral Artery Anatomy

- The vertebral arteries are paired vessels that lie close to the cervical spine.
- The course of the vertebral artery is divided into four segments.
- The V1 segment represents the segment from origin until the artery enters its first foramen transversarium. In 87.5% of cases, this is at the C6 level.



Important

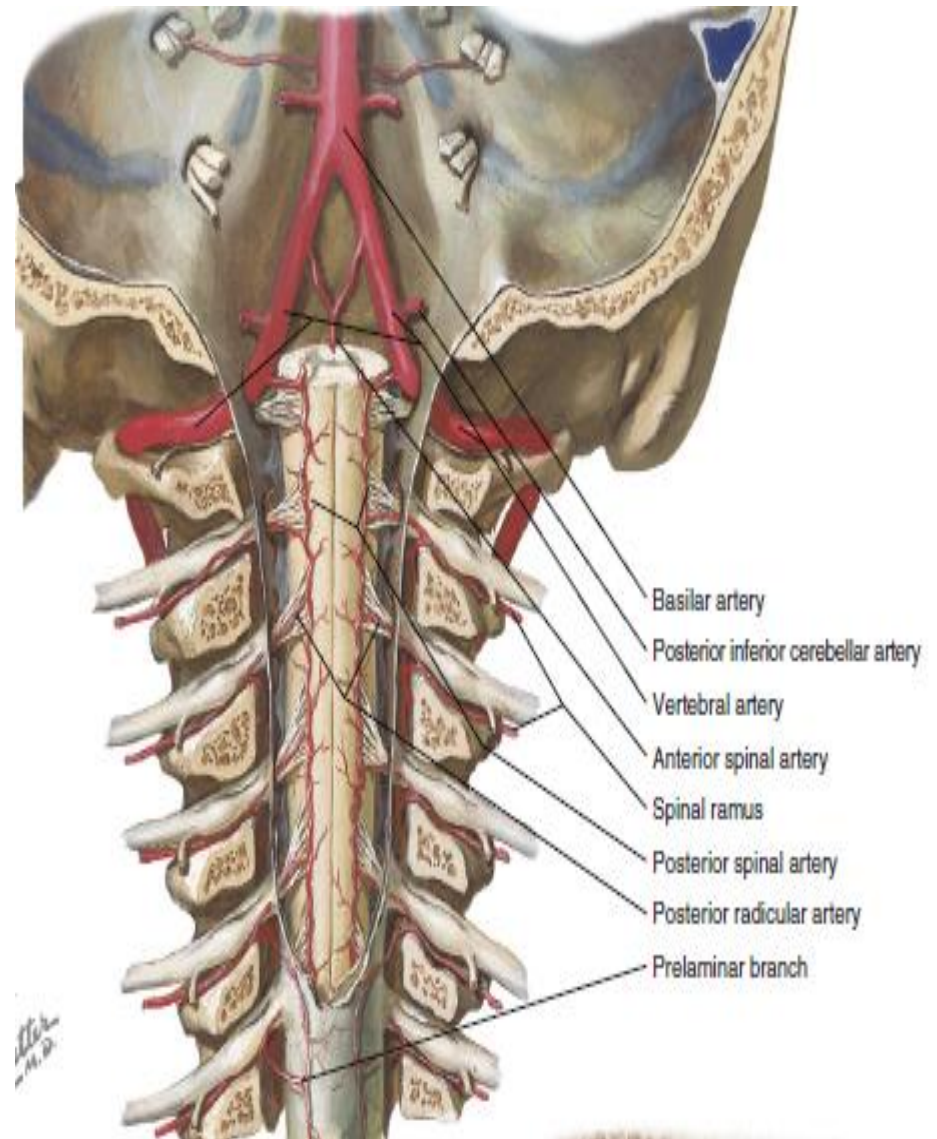
- The V2 segment is the portion that traverses the foramina transversaria and terminates after the C2 foramen transversarium. This is the most vulnerable segment of the vertebral artery in most common cervical spine surgeries.
- The V2 segment may have a tortuous course, and awareness of these anomalies must be achieved radiographically before performing cervical surgery .





The V3 segment continues until the vertebral artery penetrates the dura.

The V4 segment is the intradural portion of the vessel, ending at the vertebrobasilar junction.



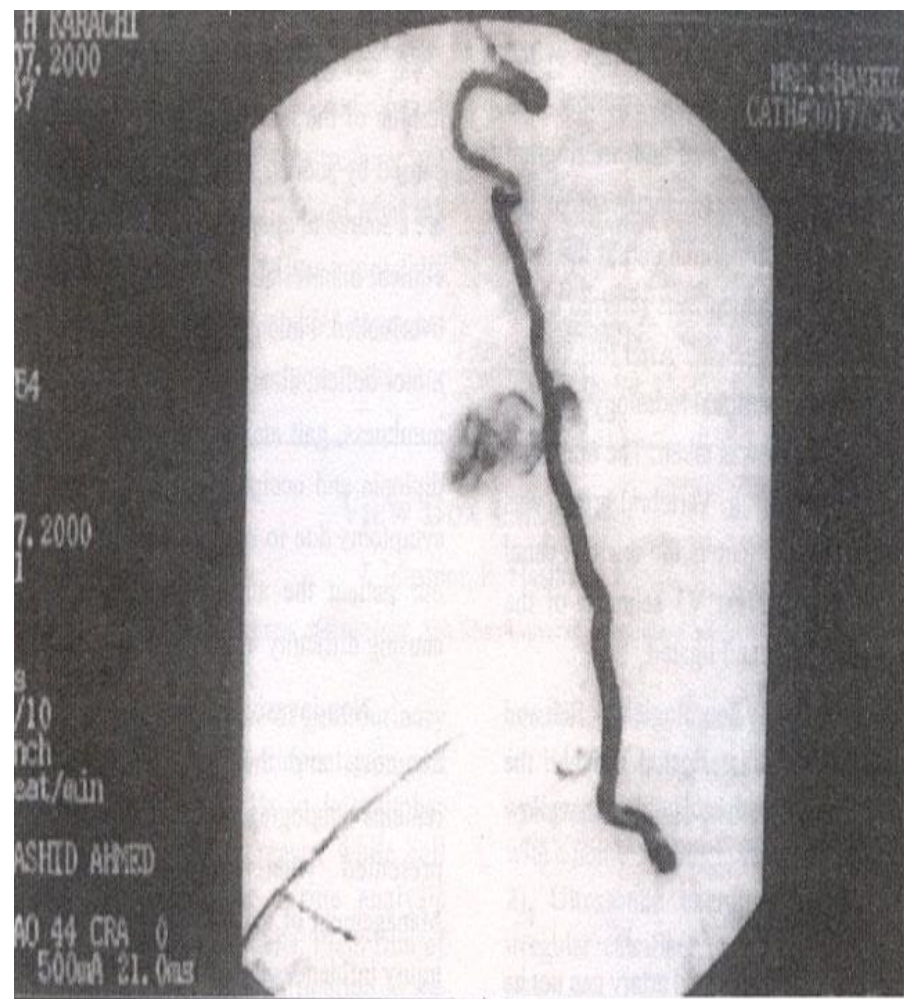
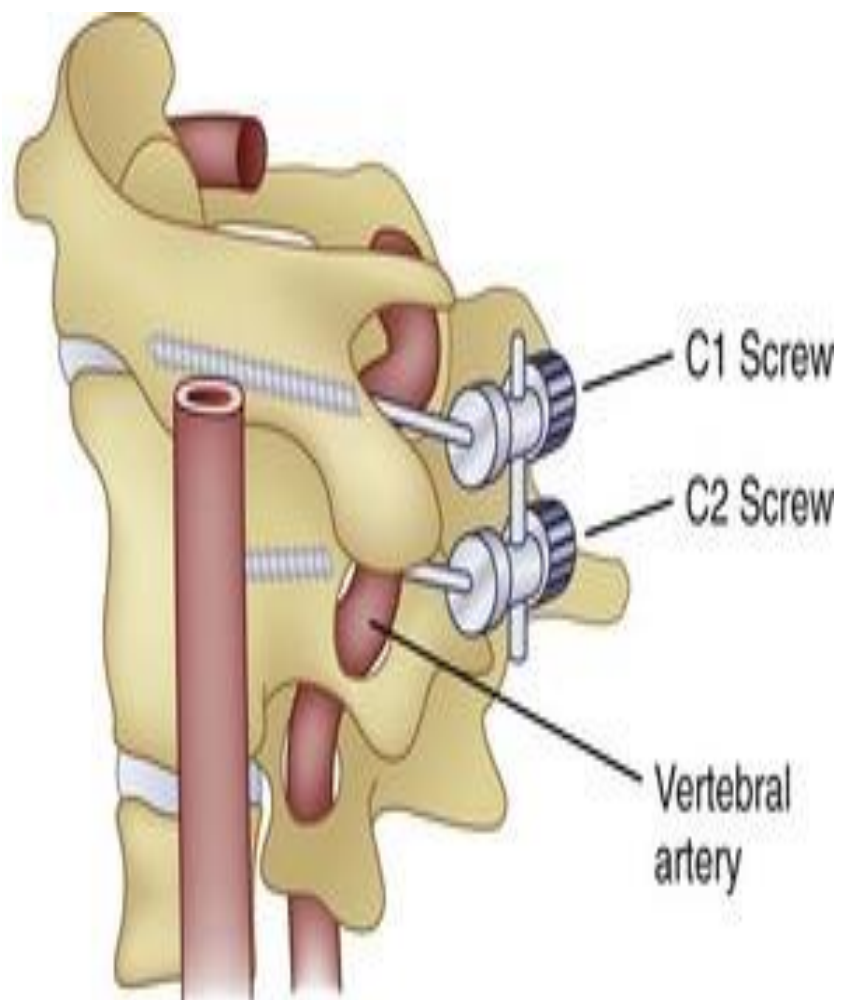
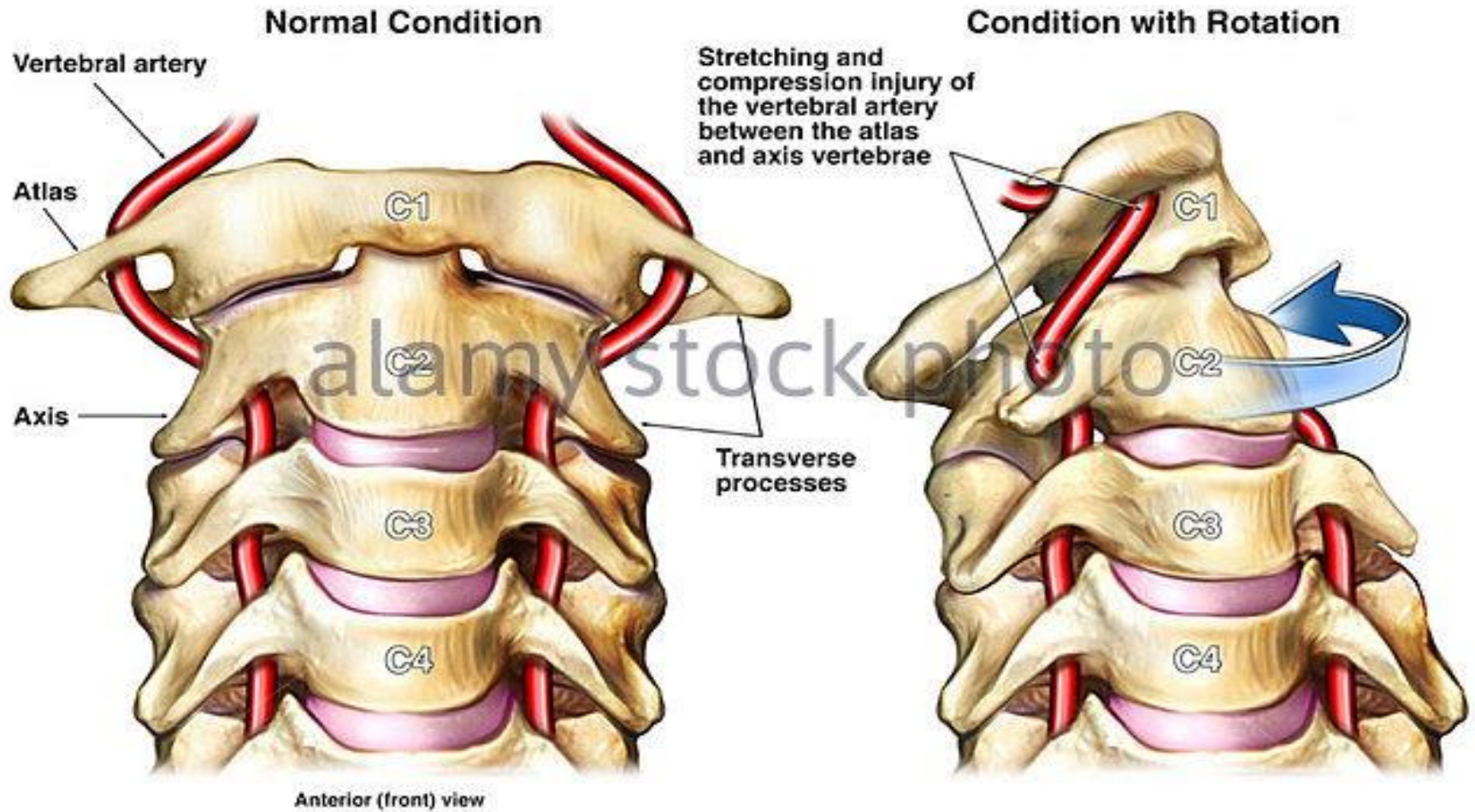


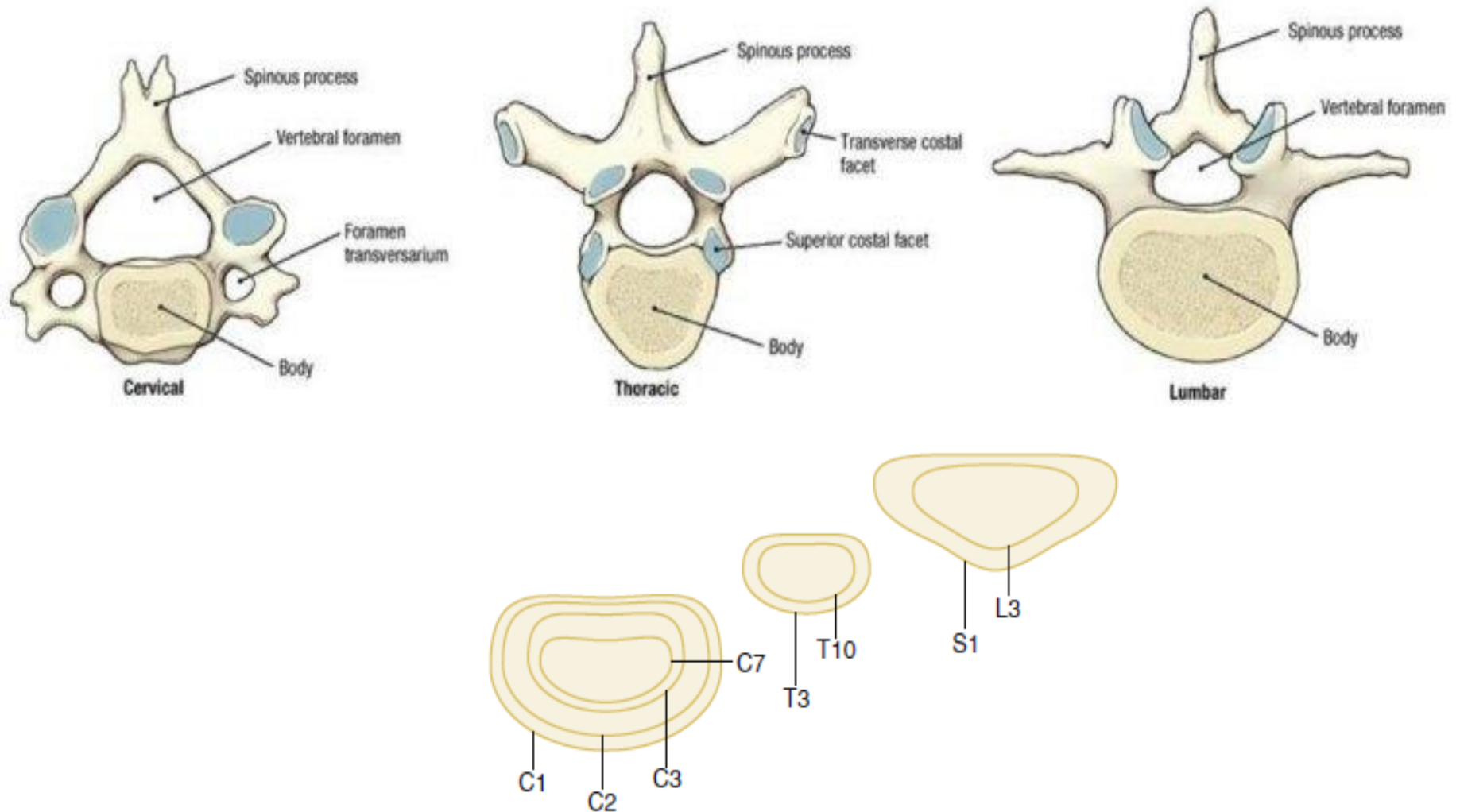
Figure 1. Showing pseudoaneurysm of vertebral artery.



# Rotational Injury of the Vertebral Artery

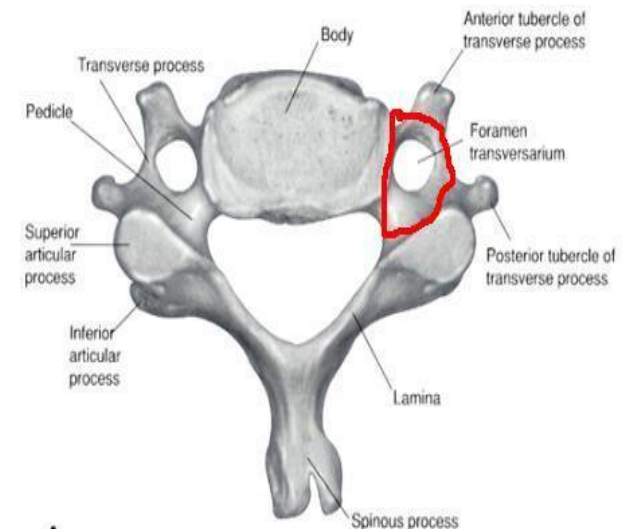
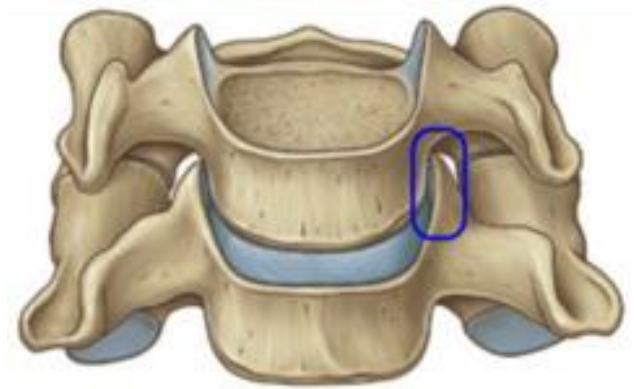


# Variation in the shape of the vertebrae

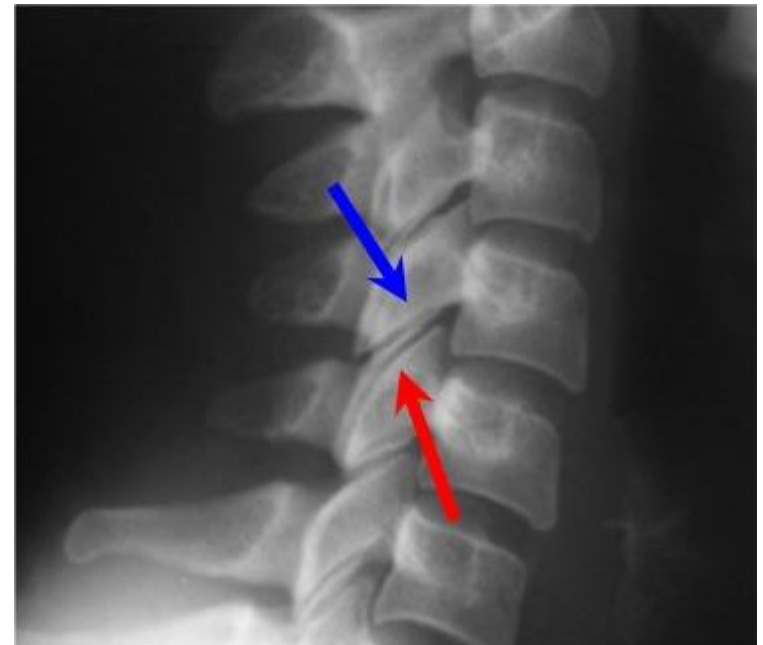


# TYPICAL CERVICAL VERTBRA(SUBAXIAL)

- vertebral body is roughly **cylindrical** in geometry ,are **smaller** than the vertebral bodies of the thoracolumbar spine .
- The lateral edges of the superior end plate curve sharply upward to form the uncinate processes bilaterally which articulate with complementary bevels on the lateral surfaces of the adjacent inferior end plate. “**uncovertebral joint,**” it contains no synovial fluid
- The transverse foramen, or **foramen transversarium**, fenestrates the transverse process and carries the vertebral arteries bilaterally .

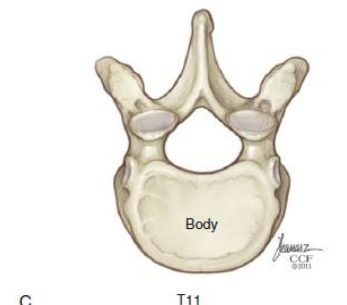
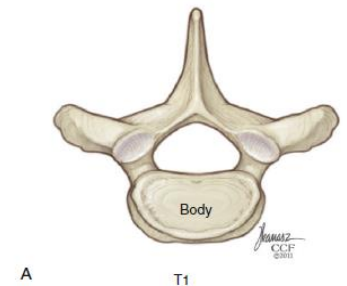


- The superior and inferior articular processes of the cervical spine are **oriented obliquely** on sagittal projection .
- A **bifid spinous process** **rostrally** (typically from C2 to C6) and a monofid spinous process caudally (typically from C6 and below).



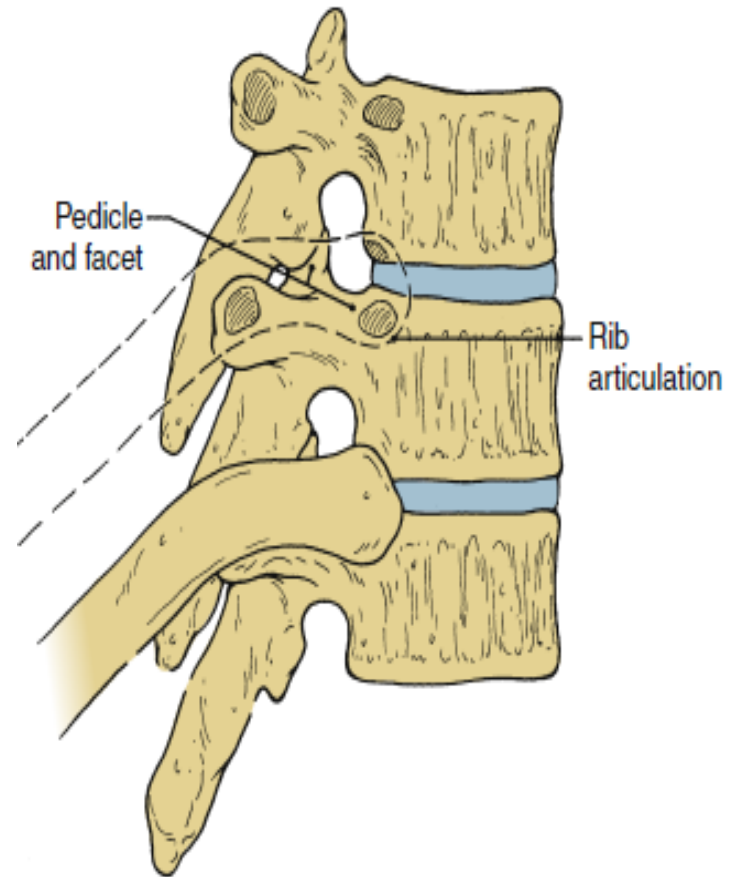
# Typical thoracic vertebra

- In cross section, thoracic vertebrae possess a heart shape,
- In Sagittal vertebral morphology, thoracic vertebral bodies are wedge shaped, ventral height being shorter than dorsal height. This results in the normal thoracic kyphosis.
- The vertebral body gradually increases in cross-sectional area and height from the thoracic spine to the midlumbar spine .



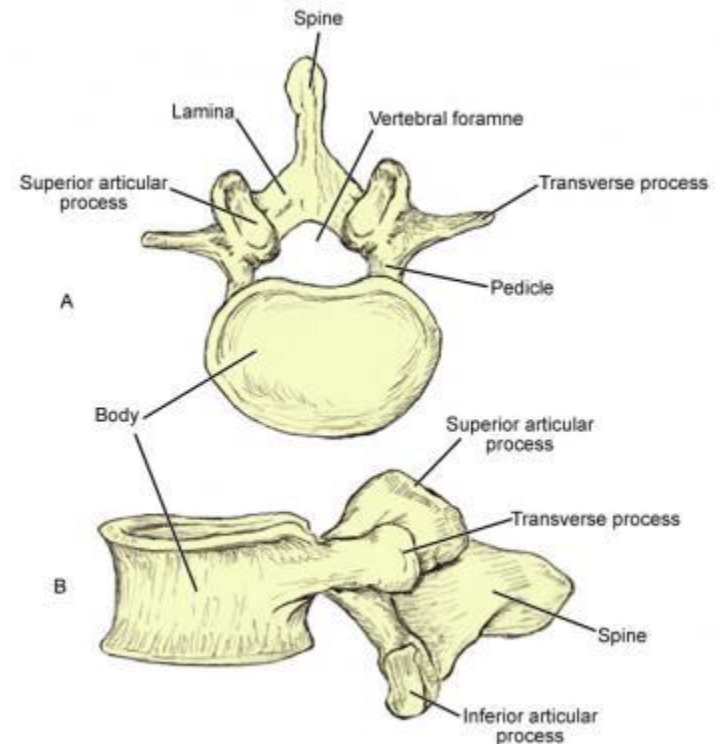


- Thoracic facets have an alignment that is oblique to all three cardinal planes .
- The transverse process projects dorsolaterally and articulates at its tip with the like-numbered rib.
- The 2nd through 9th ribs articulate with their like-numbered vertebrae, as well as the vertebra below, via paired demifacets.

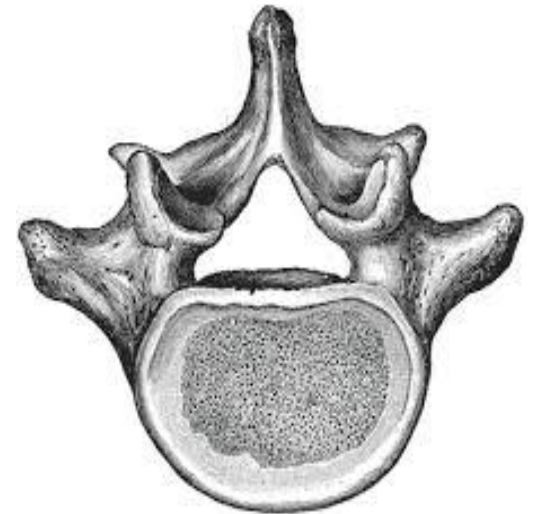


# Typical lumbar vertebra

- The 11th and 12th vertebral bodies, in particular, possess a mixture of thoracic and lumbar morphology.
- lumbar vertebrae are more kidney shaped; a concavity along the dorsal aspect of each marks the ventral portion of the spinal canal.
- In the lumbar spine, ventral and dorsal heights are generally comparable, and it is the disc shape, rather than vertebral body shape, that is the principal contributor to lumbar lordosis.

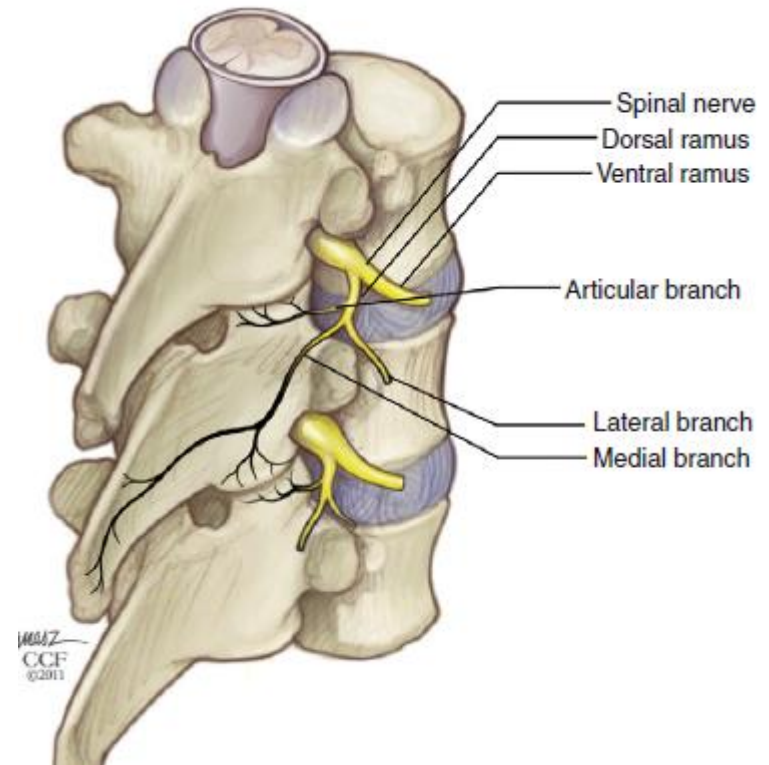


- Lumbar facets occupy a plane that is intermediate between the sagittal and coronal planes.
- Thick shorter pedicles and transverse processes compared with that of thoracic vertebra.



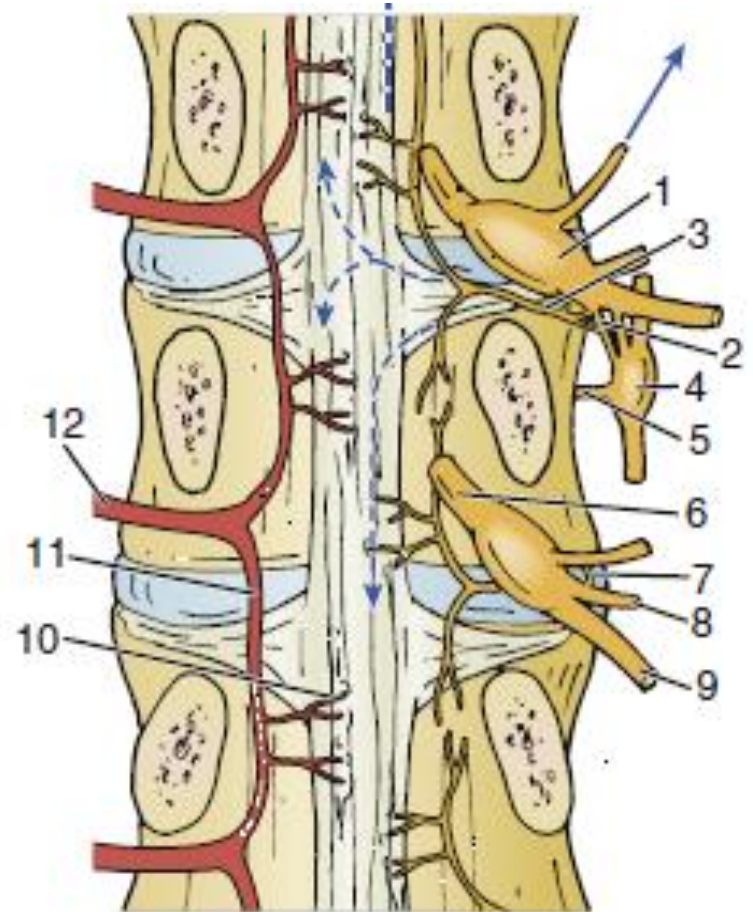
# Innervation of the Spine

- 1-The medial branch of the dorsal primary ramus is believed to be important because it is a major source of innervation to the facet joint.



2-The sinuvertebral nerve (nerve of Luschka ) is a recurrent nerve that may originate from the distal margin of the dorsal root ganglion, the spinal nerve, or the rami communicantes .

It then passes back through the the neural foramen to innervate the intervertebral discs above and below, as well as the ventral dura.





# The Atypical vertebra

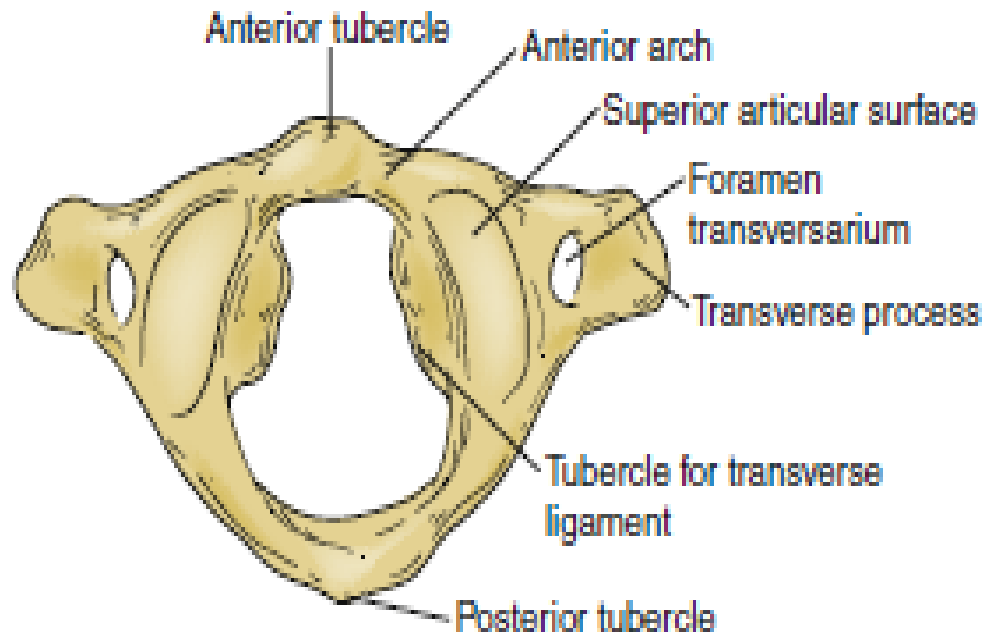
## C1 or the *atlas*:

*Is composed of a ventral and dorsal arch, joined laterally by symmetrical lateral masses.*

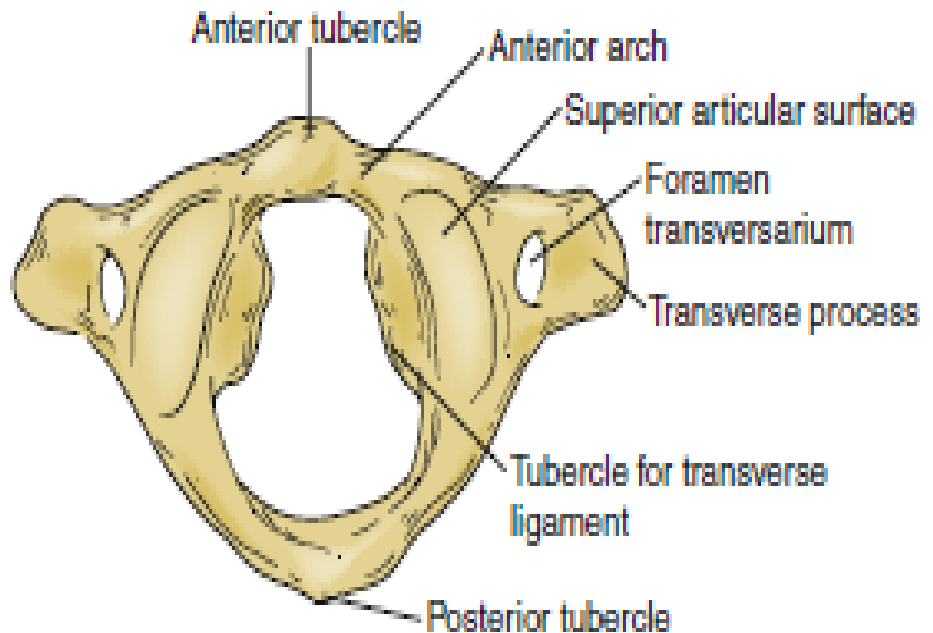
*- The ventral arch with- a dorsal articular surface forming a synovial joint with the odontoid process*

*-an anterior tubercle ventrally to which the longus colli muscle attaches.*

*-The dorsal arch of the atlas typically forms a posterior tubercle in the midline .*

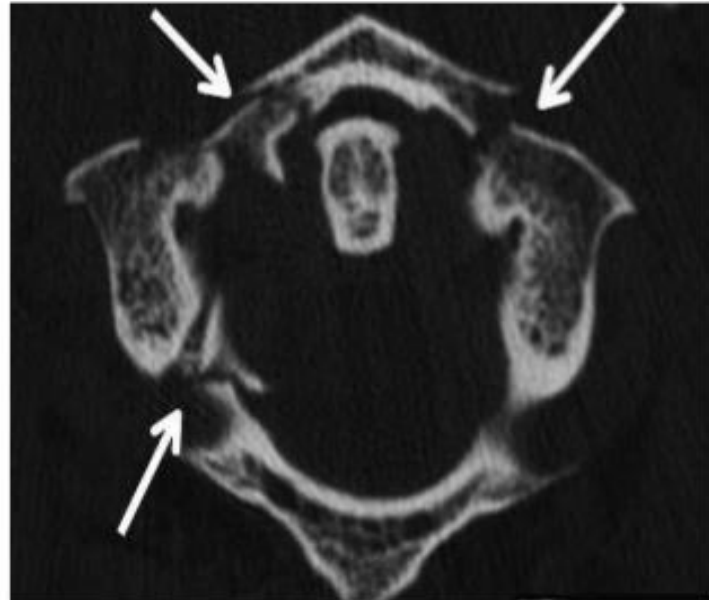
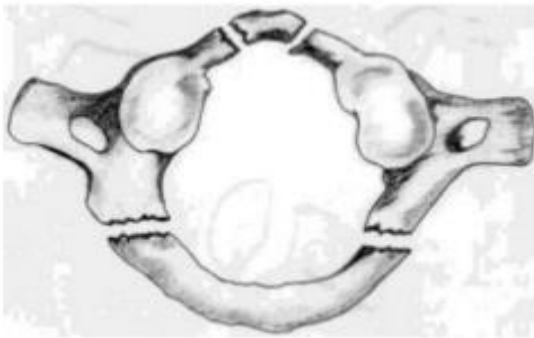


- . The dorsomedial walls of the C1 lateral masses form a small tubercle that serves as the attachment for the transverse atlantoaxial ligament.
- The superior surface of the lateral dorsal arch forms a groove known as the *sulcus arteriosus* on which the vertebral arteries run bilaterally
- 



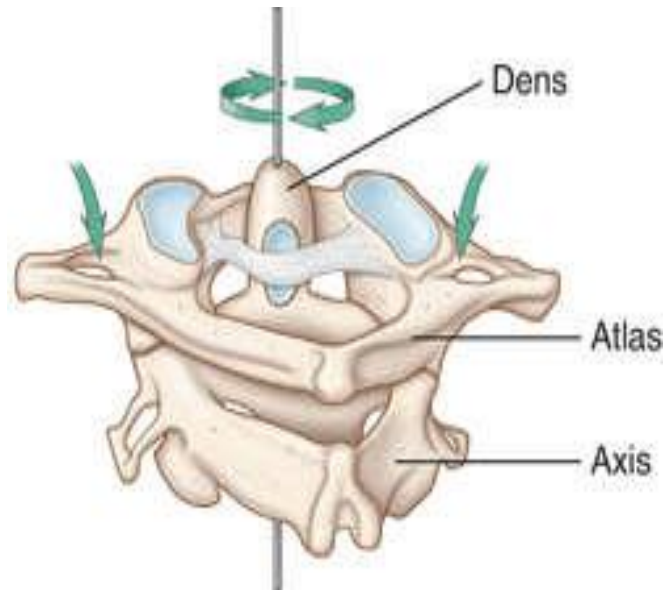
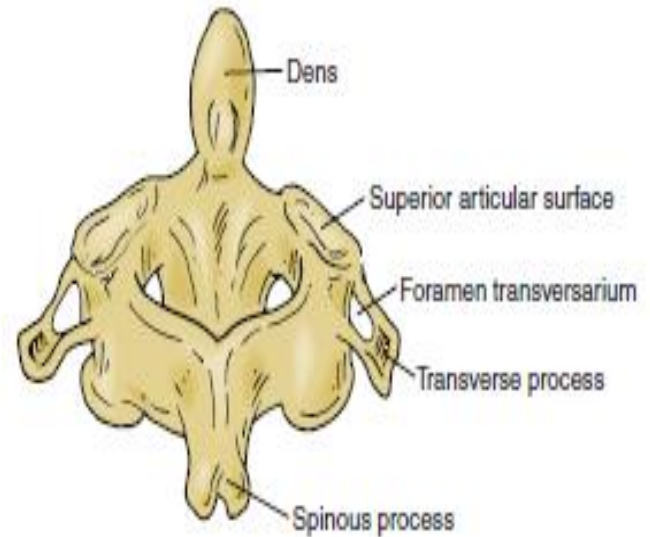
# Jefferson fracture

## Jefferson Fracture



# The C2, or *axis*

The **odontoid process**, a peg like rostral projection, forms a synovial joint with the atlas along its ventral border and allows the atlas to rotate on C2, with translational restriction created by a complex of ligaments.

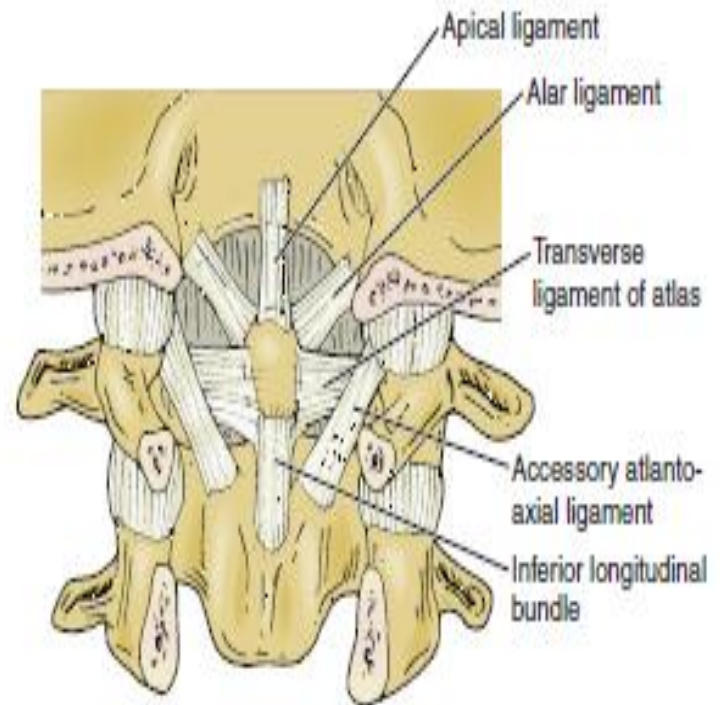


# Ligaments Of The Odontoid

The tip of the odontoid process serves as the attachment for the **apical ligament**, which connects C2 to the basion (the ventral lip of the foramen magnum).

The paired **alar ligaments** span the divide between C2 and the occipital condyles.

The **transverse atlantoaxial ligament** traverses the dorsal border of the odontoid process, which often carries a groove for this strong ligament.





- C2 has a relatively long **pars interarticularis** between superior and inferior articulating processes
- The disproportionate length of the C2 pars interarticularis has important clinical implications. Because the superior and inferior articulating processes of C2 are **coronally offset**, extension applies significant strain on the C2 pars interarticularis.
- Under forceful hyperextension, the pars interarticularis may fracture, giving rise to the mechanism and morphology of the so-called **hangman's fracture**

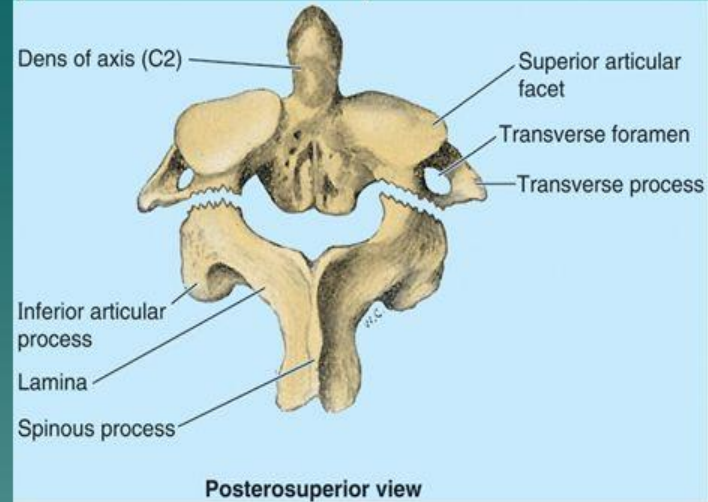
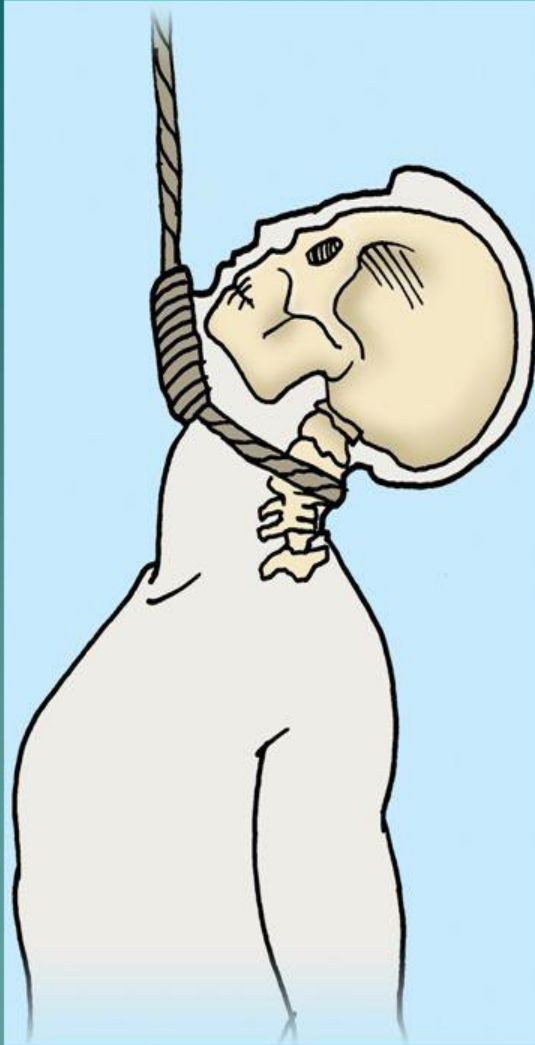


Source: Schwartz DT: *Emergency Radiology: Case Studies*:  
<http://www.accessemergencymedicine.com>

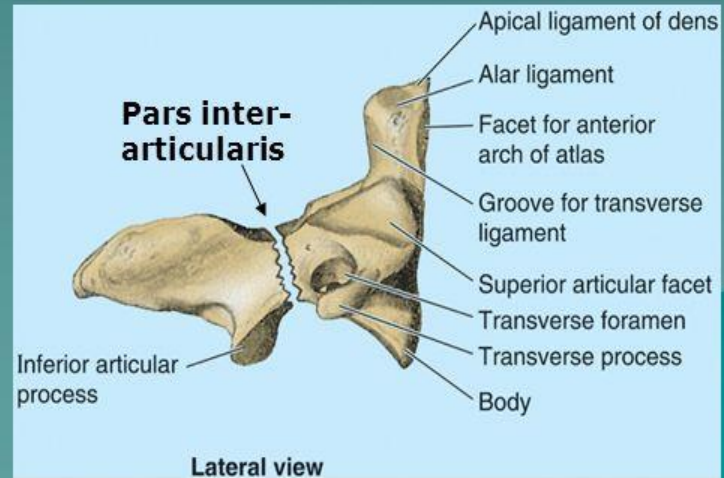
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# HYPEREXTENSION OF THE HEAD ON THE NECK

## FRACTURE OF THE AXIS (HANGMAN'S FRACTURE)

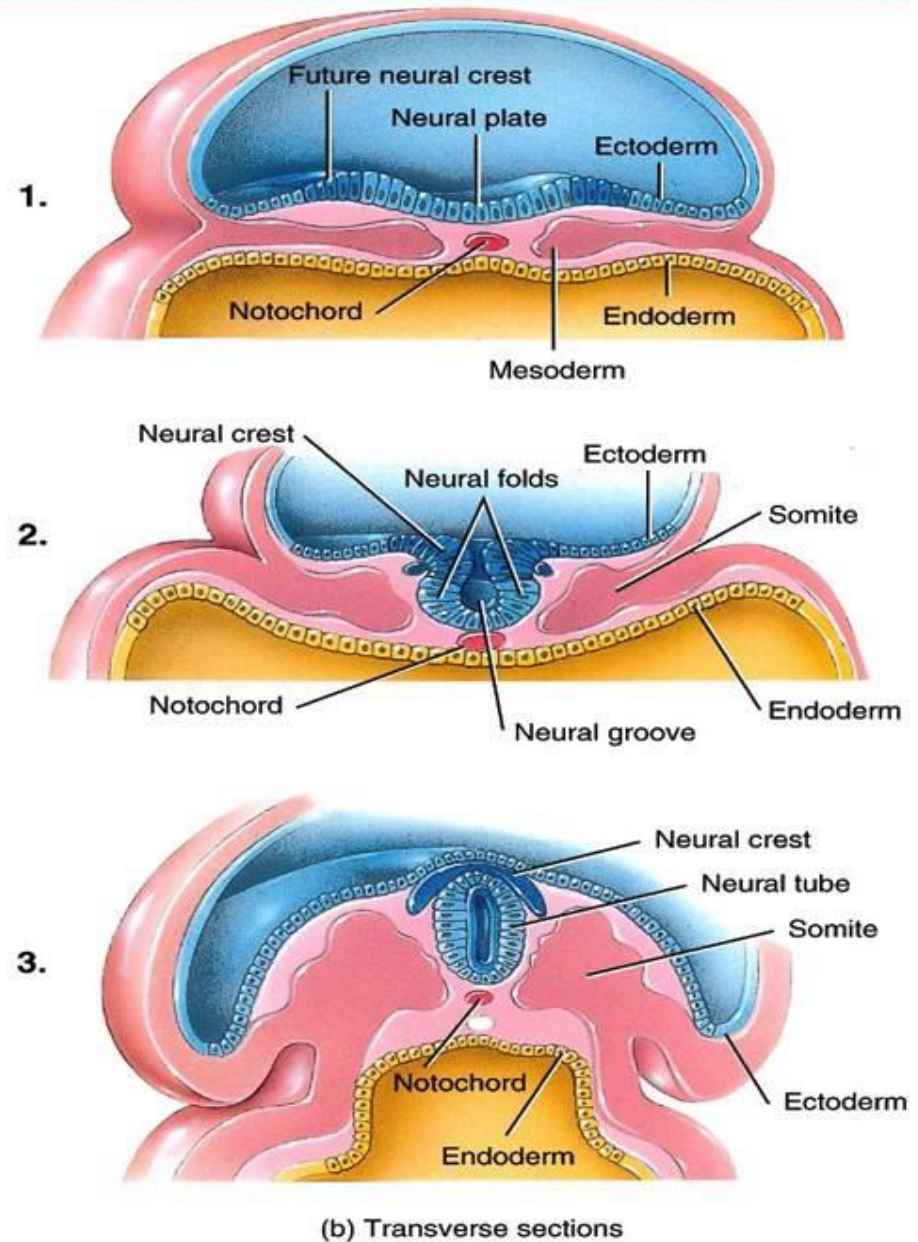
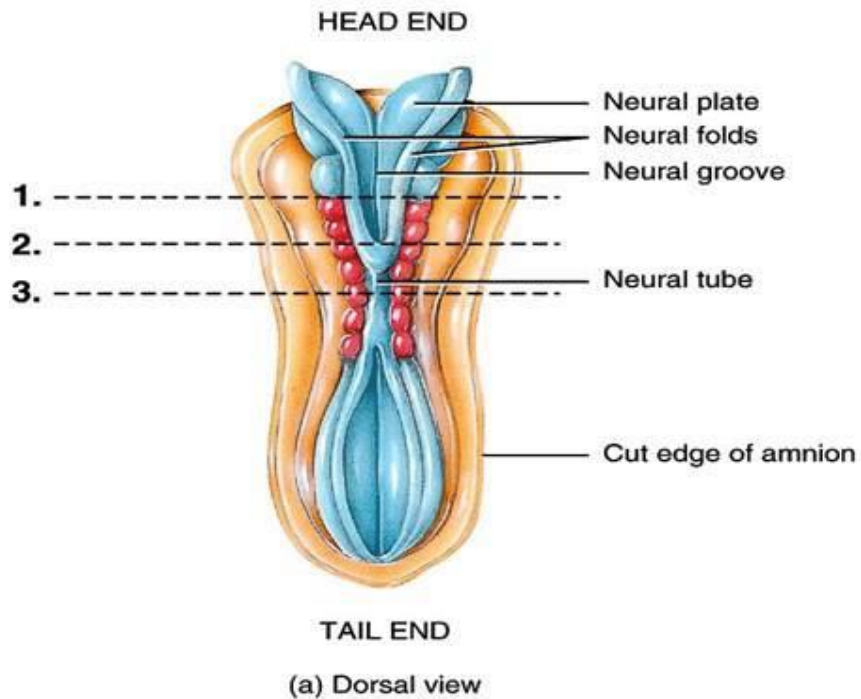


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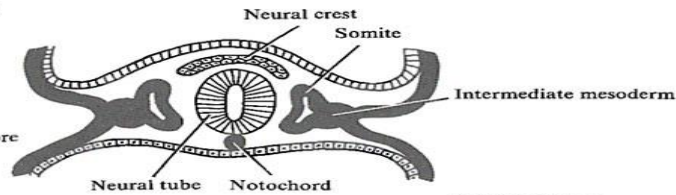
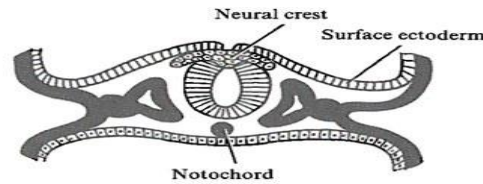
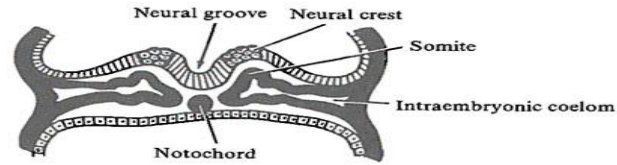
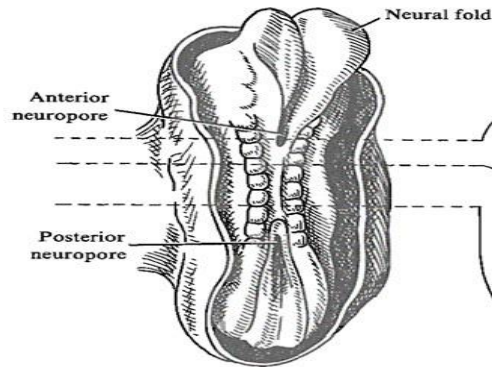
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# Embryology

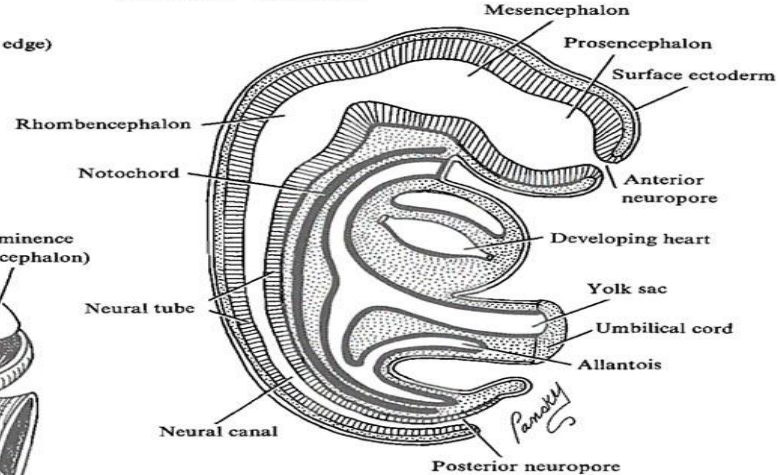
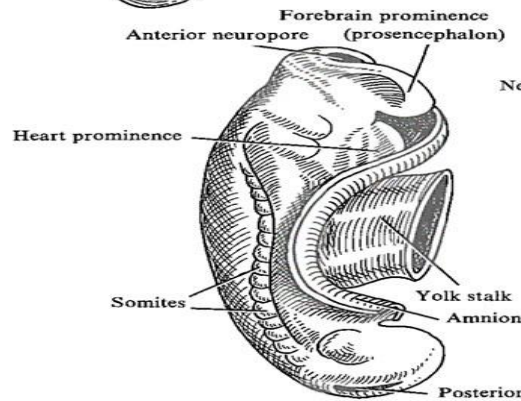
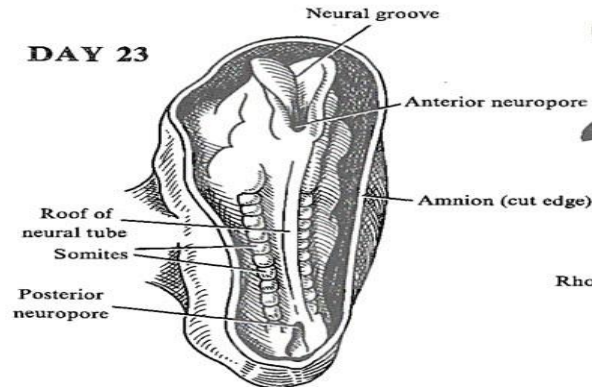




# **DAYS 21-22**



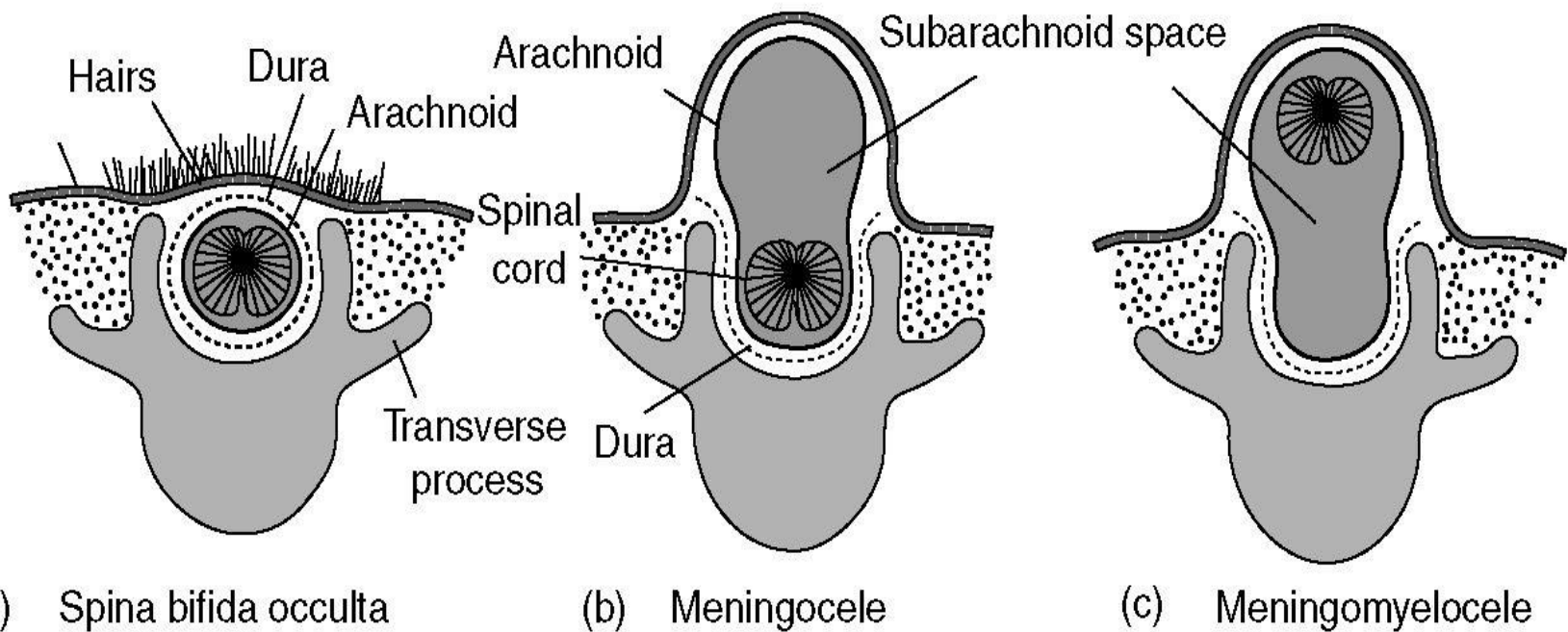
## **DAY 23**



## **DAY 25**

SAGITTAL VIEW

# Spina bifida occulta and aperta



Important



# Congenital disorders(dysraphism)



