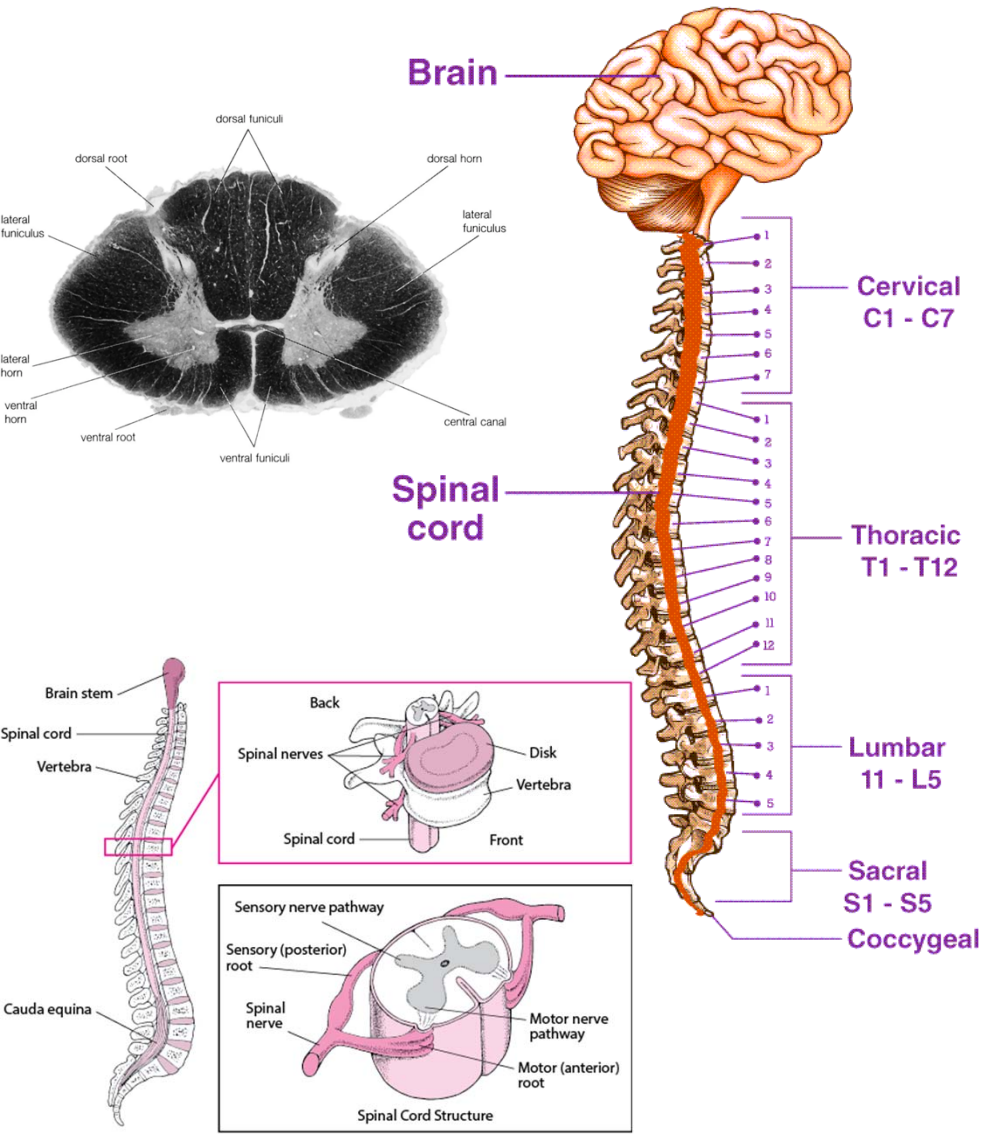


The Spinal Cord

Assist. Proff. Dr. Sameh S. Akkila
UOMCOM

What to know?

1. Understand the general features, beginning, end & functions of the spinal cord.

2. Recognize the external features, meningeal coverings protection, & blood supply of the cord.

3. Study the internal grey & white mater distribution of the spinal cord & relate it to important clinical disorders.

Objectives

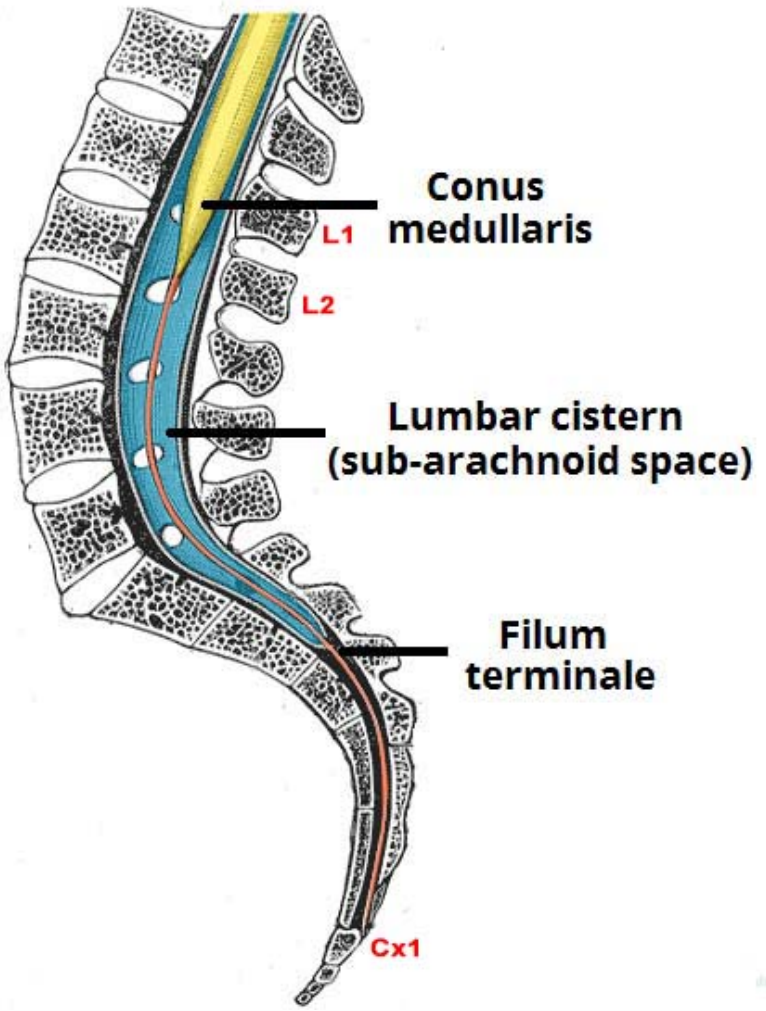
General description

What is?

The spinal cord (=spinal medulla) is the long (45cm, 30 gm) cylindrical caudal part of the CNS that occupies the upper **2/3 of the vertebral canal** as a continuation of MO of hindbrain.

It begins as continuation of MO at the level of upper border of **C1 (atlas)** & ends as a conical end known as **conus medullaris** at the level of L1-L2 disc.

A connective tissue filament known as **Filum terminale** extends from conus medullaris downwards to be attached to the back of first piece of coccyx.



Ending

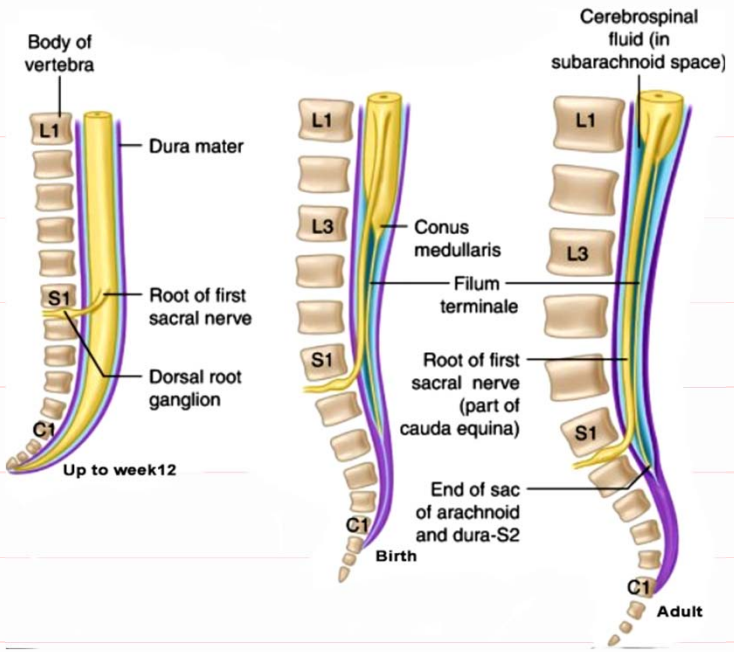
What does it do?

1. Provides motor innervation & receives sensory information from the receptors distributed peripherally in the trunk and limbs through 31 pairs spinal nerves.

2. Contains cell groups at **some levels** which form spinal autonomic centers (**sympathetic [T1-L2/3]** and **parasympathetic [S2-S4]**).

3. Forms local circuit (at its segmental level) known as **reflex arc** which regulates some bodily functions at unconscious level.

Functions



Up to 3rd month of intrauterine life, rate of growth of the vertebral column is similar to that of spinal cord. Subsequently vertebral column with the trunk grows at a faster rate than spinal cord; so that at birth spinal cord ends at the lower border L3 body. In 60 % of adults, it ends at level of L1-L2 disc. In 40% it ends at lower border of L2. Rarely it ends at the lower border of T12.

Development

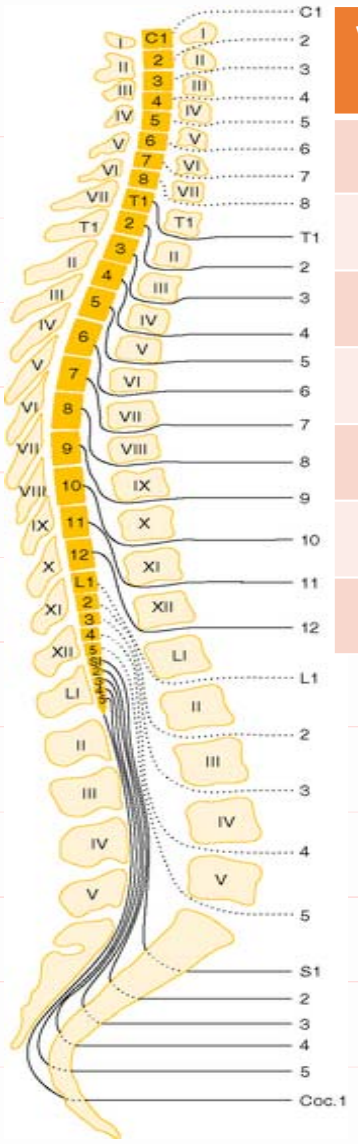
Spinal / Vertebral Disparity

There are 30 vertebrae & 31 spinal segments that give rise to 31 pairs of spinal nerves due to difference of emergence of cervical nerves (cranial to corresponding vertebrae) from other nerves (caudal to corresponding vertebrae) creating an additional C8 nerve between C7&T1 vertebrae.

Because the spinal cord is shorter than the spinal column, the spinal segments do not always underlie their corresponding vertebrae. It's important to appreciate the spinal segment level in relation to the vertebral spine level in order to make an accurate assessment of the level of spinal cord injury from examination of the vertebral column.

<u>The lower the spinal segment, the greater the distance is from its corresponding vertebra.</u>

Segments & Disparity



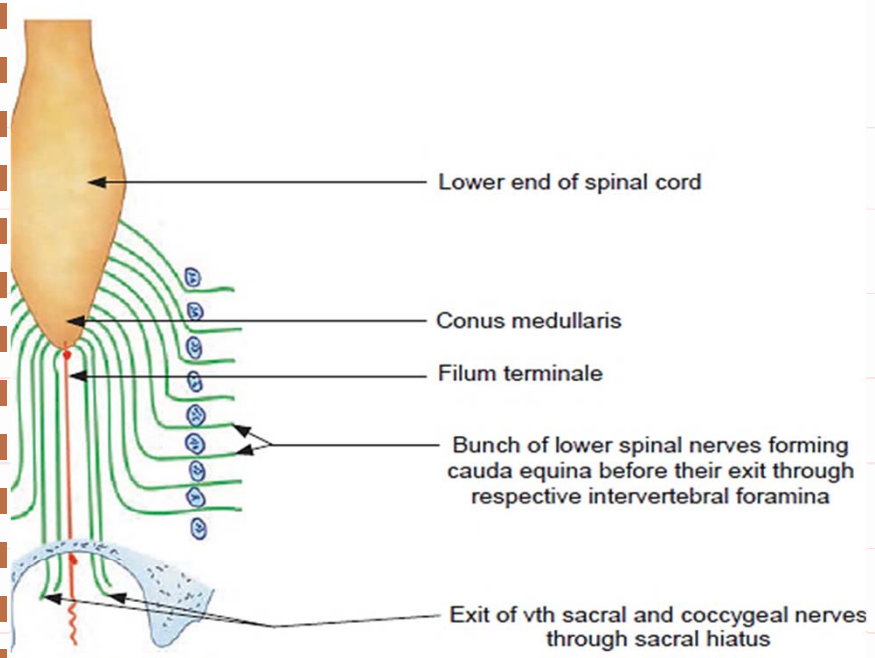
Vertebral spine	Spinal segment
C1	C1
C2	C2+C3
C3-C6	$+1^{+1}$
C7-T7	$+2^{+1}$
T8-T9	+3
T10-T12	Lumbar
T12-L1	Sacral

Like this

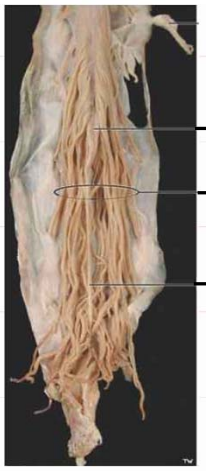
Spinal nerves & Cauda equina

Cause

All the spinal nerves come out of vertebral canal through the corresponding intervertebral foramina except fifth sacral nerve and coccygeal nerve which come out through sacral hiatus. As the spinal cord is shorter than the vertebral column, lower spinal nerves (lumbar, sacral and coccygeal) are to descend through the vertebral canal to reach corresponding intervertebral foramen in the form of a bunch of nerves known as **cauda equina** (L.= Horse-tail)



Result



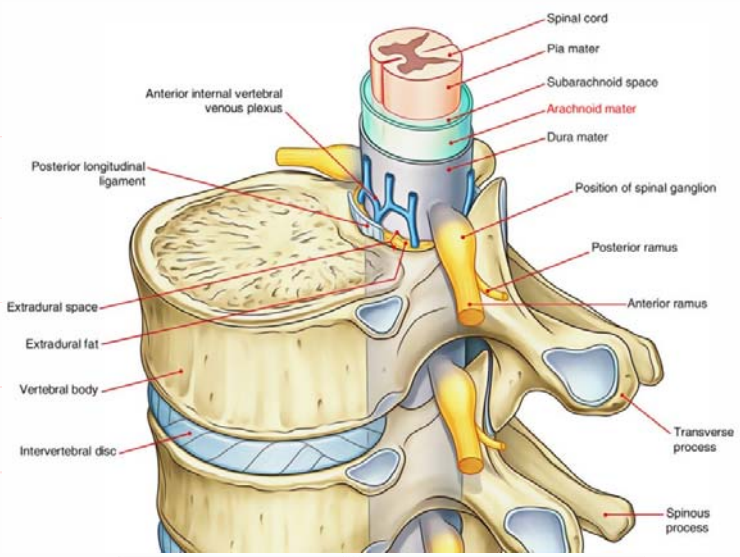
Spinal Meninges

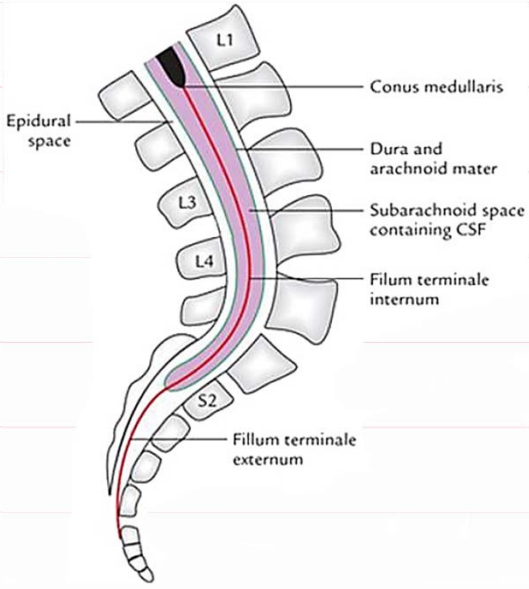
The spinal dura & arachnoid extend from the margins of the foramen magnum to the level of S2 beyond lower end of spinal cord to enclose cauda equina and upper (internal) larger part of filum terminale.

The dura is separated from the periosteum of the bony vertebral canal by the **epidural space** which contains loose areolar tissue with semiliquid fat & the internal vertebral venous plexus.

The dura extends on the ventral & dorsal roots of the spinal nerves and merges with the epineurium of the spinal nerve trunk at the intervertebral foramina while arachnoid is prolonged for a short distance around spinal nerves beyond intervertebral foramen. Arachnoid is separated from pia by subarachnoid space filled with CSF.

Dura & Arachnoid





Illustration

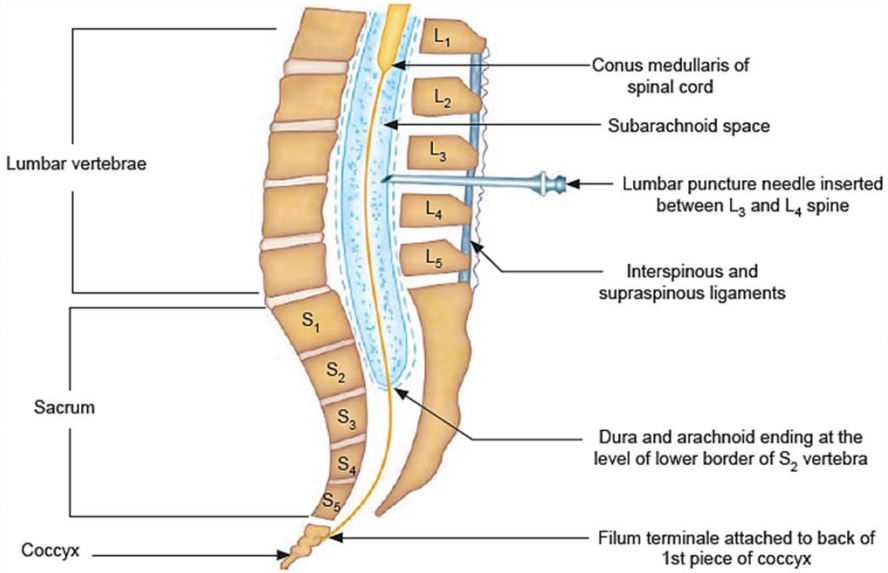
Lumbar puncture anatomy

The subarachnoid space around the spinal cord becomes more spacious below the lower end of spinal cord (L2) down to its lower limit (S2), which contains CSF of considerable known as the **lumbar cistern**. The ideal level for lumbar puncture is the space between L3/L4 spines.

To locate the levels of lumbar spines the Transcristal line (line passing through the level of highest point of both iliac crests) is used as it passes through the level L4 spine.

With the trunk of the body ventrally flexed (in lateral lying or sitting position) , the interspinous space becomes wider & lower end of spinal cord is raised slightly upwards.

LP = Spinal tap



As the needle is introduced, uniform (sustained) pressure is to be applied.

After supraspinous and interspinous ligaments, IVD & tough layer of dura mater are penetrated, suddenly a loss of resistance is felt. It confirms that needle has reached the subarachnoid space.

Procedure

Spinal pia

Pia mater is a thin delicate membrane which closely invests the surface of spinal cord. It is made up of fine layer of fibroreticular tissue that extends over the perforating vessels forming a perivascular sheath. It also extends over the rootlets of the spinal nerves and merges with the perineurium of the spinal nerve trunk. It extends into 4 areas:

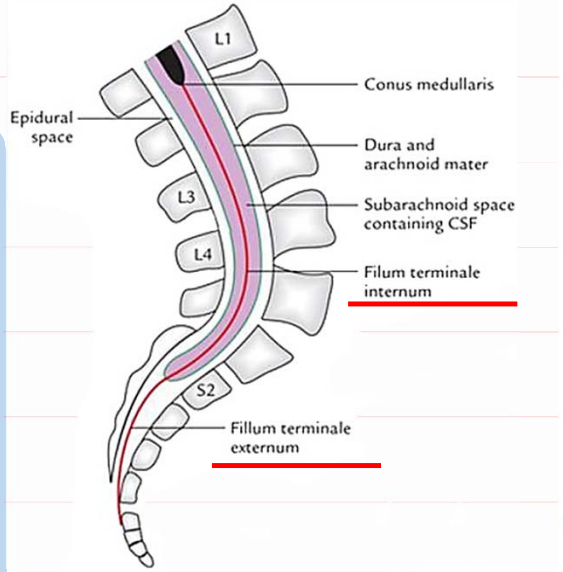
1. The filum terminale represents the terminal 20 cm of the pia (proximal 15 cm internal, distal 5 cm external).

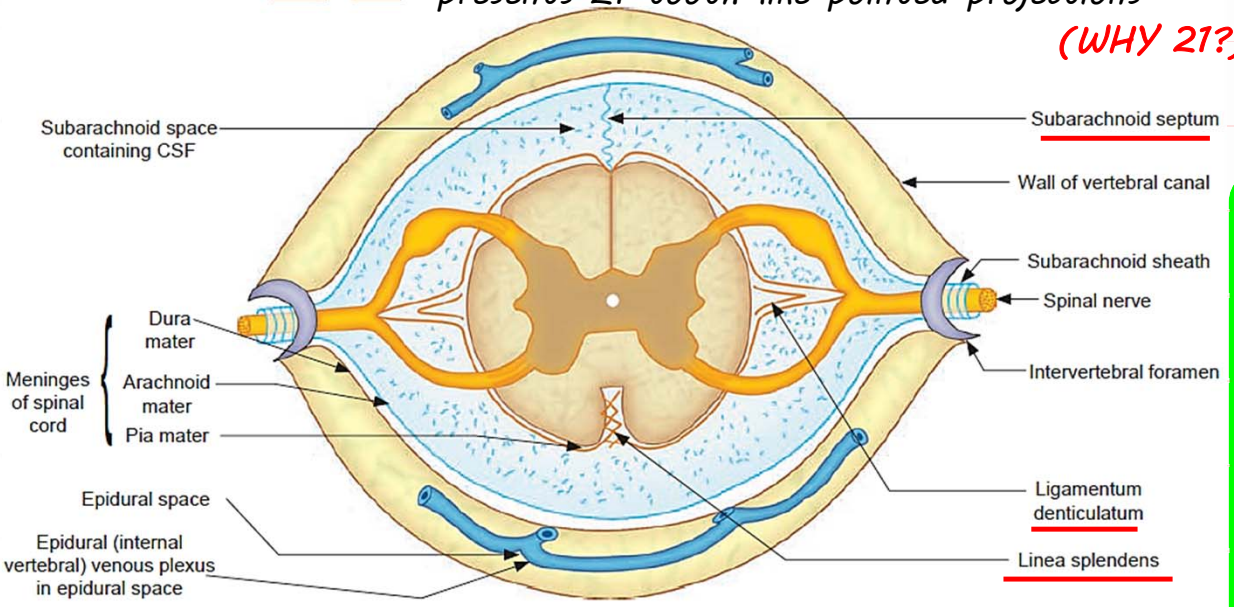
2. Linea splendens: condensation of pia along the anterior median line of spinal cord, where it dips into anterior median fissure.

3. Subarachnoid septum: a thin septum along the posterior median line of spinal cord extending from posterior median sulcus to deep surface of arachnoid mater.

4. Ligamentum denticulatum: a bilateral pial septum extending throughout whole length of spinal cord in between lines of attachment of ventral and dorsal nerve roots. Lateral margin presents 21 tooth like pointed projections.

(WHY 21?)





Pia mater

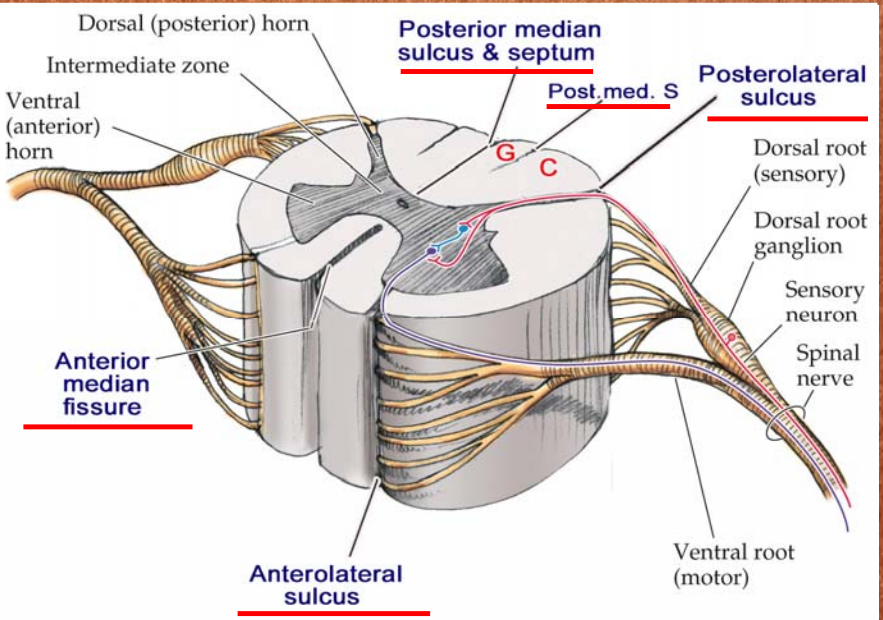
Extensions

External Features

Shape

The cylindrical spinal cord is slightly flattened from front to back. Ventrally, it possesses a deep midline groove called the **anterior median fissure**. The pia is thickened at the mouth of this fissure forming a longitudinal band known as the linea splendens. Dorsally, the cord shows a shallow **posterior median sulcus** from which the **posterior median septum** of neuroglia extends into its substance. On its sides; the spinal nerve rootlets emerge from its **anterolateral & posterolateral sulci**.

Illustration



A shallow **post·med· sulcus** lies between the post·lat· sulcus & post· median sulcus & separates the fasciculus gracilis (G) from fasciculus cuneatus (C).

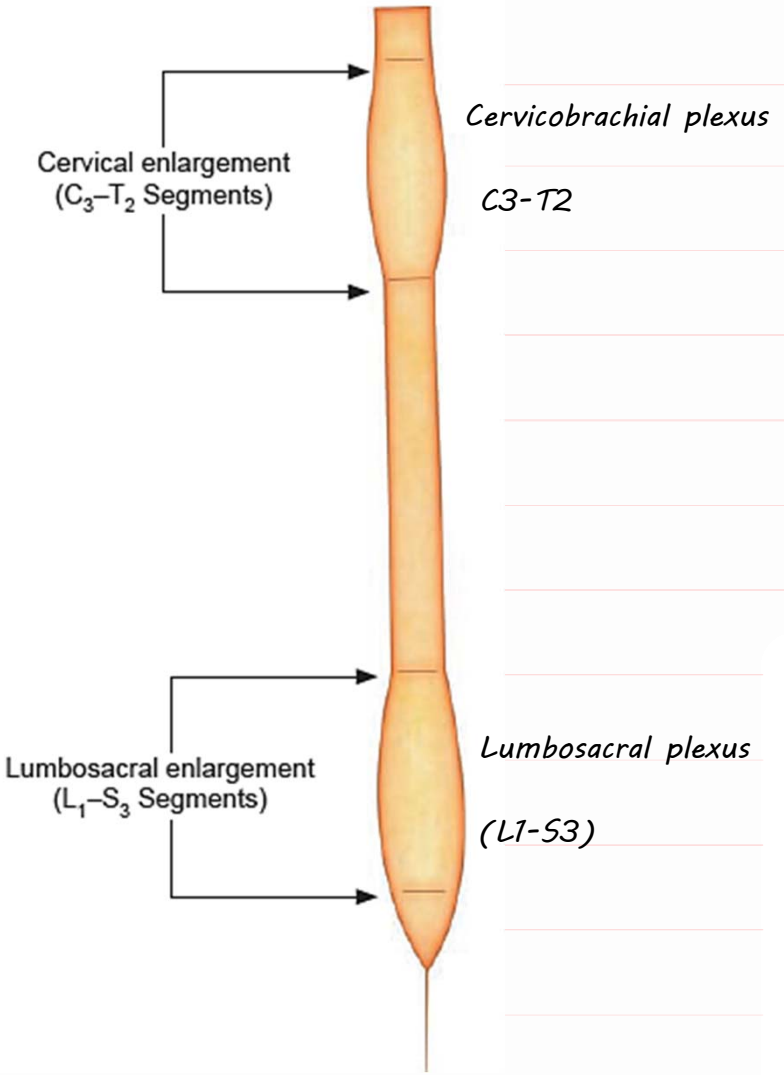
Spinal Enlargements

The spinal cord is almost cylindrical throughout its length. However, it presents two expansions as enlargements:

1. Cervicothoracic (C3 - T2 segments)
2. Lumbosacral (L1-S3 segments)

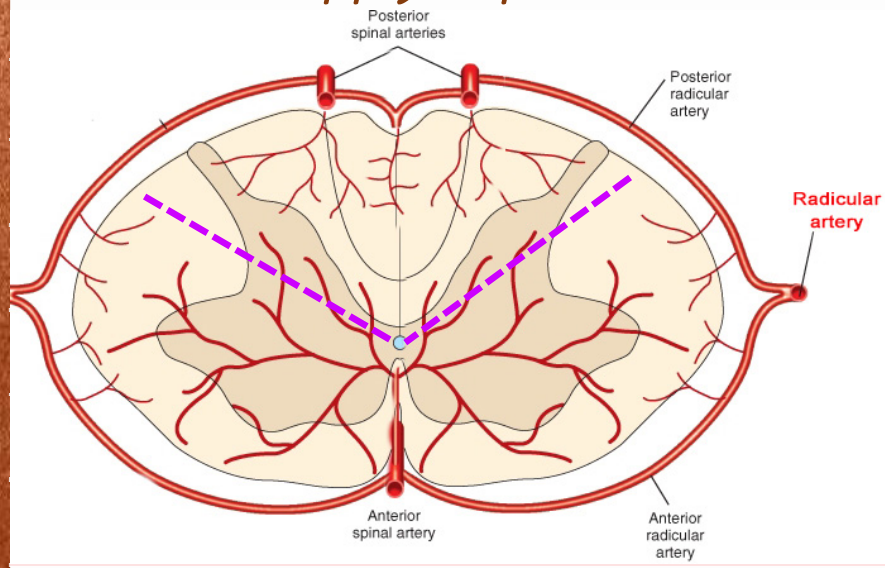
Where? Why?

These enlargements appear in fetal life with the formation of upper & lower limb buds, because of more amount of motor neurons in these segments to supply limb musculature by the plexuses for upper and lower limbs.



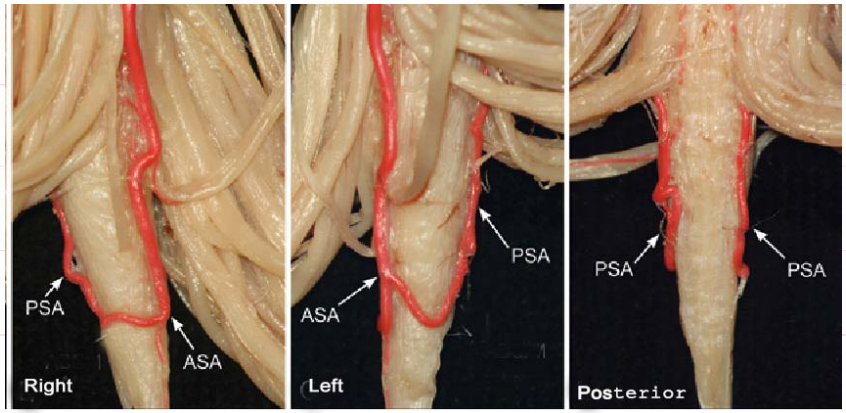
Like this

Arterial Supply: Spinal aa.



ASA

The **anterior spinal artery** is a single median artery formed by the union of a branch each from a vertebral artery and descends on the ant. median fissure deep to the linea splendens. It gives peripheral & perforating branches through the anterior median fissure to the **ventral 2/3** of the cord including most of the motor grey matter. It also gives anastomotic branches to the dorsal surface of the cord to anastomose with the posterior spinal arteries.



The **posterior spinal arteries** (right & left) each arise as a branch from the vertebral artery & descend on the dorsal surface of the cord (on the post.med. sulci) supplying the **dorsal 1/3** of the cord.

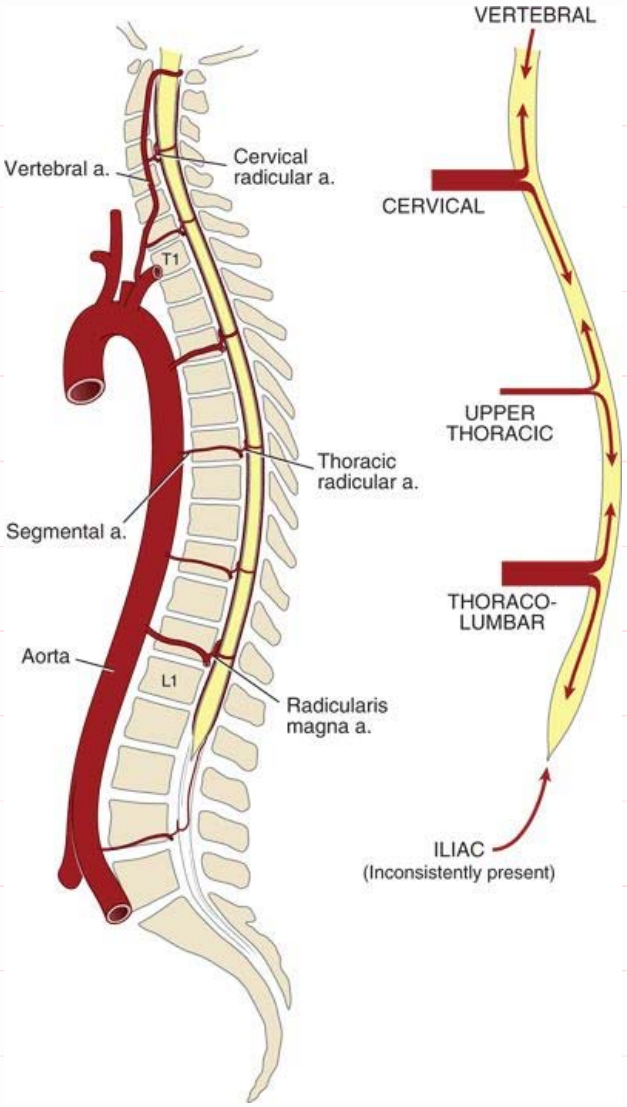
At the conus medullaris, the posterior spinal arteries sweep anteriorly and join the anterior spinal artery which continues with the filum terminale as a slender artery to supply the cauda equina.

PSA

Arterial Supply: Radicular aa.

Segmental arteries reinforce the longitudinal trunks formed by the spinal arteries. The radicular arteries are derived from various parent vessels according to the level of the spinal cord:

- **In the neck**: from the vertebral (3rd part) & ascending cervical arteries.
- **In the thorax**: from the post. intercostal aa.
- **In the abdomen & pelvis**: from the lumbar & lateral sacral aa. (±Int. Iliac a.)



Radicular arteries

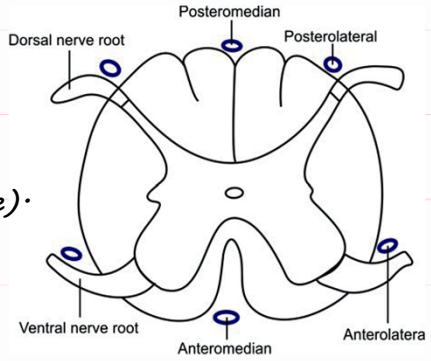
Radicular arteries

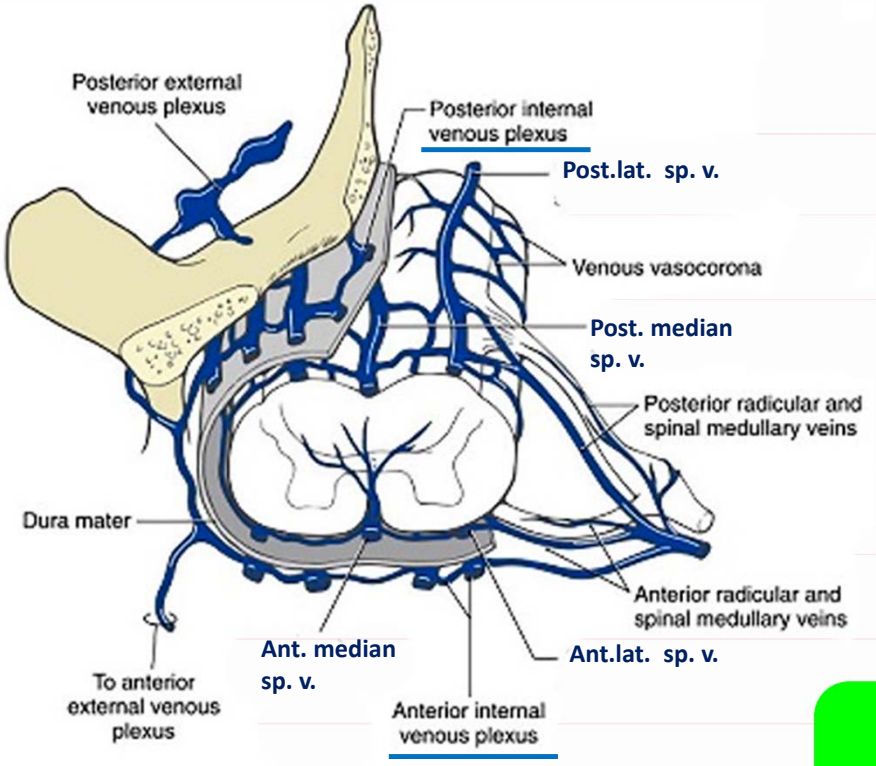
Venous Drainage

1· The spinal veins are numerous small tortuous veins in the subarachnoid space that form 6 longitudinal channels around the cord: **1 on the anterior median fissure, 1 on the posterior median sulcus** and **4 on** the attachments of the sets of the dorsal & ventral roots of the spinal nerves (**ant· lat· & post· lat·**)· They all drain into the internal vertebral venous plexus·

The **internal vertebral venous plexus** extends the whole length of the vertebral canal (in the epidural space) & is divided into 4 pairs of longitudinal (vertical) channels:

- 2 anterior pairs (on the dorsal surface of the vertebral bodies)
- 2 posterior pairs (on the ventral surface of the vertebral laminae)·



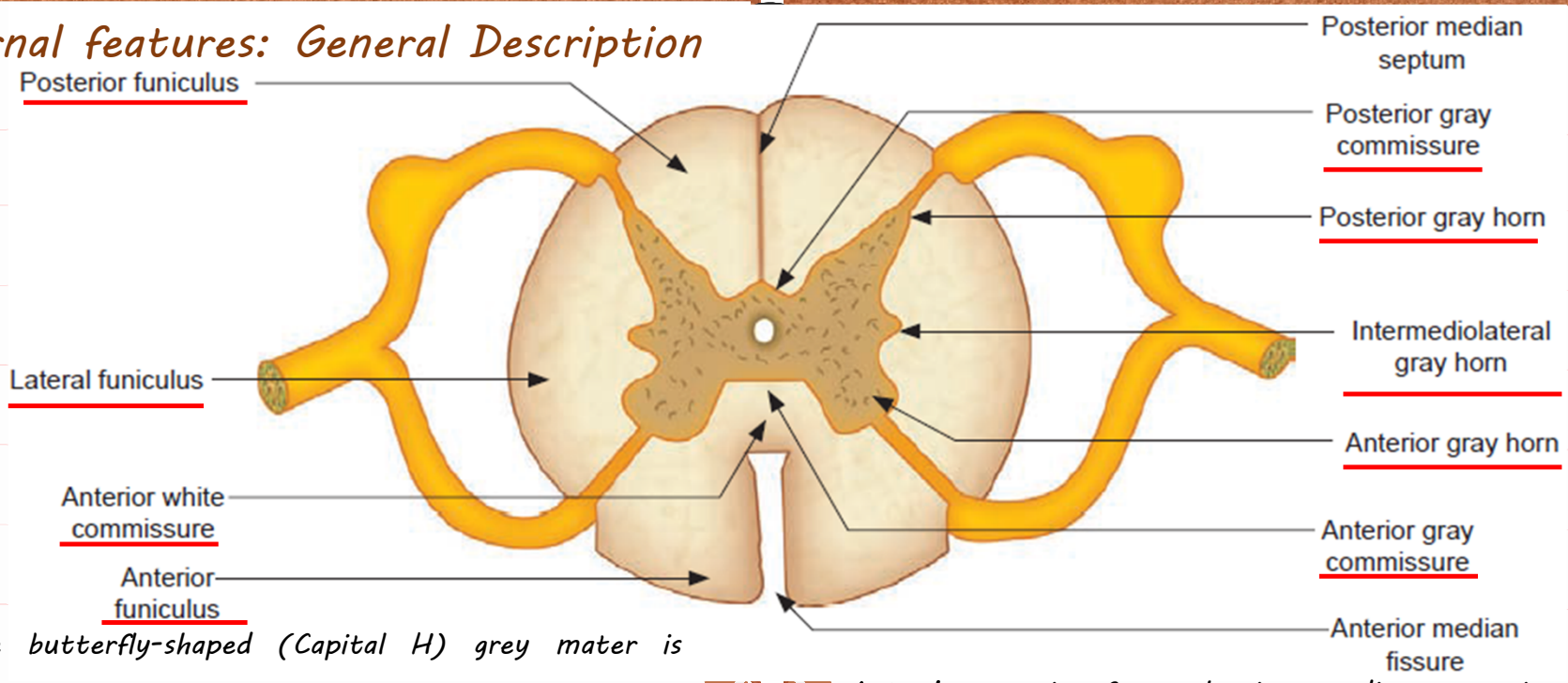


The plexus receives veins from the spinal cord and bones of the vertebral canal & communicates with veins of the body wall = ext· vertebral venous plexus (suboccipital venous plexus, vertebral veins, posterior intercostal veins, lumbar veins & lateral sacral veins)·

Spinal veins

IVVP

Internal features: General Description



Grey mater

The butterfly-shaped (Capital H) grey mater is central & is surrounded by columns of white mater. The gray matter ant. & post. to central canal are called **ant. & post. grey commissures**. The **anterior white commissure** lies ant. to the ant. grey commissure.Each side of spinal cord gray matter is composedof **ant. horn** [away from surface]=(**Motor**), **post. horn** [reaches surface] (**Sensory**) & **intermediate area** of **interneurons**.

White mater

Lat. horns arise from the intermediate area in 2 regions: [T1-L2→ pregangl. sympathy cells] & [S2-S4→ pregangl. parasymp. cells].

The anterior & posterior horns of the grey matter divide the white matter in the periphery into **three columns [Funiculi] (ant., lat. & post.)**. They contain ascending, descending or intersegmental & intrasegmental tracts of nerve fibers.

White mater: Ascending (post·)

Discription

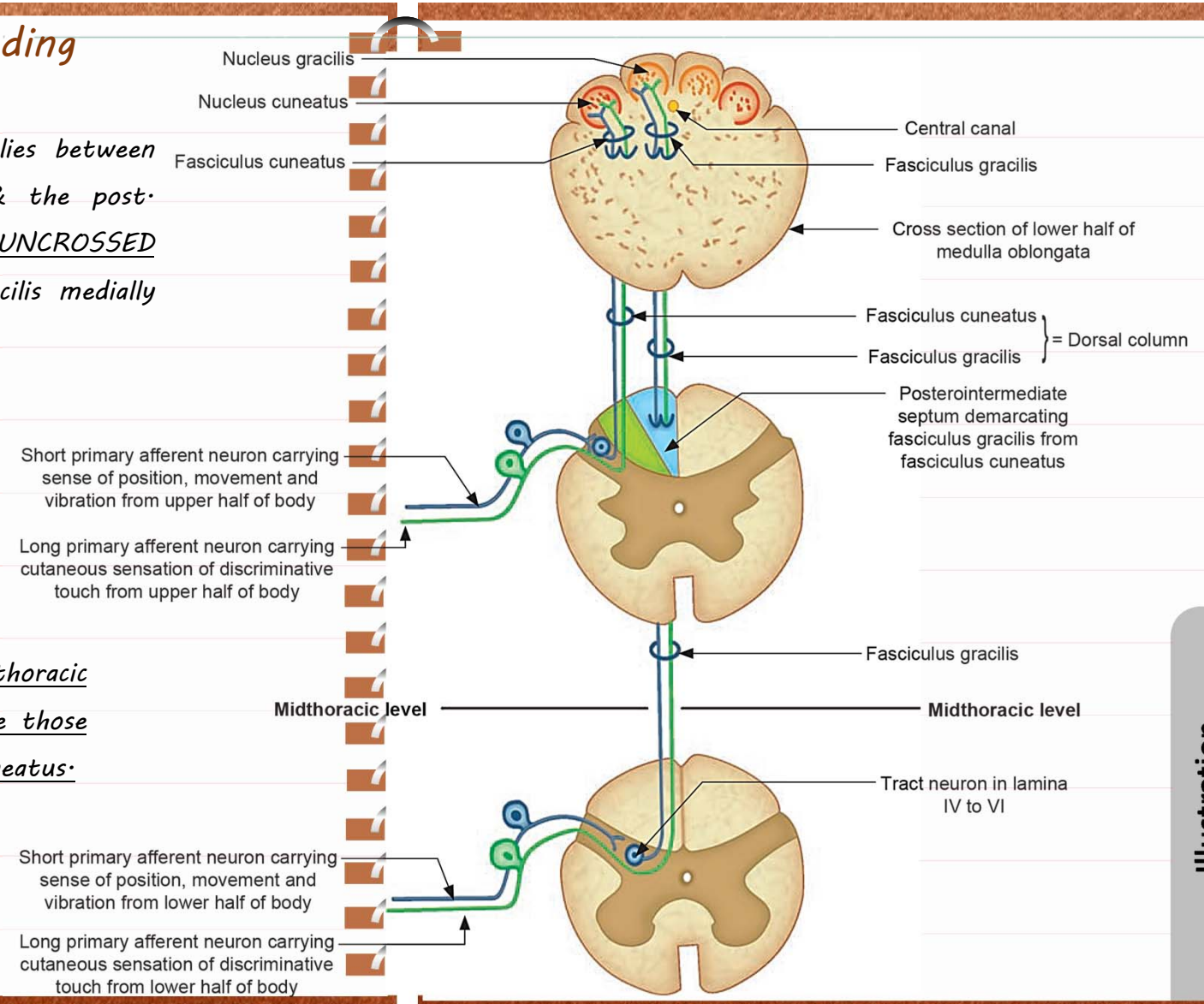
The posterior white column lies between the post· median septum & the post· horn & is composed of UNCROSSED ascending tracts only (F· gracilis medially & F· cuneatus laterally)·

Long neurons carry pressure & discriminative touch info while short neurons carry proprioceptive & vibration info· Both carry visceral fullness info·

Fibers below the midthoracic region form F· gracilis while those above the level form F· cuneatus·

All fibers end in the gracile & cuneate nuclei of MO → arcuate fibers → MEDIAL LEMNSICUS·

Illustration

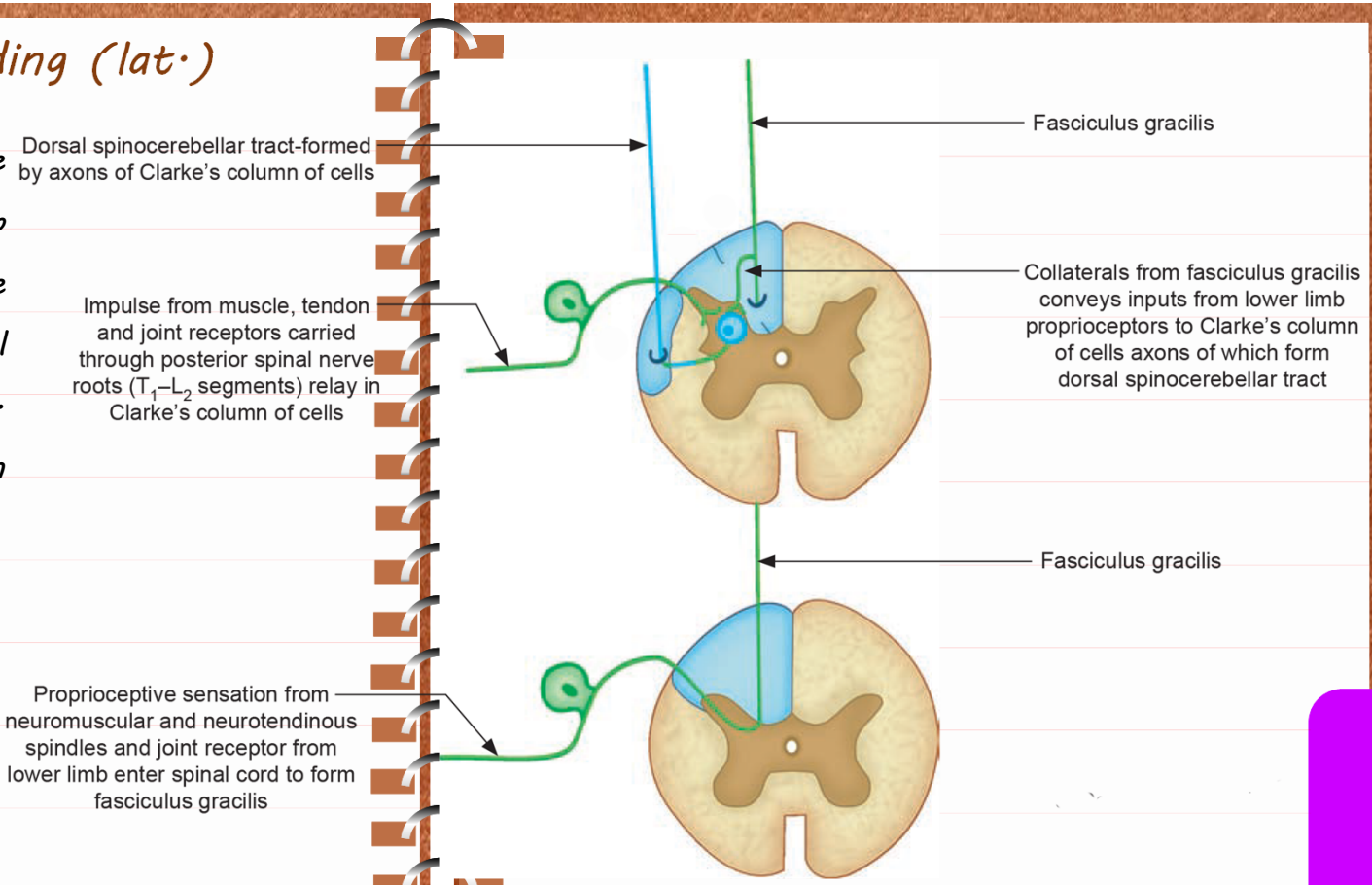


White mater: Ascending (lat·)

UNCROSSED Proprioceptive info· from the lower limb via F· gracilis & from the trunk by segmental afferents from L1,L2→ T1· Above T1 receives info· from F· cuneatus·

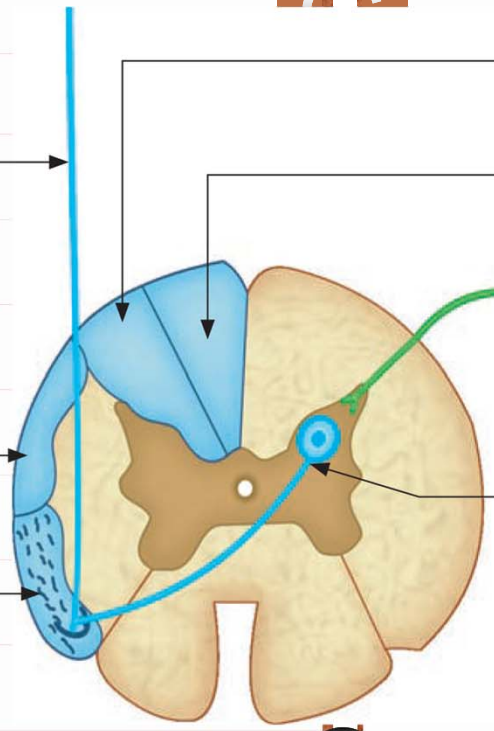
Decussates at MO → ICP·

Dorsal spinocerebellar tract



Illustration

White mater: Ascending (lat·)

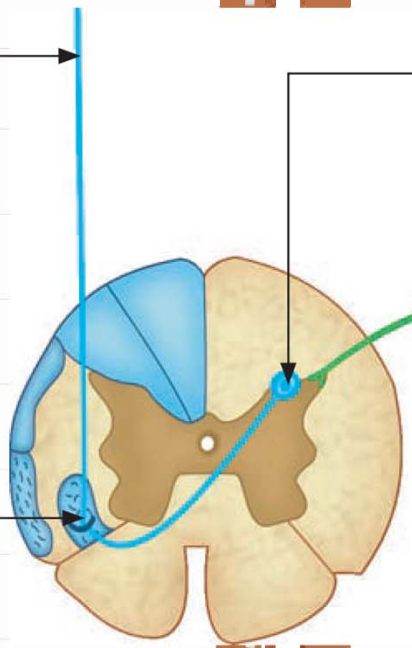


Ventral spinocerebellar tract

CROSSED Proprioceptive info· from contralateral side of body via segmental afferents that cross the ventral white commissure· Ascend to MO & ipsilateral ICP·

Illustraion

White mater: Ascending (lat·)

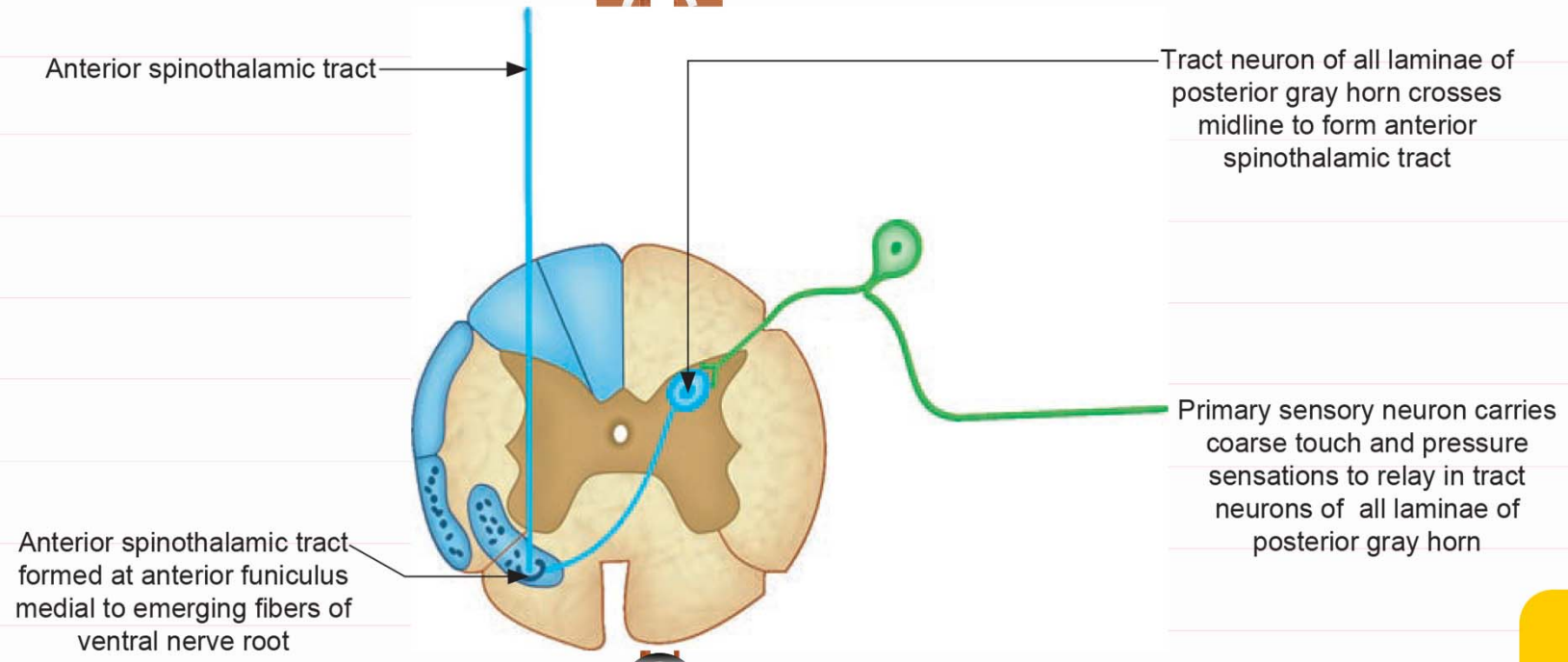


CROSSED fibers (via ant· commissure) of pain & temperature from the opposite side of the body·

Lat. spinothalamic tract

Illustration

White mater: Ascending (ant·)



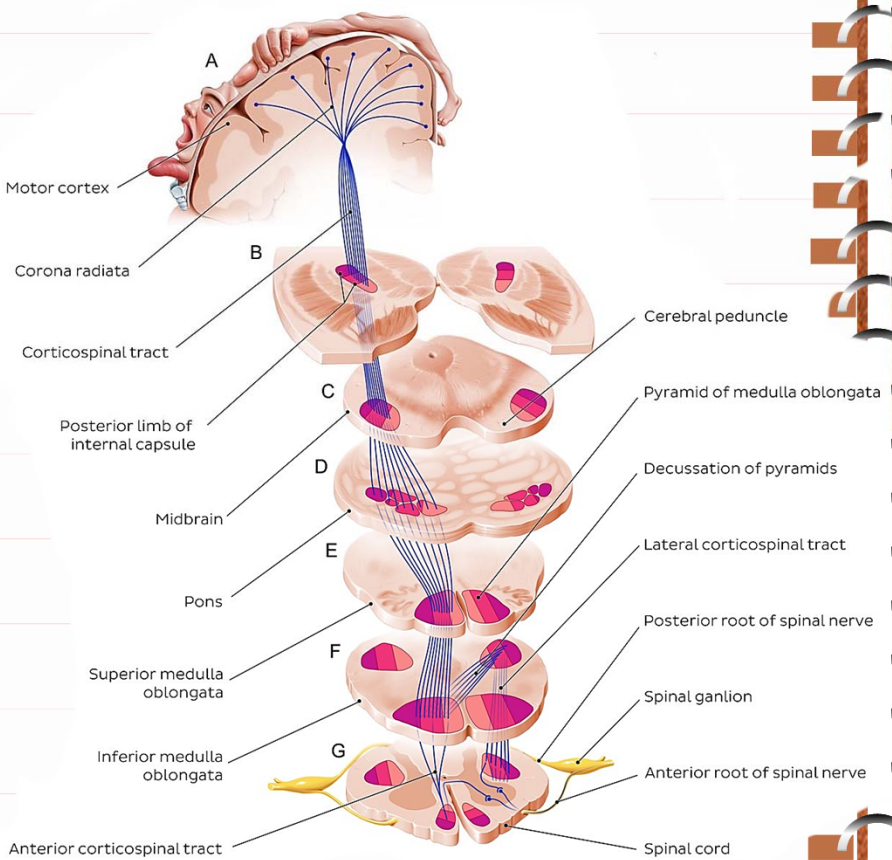
Ant. spinothalamic tract

CROSSED fibers (via ant· commissure) of crude (nondiscriminative) touch & pressure from the opposite side of the body·

Illustration

At the upper part of closed MO the 2 spinothalamic tracts unite and continue up as the SPINAL LEMNISCUS which has connections with the reticular formation & ends in the postcentral gyrus·

White mater: Descending (lat·)

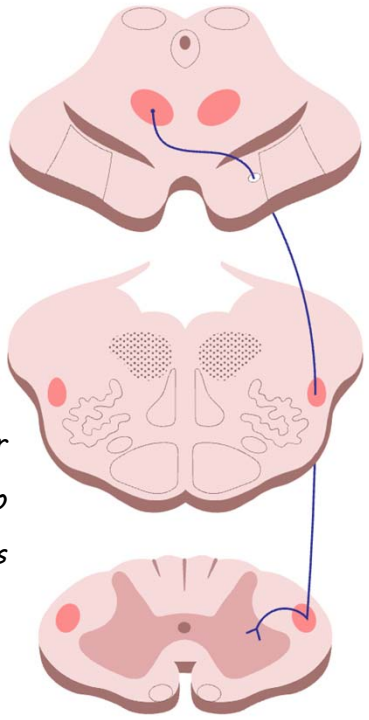


CROSSED

Lateral corticospinal tract

White mater: Descending (lat·)

Red n· → ventrotegmental decussation → rubrospinal tract→ ant· horn cells·



FUNCTIONS

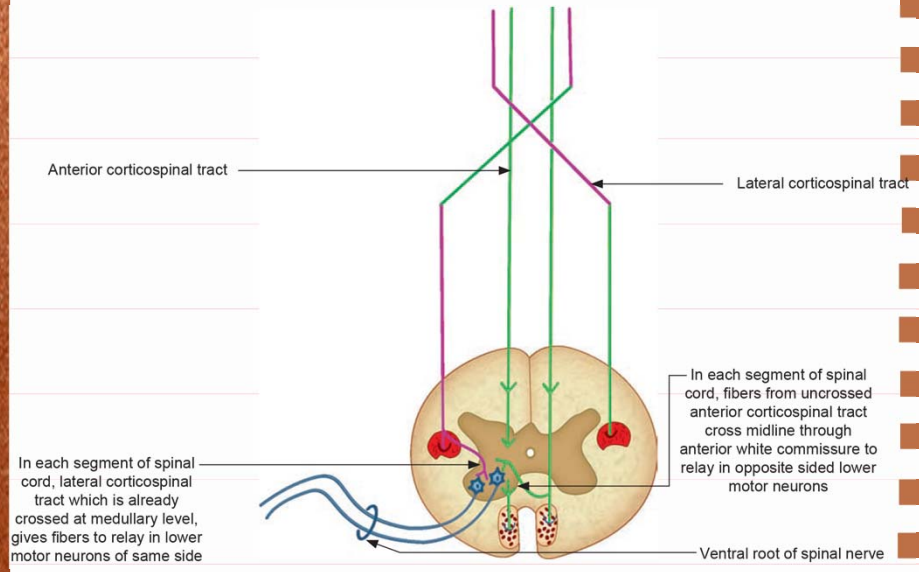
1· Modulation of motor tone, causing flexors to contract and extensors to relax and vice versa·

2· Modulation of flexor reflex activity (e·g· withdrawing hand after touching a hot object)

CROSSED

Rubrospinal tract

White mater: Descending (ant·)



Ant. Corticospinal tract

UNCROSSED· Crosses segmentally via ant· commissure to opposite ant· horn cells·

Ant· extrapyramidal tracts

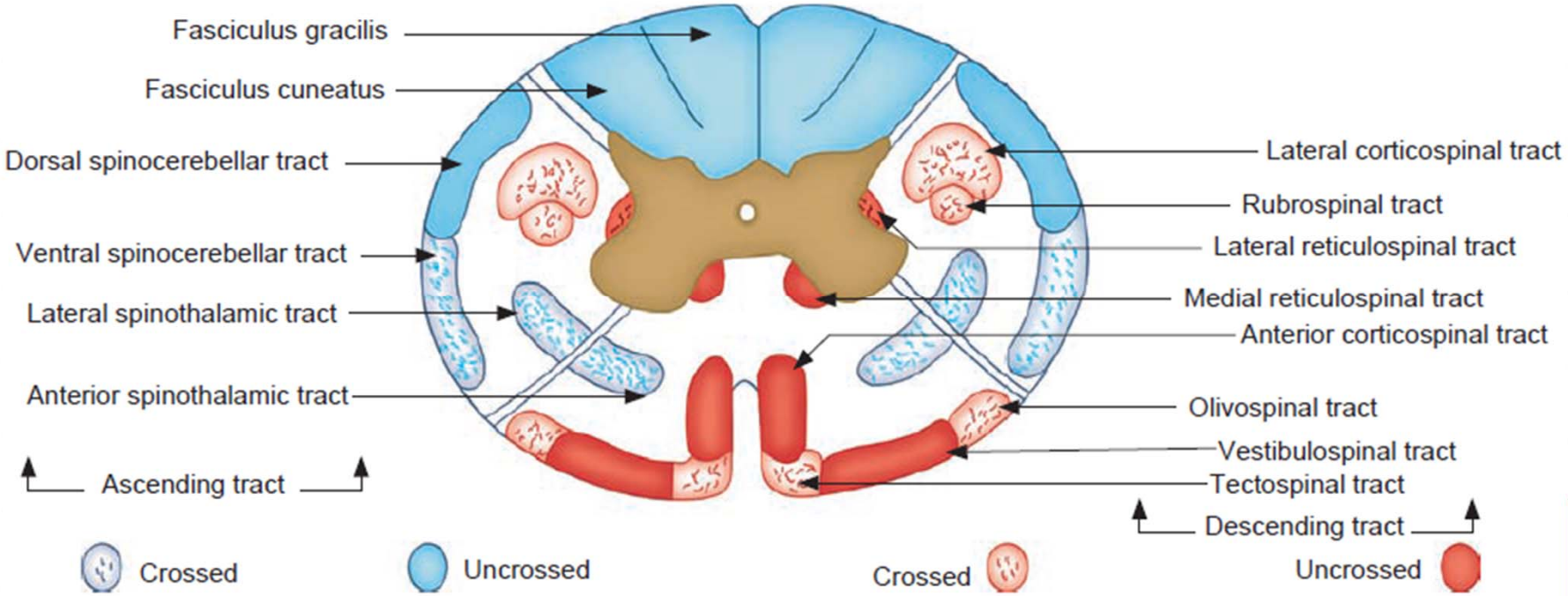
1· **From MB:** <u>CROSSED</u> Tectospinal tract (from sup· colliculus→ tectospinal decussation→ Tectospinal tract→ Cervical ant· horn cells for general visual reflex·

2· **From PONS & MO:** <u>UNCROSSED</u> Lateral & Medial vestibulospinal tracts: From vestibular nuclei → contralat· ant· horn cells· [Lateral is excitatory to extensors & inhibitory to flexors of neck, back and limbs· Medial is inhibitory to cervical & upper back muscles·]

3· **From MO:** <u>CROSSED</u> from inf· olivary nucleus→ olivary decussation→ tract→ ant· horn cells→ facilitates muscle tone·

Extrapyramidal

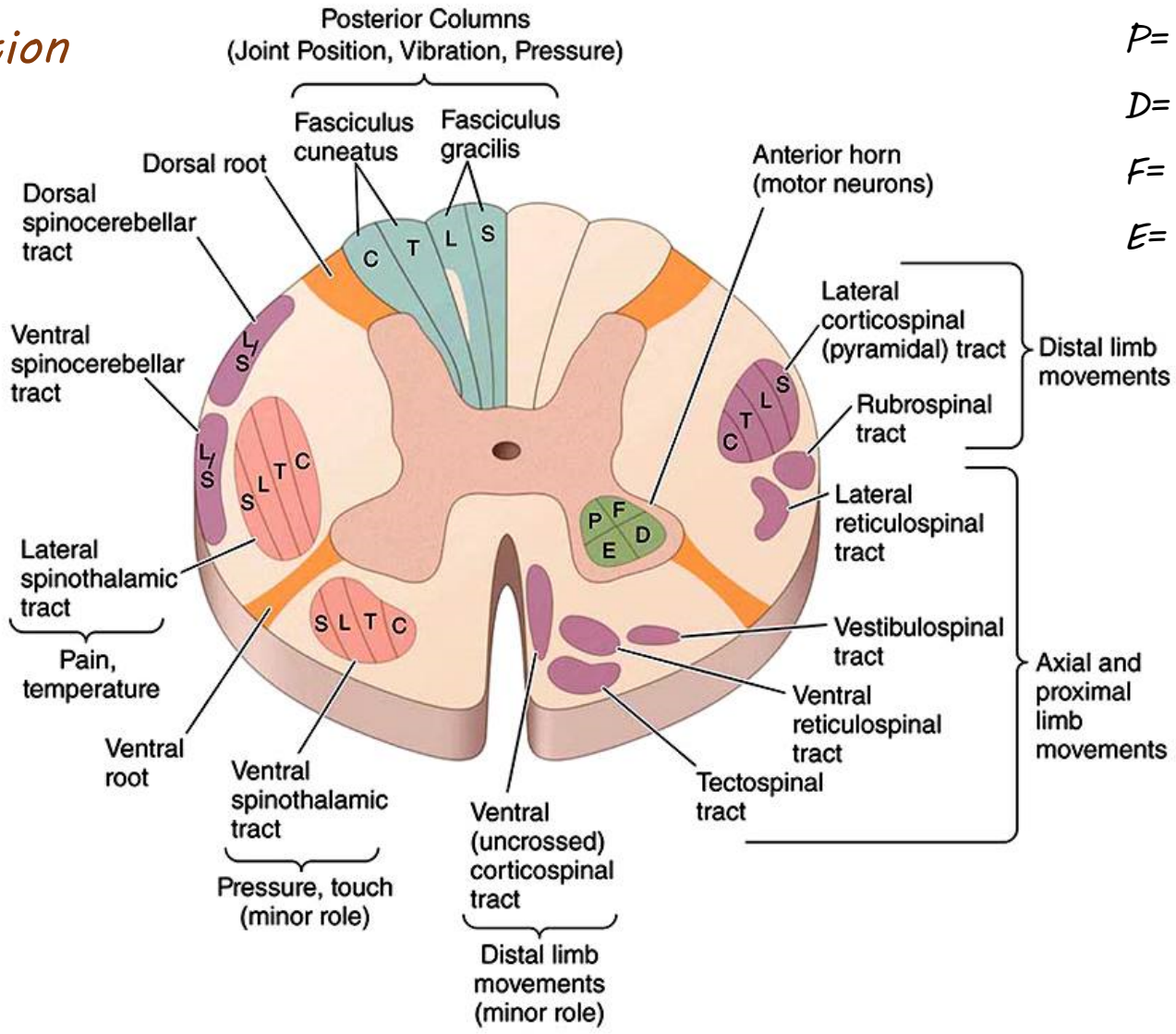
SUMMARY



Illustration

Summary

Body Lamination



P= Proximal

D= Distal

F= Flexors

E= Extensors

C= Cervical

T= Thoracic

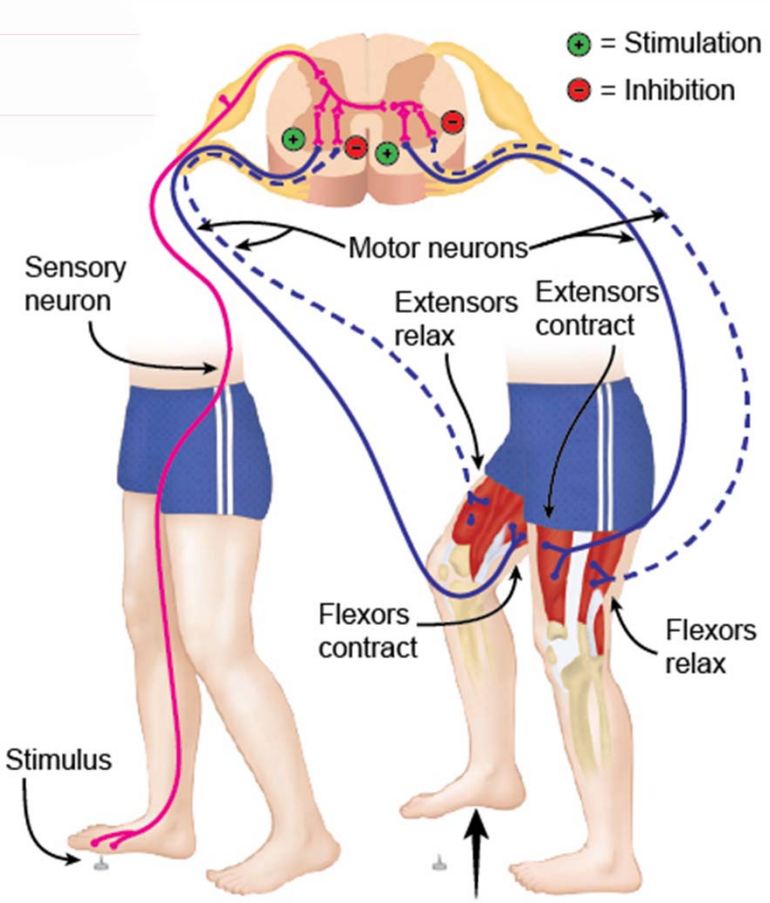
L= Lumbar

S= Sacral

Sensory

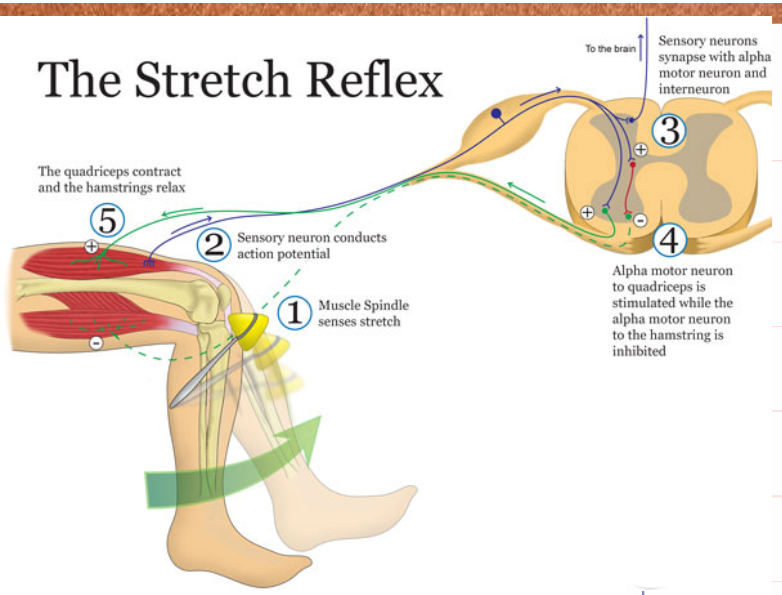
Motor

Spinal reflexes

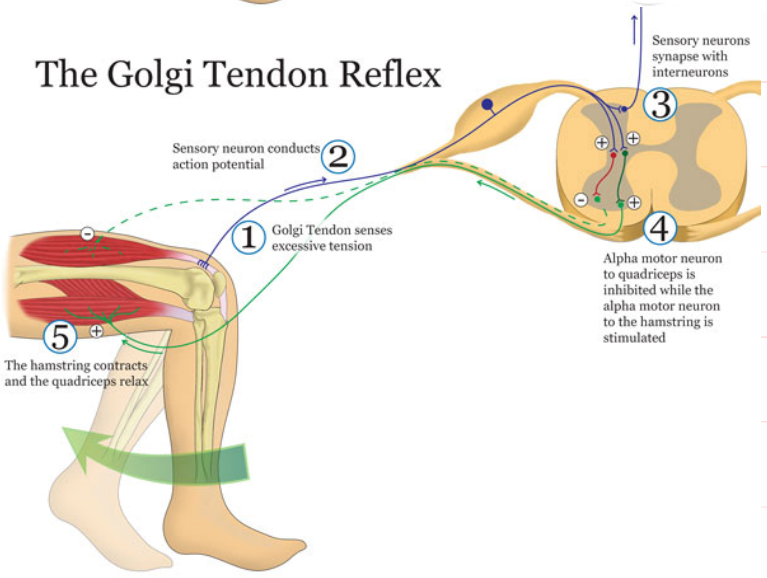


Withdrawal reflex

The Stretch Reflex



The Golgi Tendon Reflex



Stretch & Tension reflexes

Spinal cord syndrome

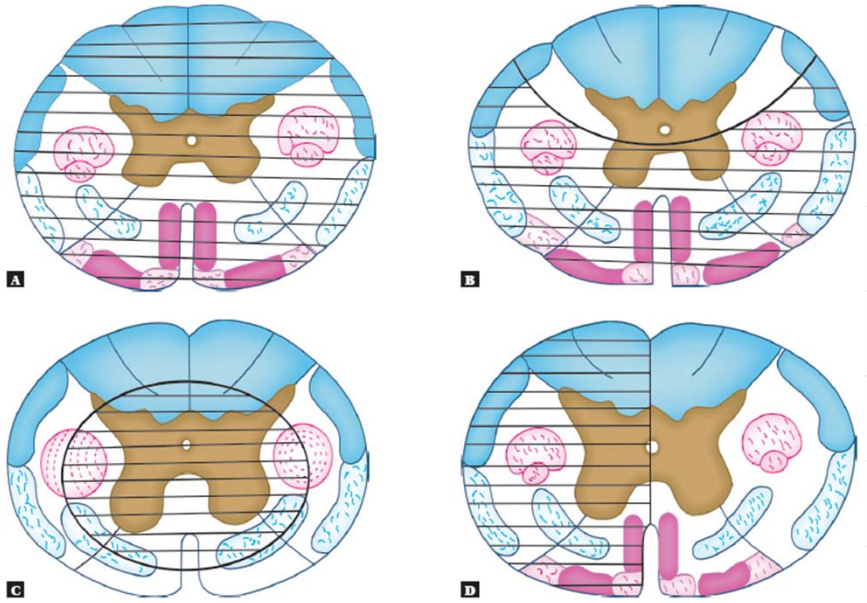
spinal cord may be compressed completely or partially leading to different types of clinical manifestations. These are as follows:

A. Complete cord transection syndrome
B. Anterior cord syndrome
C. Central cord syndrome
D. Cord hemisection syndrome (Brown-Séquard syndrome).

The patient passes initially and temporarily through an acute phase of shock, which is called **spinal shock syndrome** (usually 24 hours) characterized by:

Types

1. Flaccid paralysis
2. Hypotonia or atonia, i.e. loss of muscle tone
3. Loss of tendon reflexes
4. Loss of all sensation below the level of lesion
5. If the lesion is higher level→ hypotension due to loss of sympathetic control
6. Loss of bladder and bowel function.

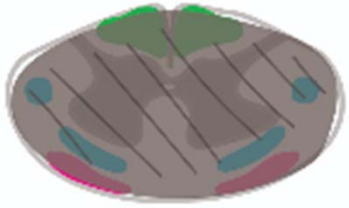


Causes

Causes of Spinal Cord Lesion

1. Traumatic: Fracture dislocation of vertebra or Penetrating injury.
2. Vascular: (arterial infarction or venous edema)
3. Infective: Viral or bacterial.
4. Degenerative: Causing demyelination.
5. Neoplastic: By expanding tumor.

Complete Cord Syndrome



Transverse Cord Lesion

Mostly traumatic· Less commonly due to tumor invasion or localized inflammation· There will be:

1· Bilateral flaccid paralysis of muscles supplied by motor nerve roots arising from the affected segment·

2· Below the level of lesion there will be bilateral spastic paralysis, loss of tendon reflexes & +ve Babinski sign·

3· Bilateral loss of all sensations below the level of lesion·

4· Loss of voluntary control of bladder and bowel function due to damage of descending autonomic fibers·

Anterior cord Syndrome

Anterior Cord Syndrome

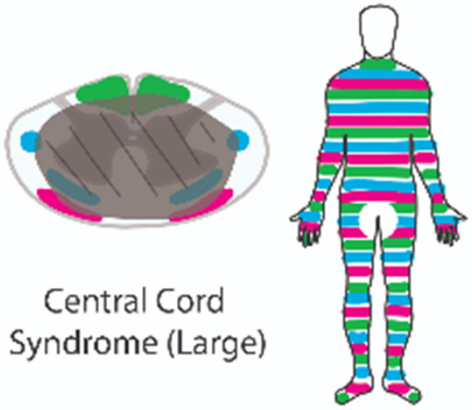
Mostly ischemic, may be traumatic· Effects are bilateral:

1· Bilateral flaccid paralysis of muscles supplied by motor nerve roots arising from the affected segment·

2· Below the level of lesion there will be bilateral spastic paralysis·

3· Bilateral loss of pain, temperature (lat· spinothalamic tr·) + pressure and crude touch (ante· spinothalamic tr·)· <u>Fine touch & proprioception are SPARED· (Post· column OK)·</u>

Central Cord Syndrome

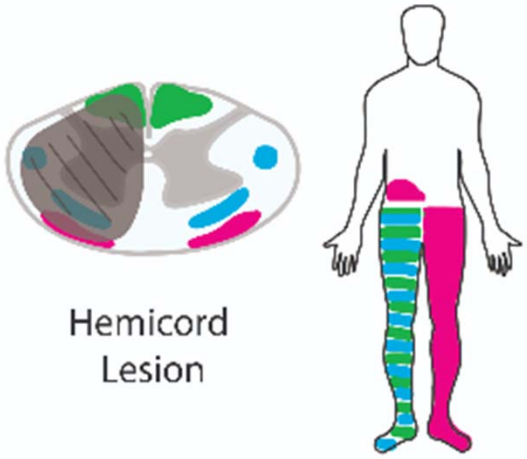


Typically caused by severe hyperextension of cervical part of vertebral column in a car accident. It affects both upper & lower limbs, causing:

1. Bilateral flaccid paralysis of muscles supplied by motor nerve roots arising from the affected segment.
2. Below the level of lesion there will be bilateral spastic paralysis.
3. Bilateral loss of pain, temperature (spinothal. tracts) and pressure but not fine touch & proprioception as peripheral parts of F. gracilis & cuneatus remain undamaged.

<u>Lower limb & Urofecal fx. may be unaffected because in both motor and sensory tracts, peripherally placed sacral fibers are spared.</u>

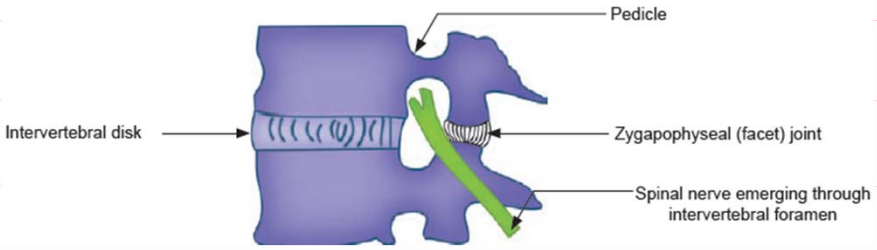
Brown-Séquard Syndrome

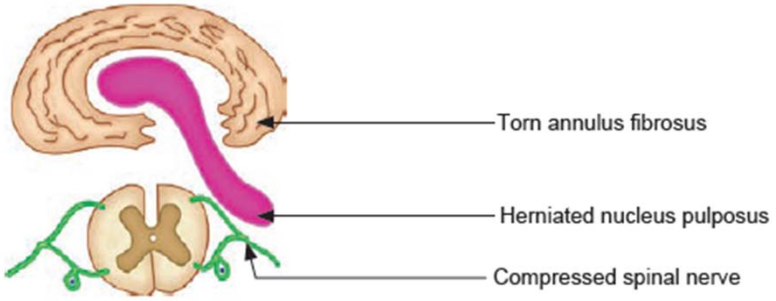


Mostly due to penetration injuries producing unilateral effects:

1. Ipsilateral flaccid paralysis of muscles supplied by the affected segment.
2. Ipsilateral anesthesia over the dermatome of the affected segment.
3. Ipsilateral spastic paralysis below the level of lesion with +ve Babinski sign & exaggerated tendon jerks.
4. Ipsilateral loss of fine touch, proprioception & vibration (F. graciclis & cuneatus damage) below the level of lesion.
5. Contralateral loss of pain &temperature (lateral spinothalamic tr.) and pressure sensation (anterior spinothalamic tr.) below the level of lesion.

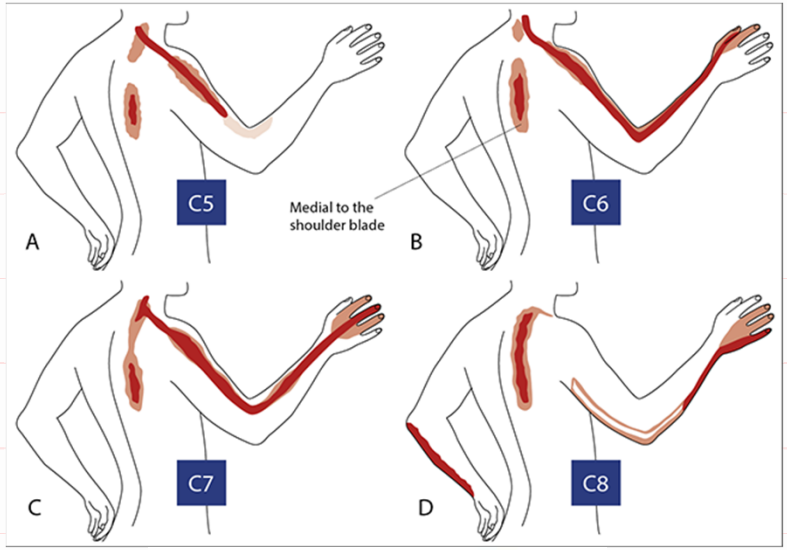
Nerve Root Compression

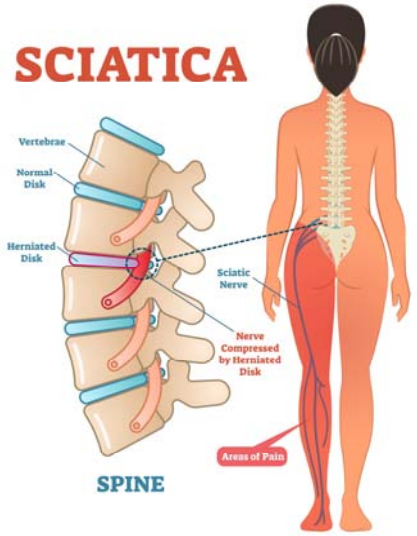




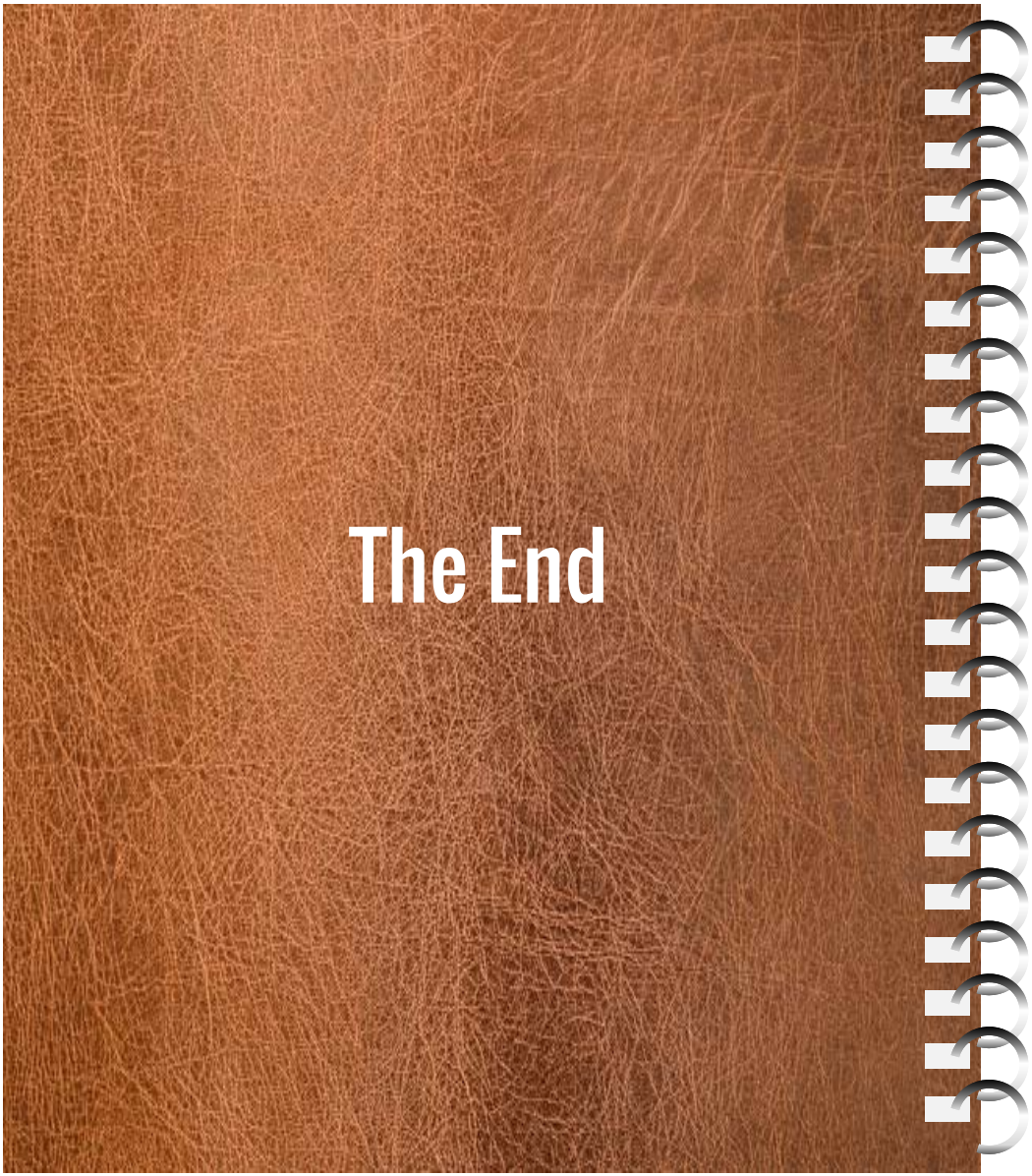
May be caused by a collapsed vertebra (root canal pressure) or herniated intervertebral disc. The spinal nerve trunk is compressed leading to paresthesia of the dermatome of the affected nerve & weakness of the myotome muscles.

Proximal cut





Cervical vs. Sciatica


The End