

Khalleedd✓Lecture

The Spinal Cord & Its Tracts

Dr. Eyad M. Hussein

Ph.D. of Neurology

**Consultant & Head of Neurology Department,
Nasser Hospital**



ventricular system and CSF circulation

If tumor occurred in 3rd ventricle or a congenital anomalies happened the result is occlusion of both monro and cause acute hydrocephalus we need to treat the patient by a surgery → VP shunt ventriculoperitoneum to decrease the the pressure and drain the CSF
We put 2 VP shunts on the right and left

ITA → is a connection between right and left thalamus

2 Foremen of Lushka + foreman of magendi (in post. aspect of 4th ventricle) drain the CSF to the subarachnoid space

CSF is a fluid looks like the plasma because it comes from arterial blood and produced by choroidal plexus and circulated in ventricular system and subarachnoid space

Choroidal plexus is supplied by ant. and post. choroidal arteries
and PICA → supplies 4th ventricle

In choroidal plexus there is type of glial cells called ependymal cells works to filtrate the arterial blood and secretion and produce the CSF in all the ventricular system but mainly in lateral and 4th ventricle
3rd

If any tumor cause pressure on cerebral aqueduct it will cause obstructive (non communicating) or internal hydrocephalus if we wanna do a VP shunt we do it in one of the lateral ventricles

There is absorption process for CSF every day 3 times: we produce 500 ml each day and we have 150 ml → 75 ml in brain + 75 ml in spinal cord

The reason why it must change every day 3 times cause there is cellular waste must goes to venous blood

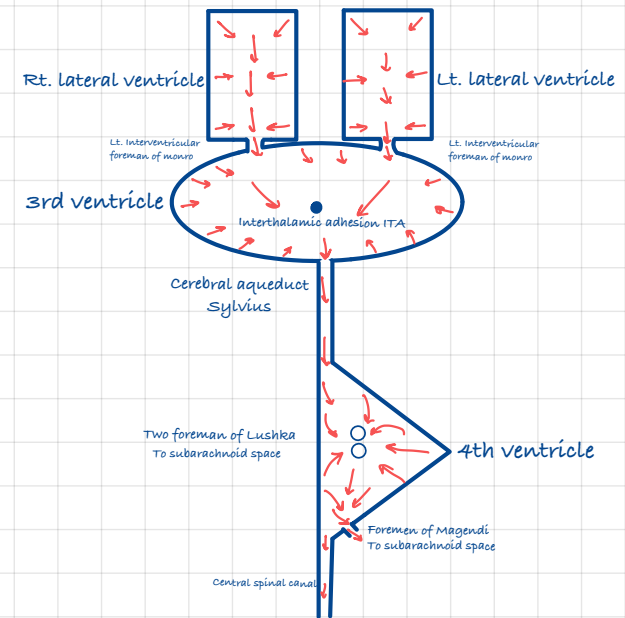
The absorption of CSF is achieved by arachnoid villi and granulation take the CSF and drain it from subarachnoid space to the dural sinuses and dural cerebral veins

If a female overweight patient came with headache we diagnose them pseudotumor cerebri after normal Ct and MRI → 10% of these people has the wrong diagnosis we should do exclusion for all organic causes, we should do MRV magnetic resonance venography → staining of dual venous sinuses to know if there is any thrombosis in intradural sinuses so that IVP + CSF pressures increased cause there is no drainage and the treatment is anticoagulant not diuretics

Functions of CSF is support and protection against trauma, take place of lymph, protection against infections, regulation of introcracial pressure, remove of cellular waste, and nourishment of CNS

CSF appear like the clear water normal saline if turbid it means it contain WBCs and may has septic meningitis

If we take a sample of CSF we take just 3 ml



The pressure of the CSF is 100-180 mm of water

Rate of production 0.3- 0.4 ml so if we are doing lumbar puncture we set the patient in flat position for some time to increase the production of the CSF and prevent the decrease that is caused by the sample itself cause if the patient has intracranial hypotension he will face post lumbar puncture headache

Cells in the sample 0-5 WBCs (lymphocyte) and 2-3 neutrophils is normal

No RBCs in the sample and if there → it may be traumatic from LP or subarachnoid hemorrhage

The technique is used that we take 3 samples and look to the appearance if the same color it may be hemorrhage but if it has been diluted and the sample is start to be clear it may be traumatic

The 2nd way to differentiate is after the labs done we ask for centrifugation for the sample if subarachnoid hemorrhage so its old bleeding and have been destructed and the color of the sample stay xanthochromic if traumatic after the centrifugation it will sedimentate the blood in the sample and the blood appear as a red point

The glucose in CSF is 70% of serum

In bacterial meningitis → decrease glucose level in CSF

Total protein in CSF = 15-45 S increase in cases like GBS (Guillain-Barré syndrome) multiple sclerosis and malignancy as a result of demyelinated process the myelin is a lipoprotein so it will increase protein in CSF

GBS is crave disorder where body immune system damage the nerves without knowing the cause

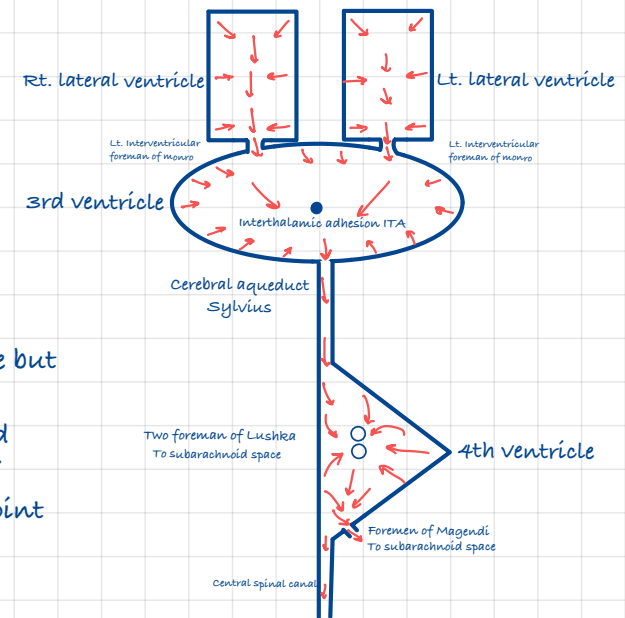
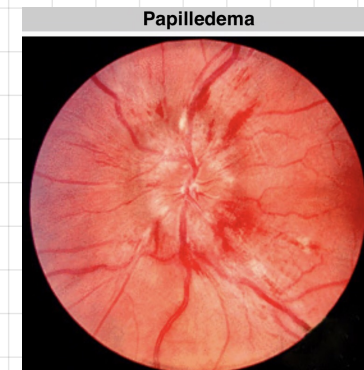
Hydrocephalus is distention of ventricular system either as a result of papilloma in choroidal plexus over secretion of CSF or obstruction in the drainage or failure of the absorption by villi and granulation

To differs between acute or chronic hydrocephalus

If subarachnoid space is open it is chronic

If subarachnoid obliterated and closed it is acute

Papilloedema refers to the swelling of both optic discs in your eyes due to increased intracranial pressure (intracranial hypertension)



Anatomy of the Spinal Cord (SC)

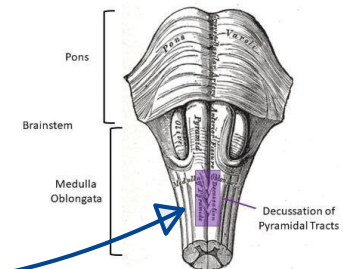
- **Shape:** compressed cylindrical column.
- **Number of neurons in human SC:** about 13,500,000
- **Length of human SC:** about 45 cm (male); 42 cm (female).
- **Weight of human SC:** about 35g and comprises 2% of the weight of the adult brain.
- **Diameter:** about 1 cm. With 2 enlargements cervical and lumbar
- **Location:** It is located in the spinal (vertebral) canal.
Spinal cord is extracrainial part of CNS

Location of the Spinal Cord

CNS → Brain and spinal cord



- The spinal cord (SC) is an **extracranial** part of the central nervous system enclosed inside the vertebral column “**Spinal Canal**”.
- Beginning:** the SC is continuous with the medulla oblongata at the **spinomedullary junction** which begin from the foramen magnum At the base of the skull downward. SC is a continuation of MO (medulla oblongata)
- A plane defined by three structures:**
Spinomedullary junction is known by
 - ✓ **The foramen magnum.** At the base of the skull
 - ✓ **The pyramidal decussation.** Posteriorly
At the lower part of it
 - ✓ **The emergence of the first cervical nerve anterior rootlets.** Exit of ant. rootlet of C1
- Lies within the **subarachnoid space.**
- The subarachnoid space extends caudally to the level of **the** Like a tail
Ends at level of S2 → sacral vertebrae 2
second sacral vertebra.





Termination of the Spinal Cord

مع التقدم بالعمر، خنأقي انه الإنسان يكبر بشكل caudally ف بلاقي انه ال spinal canal بأكبر وبتطول بينما ال spinal cord بينمو بشكل أقل بكتير منه ال vertebral column، ف هاه بيصير الاختلاف

— Spinal canal → vertebral column
— Spinal cord

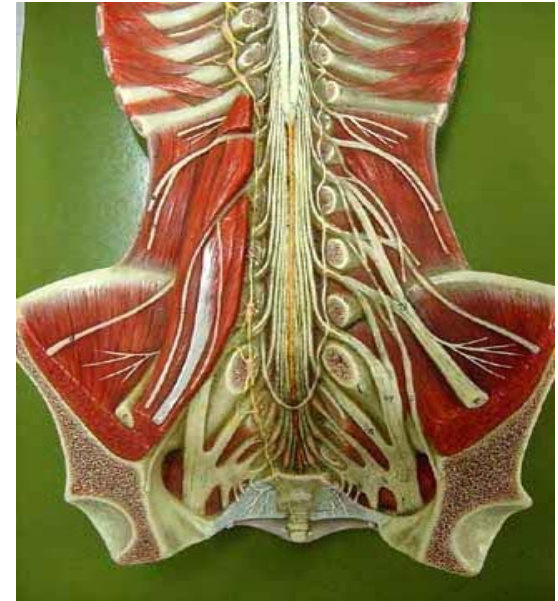
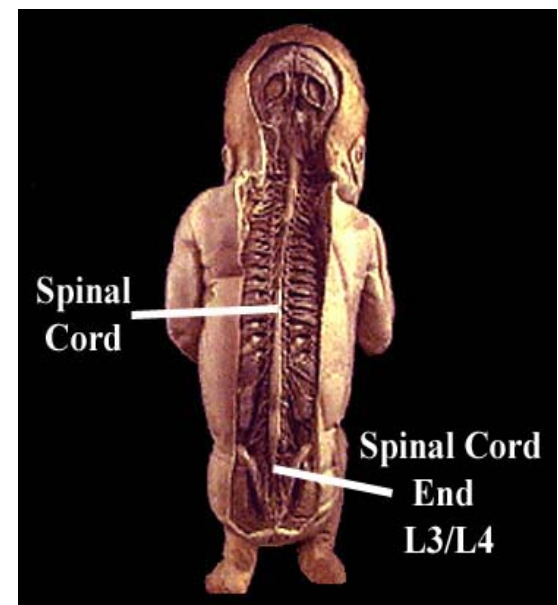
• **At the third month of intrauterine life:** the SC fills the whole spinal canal.

• **At birth:** it ends at the level of L3 vertebra.
We do LP at level of L4-L5

• **In the adult:** it ends at the level of lower border of the L1 vertebra.
The spinal canal increased in length while the spinal cord is still constant

ال vertebral column أو حتي الأصح انه يكبر لكه بشكل أقل بكتير منه ال

Clinically it is very important to differentiate cuz if we wanna do LP we should know where the spinal cord ends to avoid it's injury



Function of the Spinal Cord

1. Conduction function: from and to the brain:

a. Ascending tracts: conduct ^{Afferent to the CNS} sensory impulses
Example → lateral spinothalamic tract for pain and temp. sensation
from the SC to the brain.

b. Descending tracts: conduct ^{Efferent from the CNS} motor impulses
Example → lateral corticospinal tract for somatic motor
from the brain to SC.

2. Reflexes center: the gray matter of the SC is the

Specific for SC has no relation to the brain even if it's dead it may work and be preserved

Example: knee jerk reflex

integrative area for all spinal reflexes.

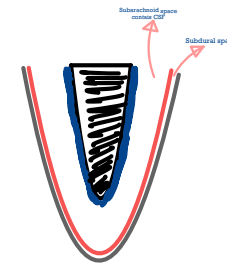
Through interneurons found between ant. and post. horn
cells it's function is integrative center or reflex center

The impulse transmits from post. to ant. horn like synaps
contact and the relay is by interneurons in SC

Meninges of the Spinal Cord

- SC
- Pia mater
- Arachnoid mater
- Dura mater

The spinal cord is covered by 3 membranes (meninges),
from inside to outside they are:



1. Pia Mater.

Ends with SC at lower border of L1

2. Arachnoid Mater.

Ends at S2

Contain B.Vs

Subarachnoid space between arachnoid and pia → contain
blood vessels and spinal nerve roots

While in brain → cranial root

Contain CSF

3. Dura mater.

Ends at S2

Subdural space between arachnoid and dura → contains
semiliquid fluid lubrication for the movement

Between dura mater and the bony vertebrae there is epidural space that contain
Semiliquid fat and venous plexus

The Pia Mater

- Closely adherent.

So ends in adult at the level of lower border of L1 and in children at the level of L3

- Ends at the level of SC termination **(lower border of the first lumbar vertebra in adult).**

- Form the **denticulate ligaments**. Its function to anchoring the spinal cord

Triangular shaped extensions

From foreman magnum to the level of T1

21 pairs of denticulate ligaments seen all along the length of the SC

- It continues as the **filum terminale** which attached to the back of **coccyx**. For fixation of spinal cord

The Arachnoid Mater

Located between pia mater and dura mater

- The inner surface of the dura matter.
- It ends at the level of **the second sacral vertebra**.
In any age S2

The Dura Mater

- It ends at the level of **the second sacral vertebra**.
In any age S2
- It is attached to: For fixation
 - Margins of foramen magnum.
 - Intervertebral foramina.
 - Bodies of the 2nd and 3rd cervical vertebrae.

Meningeal Spaces Of Spinal Cord

1. **Epidural Space:** it is a potential space located between the dura matter and vertebral periosteum. It contains semiliquid fat and internal vertebral venous plexus.
2. **Subdural Space:** it is located between the dura matter and arachnoid matter. Contains thin film of serous fluid.
3. **Subarachnoid Space:** it is located between the arachnoid and pia matter. Is a wide space contains:
 - CSF.
 - Spinal blood vessels.
 - Roots of spinal nerves.

Anatomy of the Spinal Cord

If bleeding happened it called extradural hematoma

Epidural space
(contains fat)

Subdural space

Subarachnoid space

If bleeding happened here it is not hematoma it is hemorrhage cuz it is circulated blood

Pia mater

Arachnoid

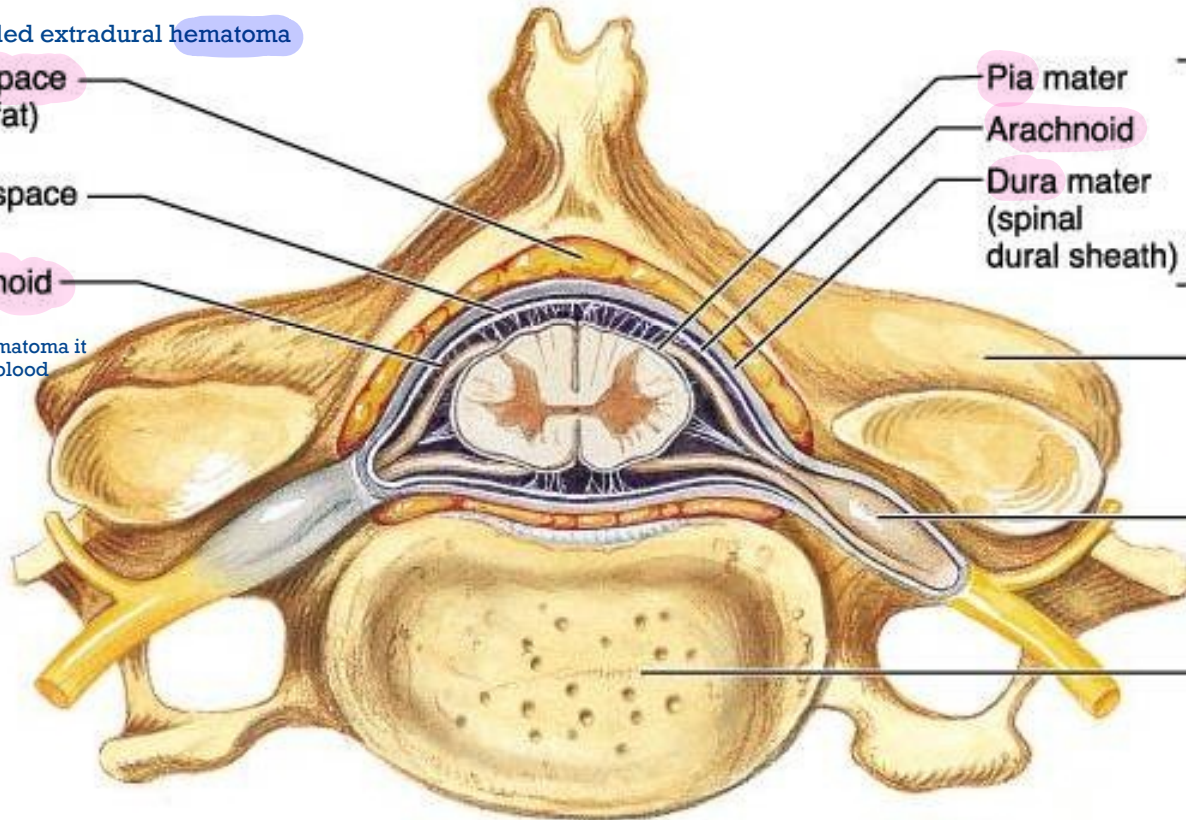
Dura mater
(spinal
dural sheath)

Spinal meninges

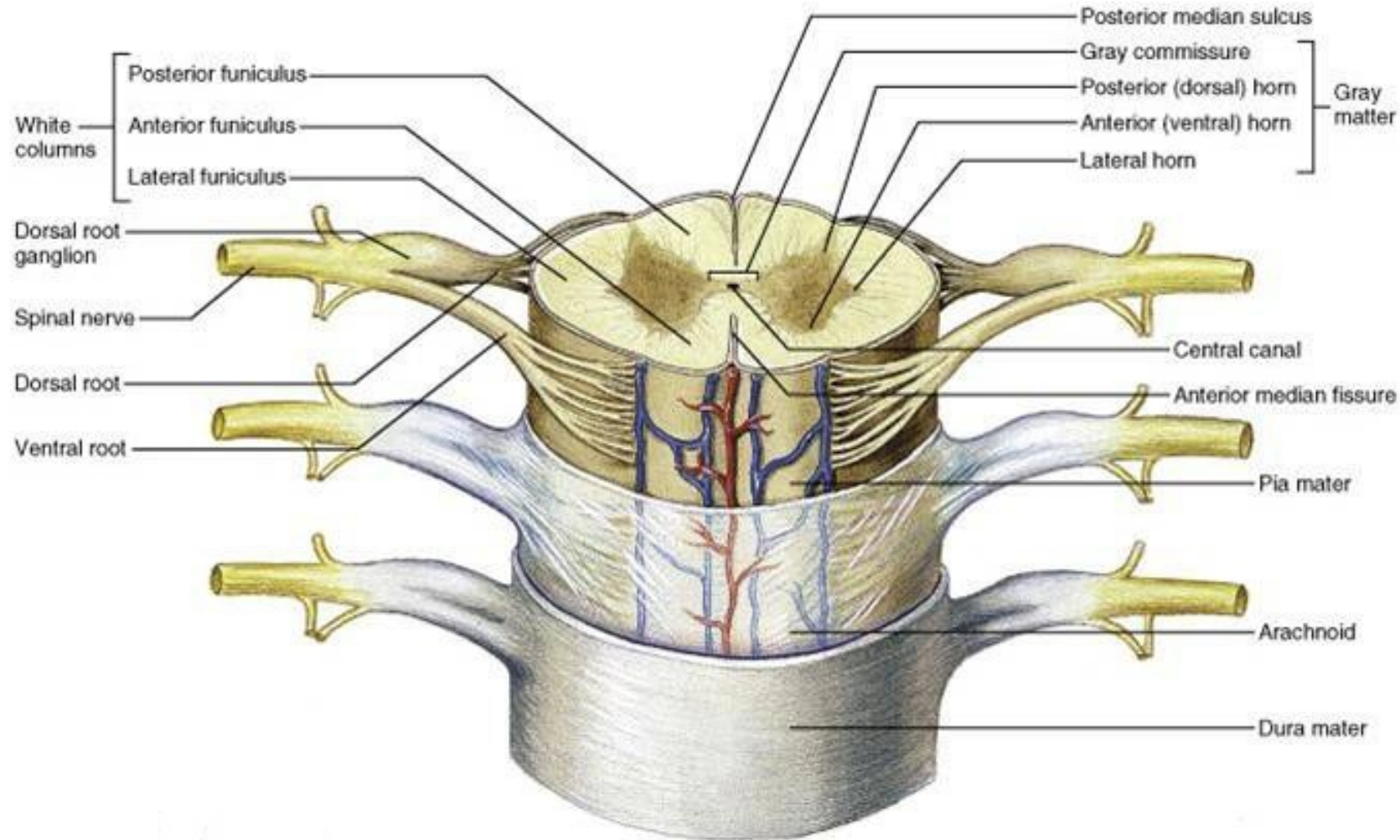
Bone of
vertebra

Dorsal root
ganglion

Body
of vertebra



Anatomy of the Spinal Cord

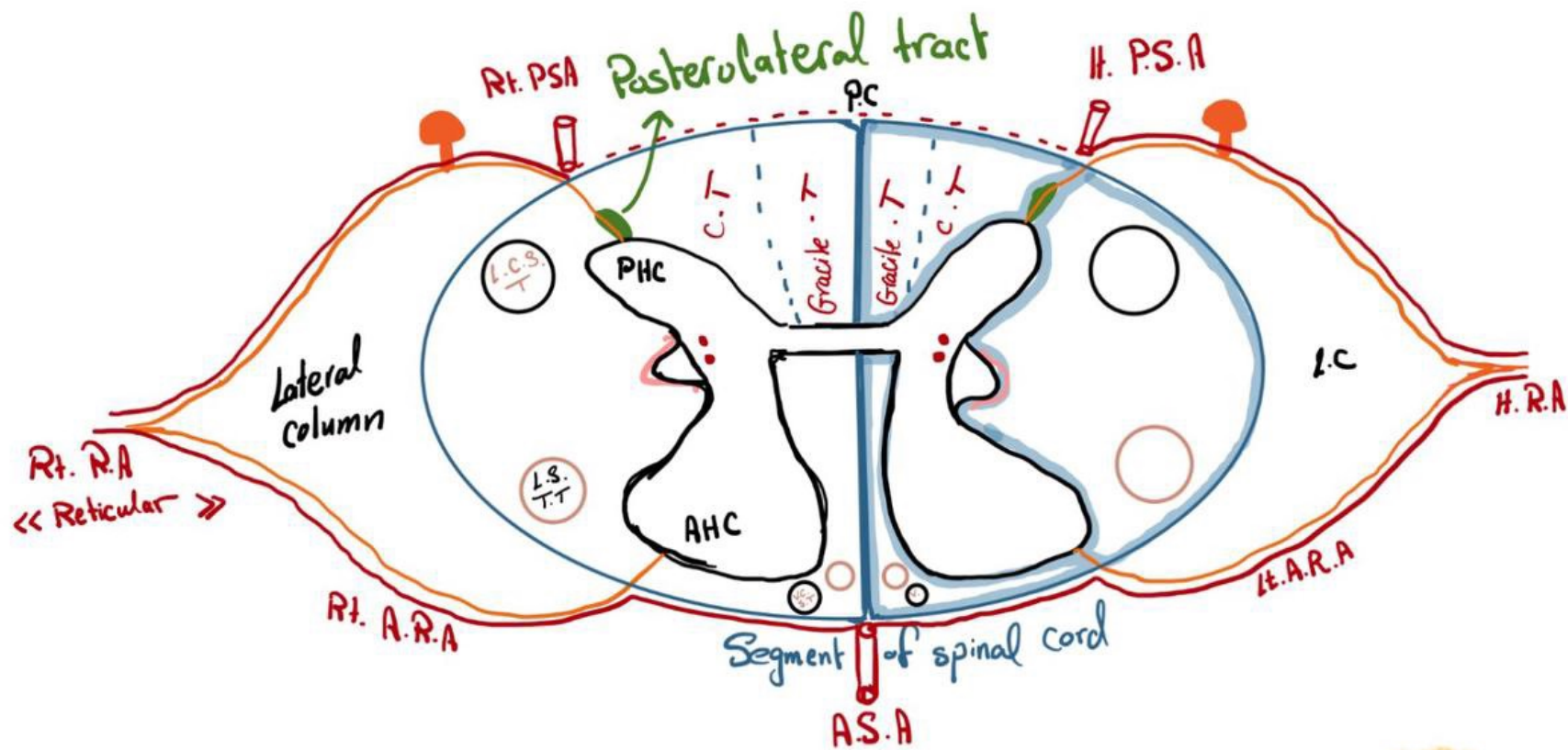


External Structure of the Spinal Cord

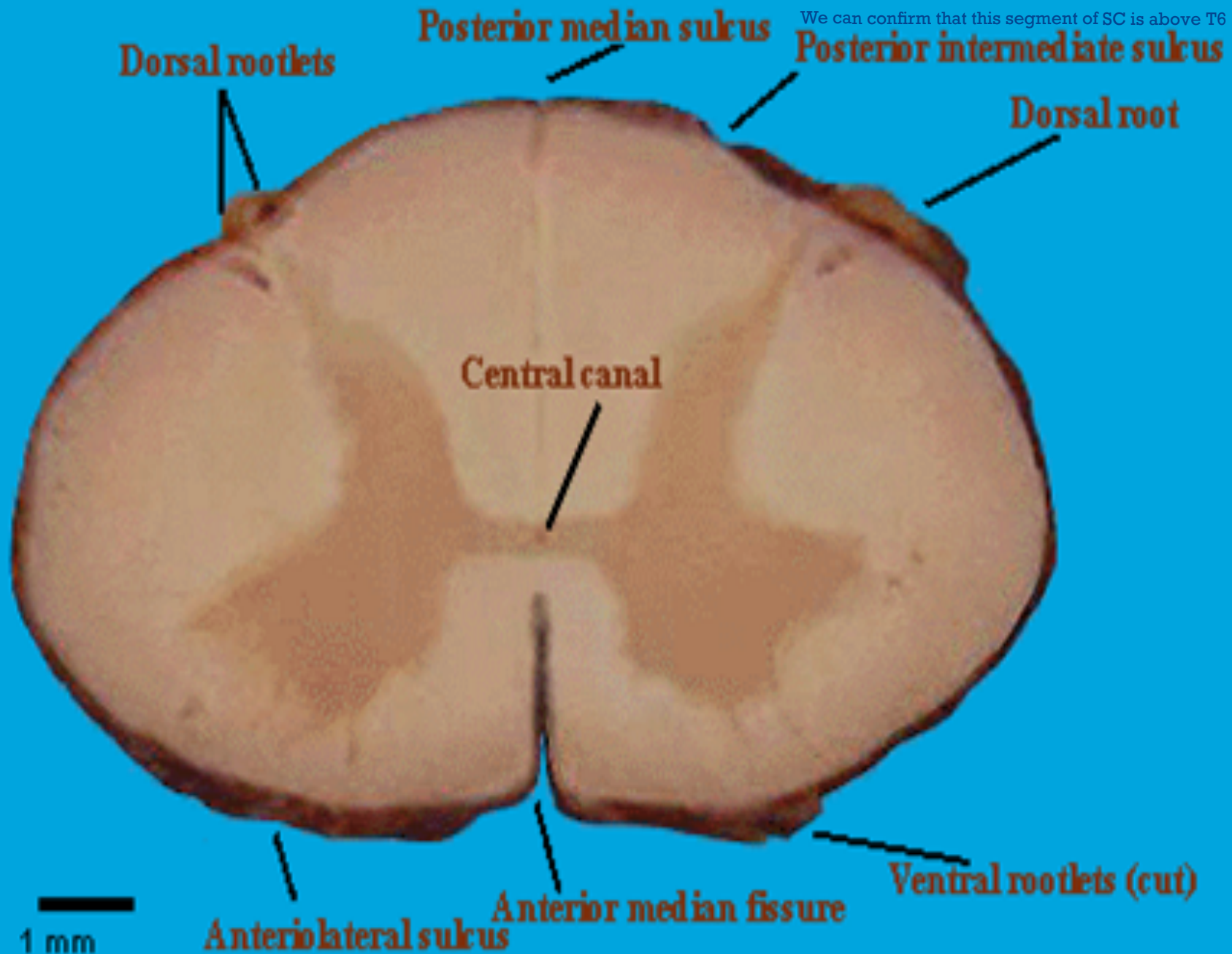
Cross section

- **Anterior median fissure:** the anterior spinal artery is found superficially.
Divide the SC to 2 parts Rt. and Lt.
- **Posterior median sulcus.**
Fissure
- ² **Anterior lateral sulcus:** from which the anterior rootlets emerge.
2 → Rt. and Lt.
- ² **Posterior lateral sulcus:** into which the posterior rootlets enter.
- **Posterior intermediate sulcus:** In some areas of SC Starts at T6 and above
 - ✓ Found between the posterior lateral and posterior median sulci but only above T6 level. For proprioception and fine touch
 - ✓ Separates the **Gracile fasciculus** from the **Cuneate fasciculus.**
 - Medial
For lower part of the body
Found in the whole length of the spinal cord
 - Lateral
For upper part of the body
Starts at T6

So



L.C.S.T. $\Rightarrow$ Lateral corticospinal tract
 L.S.T.T. $\Rightarrow$ Lateral spinothalamic tract
 V.C.S.T. $\Rightarrow$ ventral corticospinal tract



The Spinal Cord Segments

Each segment contains gray internally and white externally matter (عزلت تقسيمه الداكنة)

There are 31 segments:

8 – Cervical segments.

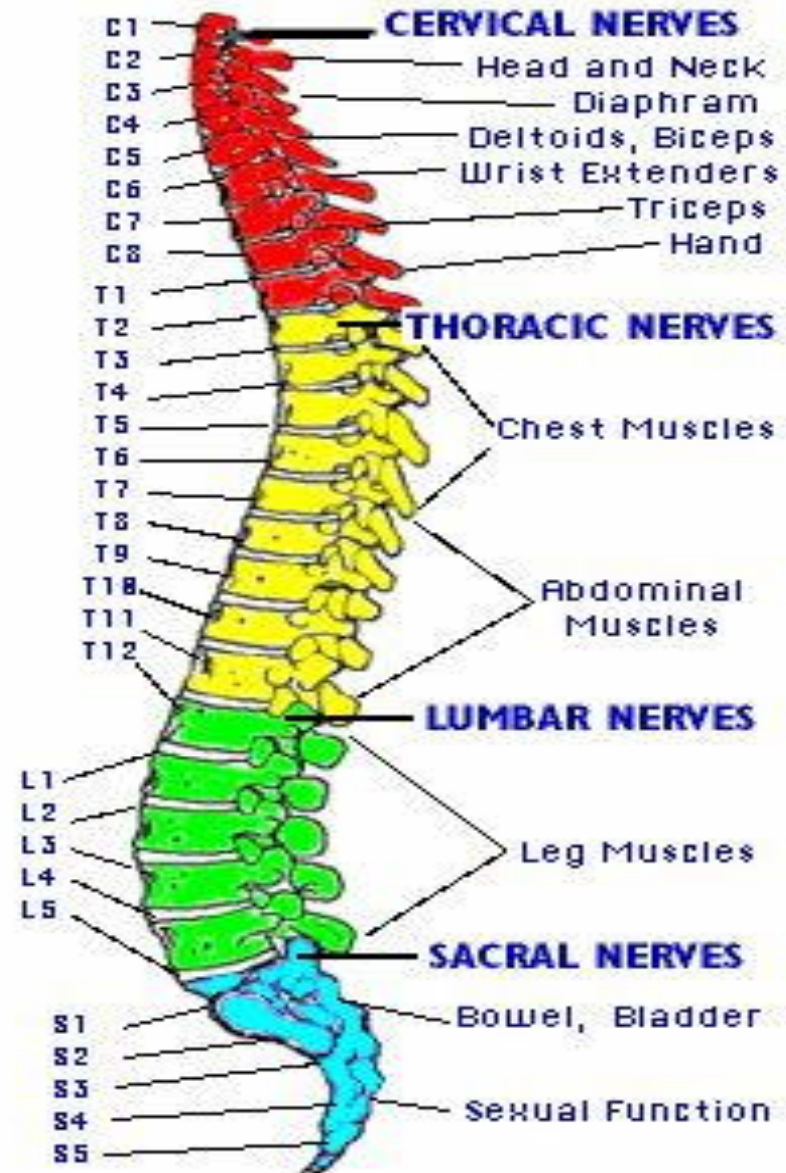
Cervical → 7 vertebrae

12 – Thoracic (dorsal).

5 – Lumbar segments.

5 – Sacral segments.

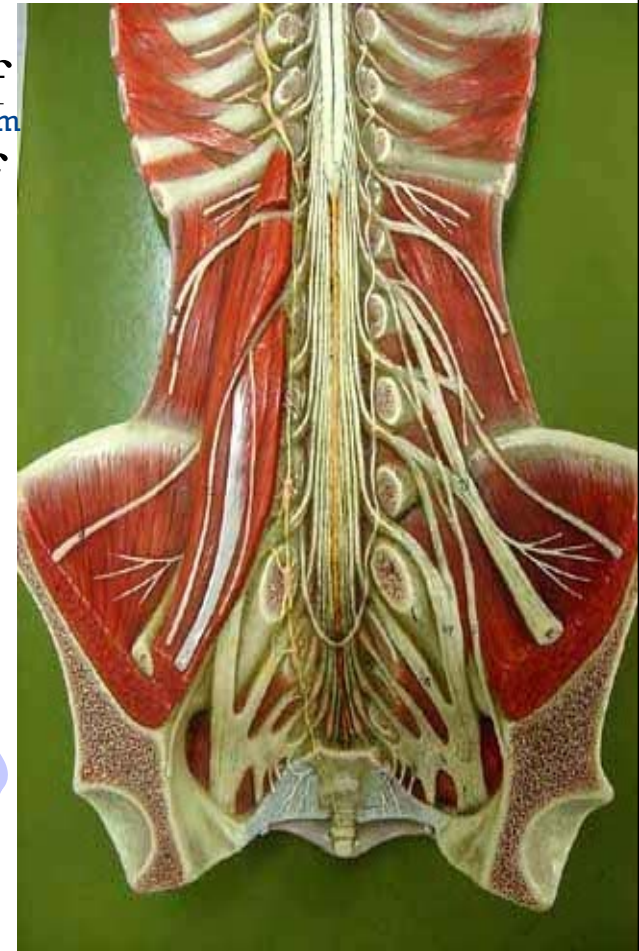
1 – Coccygeal segments.



- **Epiconus:** it is the L4, 5 and S1, 2 segments of the SC.
- **Conus medularis:** the lower end of the SC. Its importance is it has sacral part of parasympathetic nervous system. It is the S3, 4, 5 segments of the SC.

As a result to the end of the SC at the level of L1 and there is roots of spinal nerves after that level from L2-3-4-5 S1-2 so it will descend and make a collection of root called caudal equine and it has no relation to SC and its apart of peripheral nervous system

- **Cauda equina:**
Nerve roots
 - It is located below the lower border of the first lumbar vertebra, the spinal canal is filled by the collection of lumbo-sacral roots which descends in this space to their corresponding intervertebral canal.



Enlargement of the Spinal Cord

Spinal cord diameter is 1cm

It faces a load in outlet of brachial and lumbosacral plexuses so we have 2 enlargements

So in these areas the diameter exceeds 1cm

1. Cervical enlargement.

Segments of C4-5-6-7-8 → T1

Origin of brachial plexus which innervates the upper limb

2. Lumbar enlargement.

Segments of L1-2-3-4 → S1-2

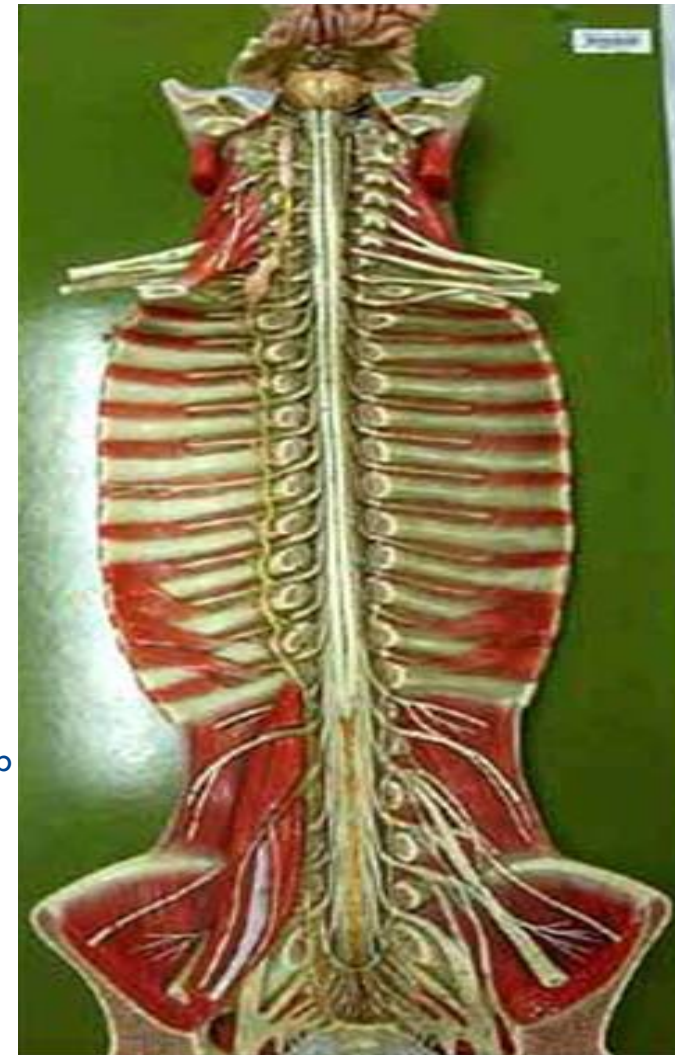
Origin of lumbosacral plexus which innervates the lower limb

Clinical scenario

What differs if we cut (damaged) the conus medullaris part or the lumbosacral plexus

The 1st is responsible for parasympathetic for sacral so if lost the patient can't control defecation and micturition

The 2nd is responsible for movement and motor function for lower limb.



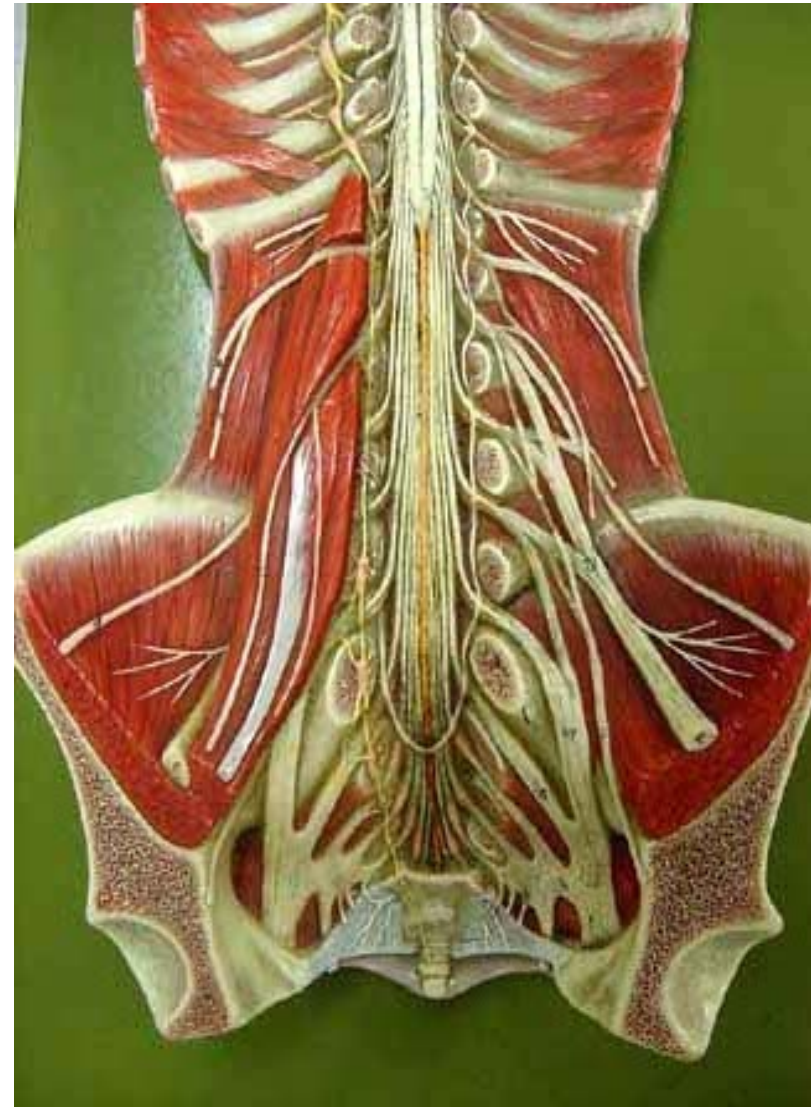
Done ✓ Cervical Enlargement of the Spinal Cord

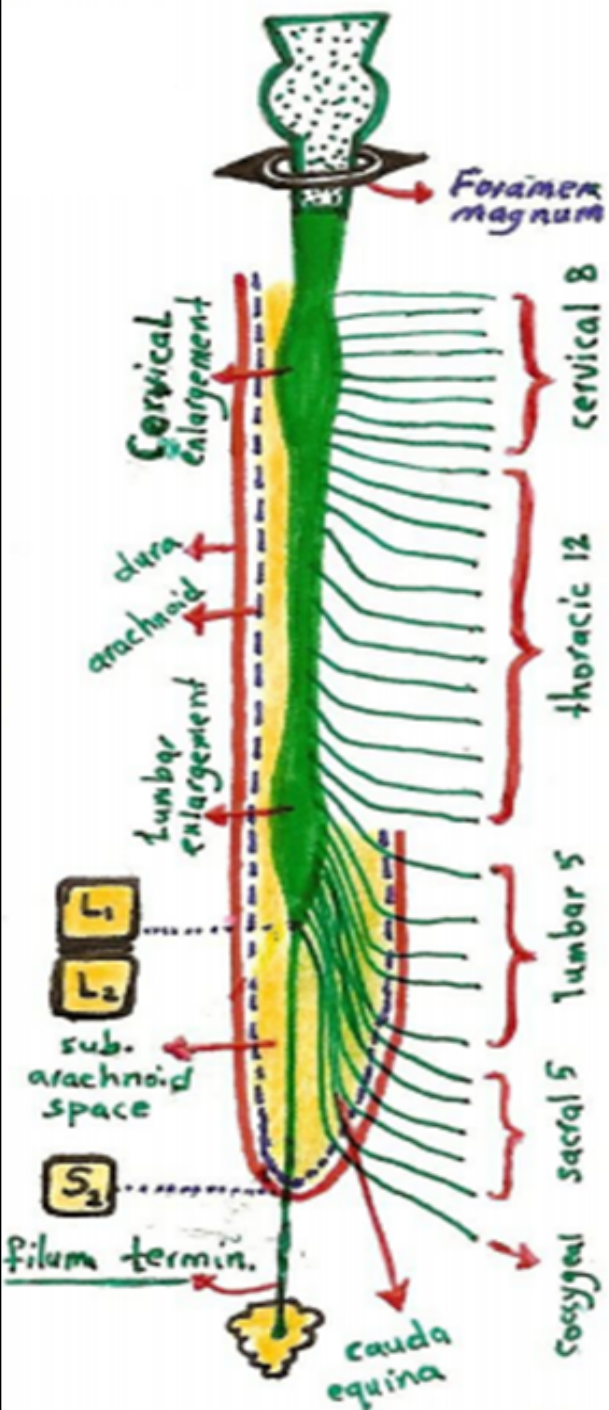
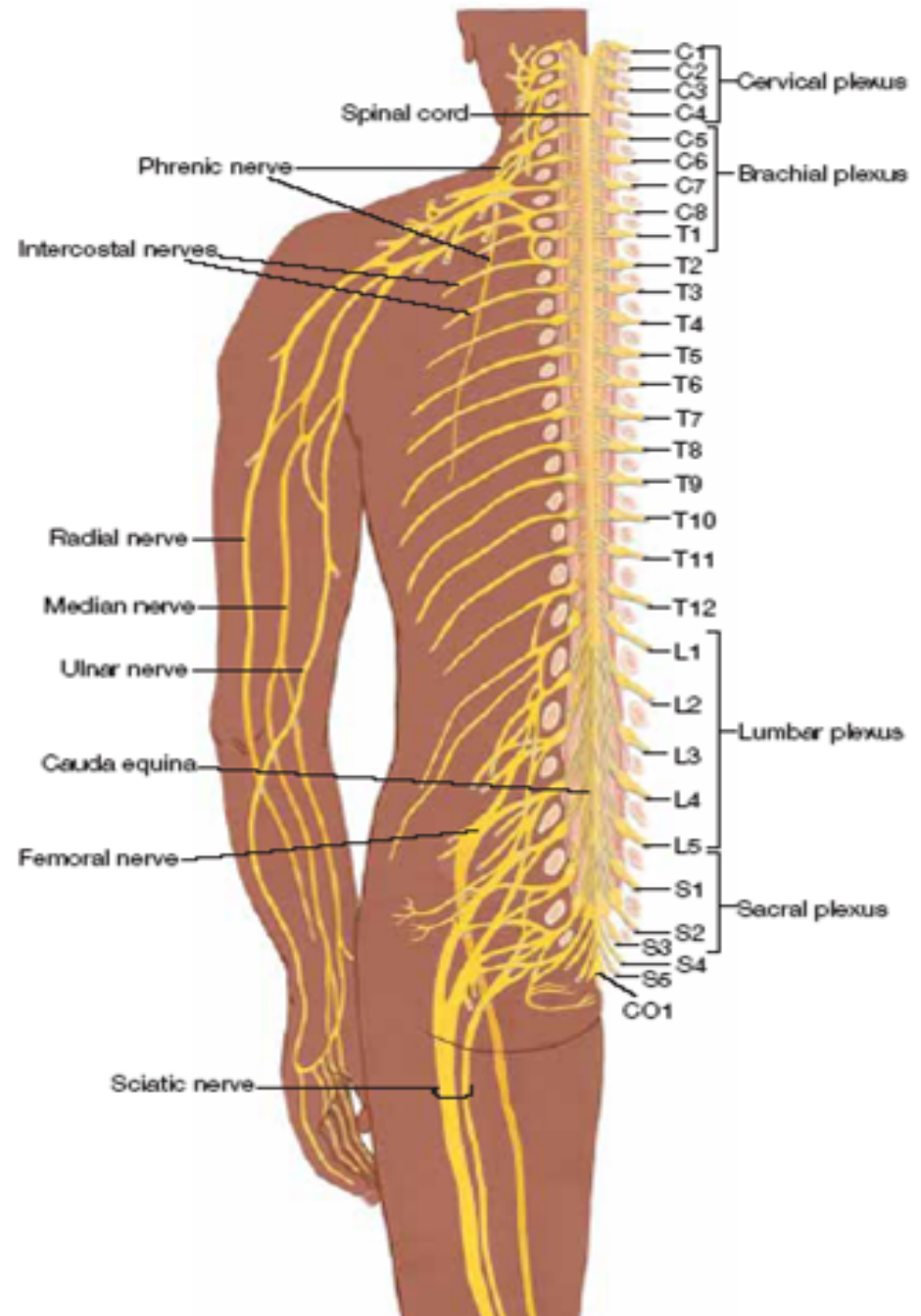
It is the **C5, 6, 7, 8 and D1 segments** of the SC, corresponding to the region from which the brachial plexus arises → give spinal nerves that supply the upper limbs.



Done ✓ Lumbar Enlargement of the Spinal Cord

It is the **L1, 2, 3, 4, 5** and **S1, 2 segments** of the SC, corresponding to the region from which the lumbar and sacral plexuses arise → give spinal nerves that supply the lower limbs.





Relationship between the Spinal Cord Segment and the Vertebra

SC is shorter than vertebral column so the segment will be before the same number of vertebra
And the size of the vertebrae differs the cervical is small while lower thoracic is larger to sustain the load

No	31 segments 8-12-5-5-1 Spinal Cord	Vertebra
1	From C ₁ - C ₄ segments	Opposite C ₁ - C ₄
2	From C ₅ - C ₈ segments	Subtract 1
3	From T ₁ - T ₆ segments	Subtract 2
4	From T ₇ - L ₂ segments	Subtract 3
5	L ₃ - L ₄ segments	Opposite T ₁₂
6	L ₅ and all sacral segments	Opposite L ₁

It we start with segment we subtract
While if we start with vertebra we add

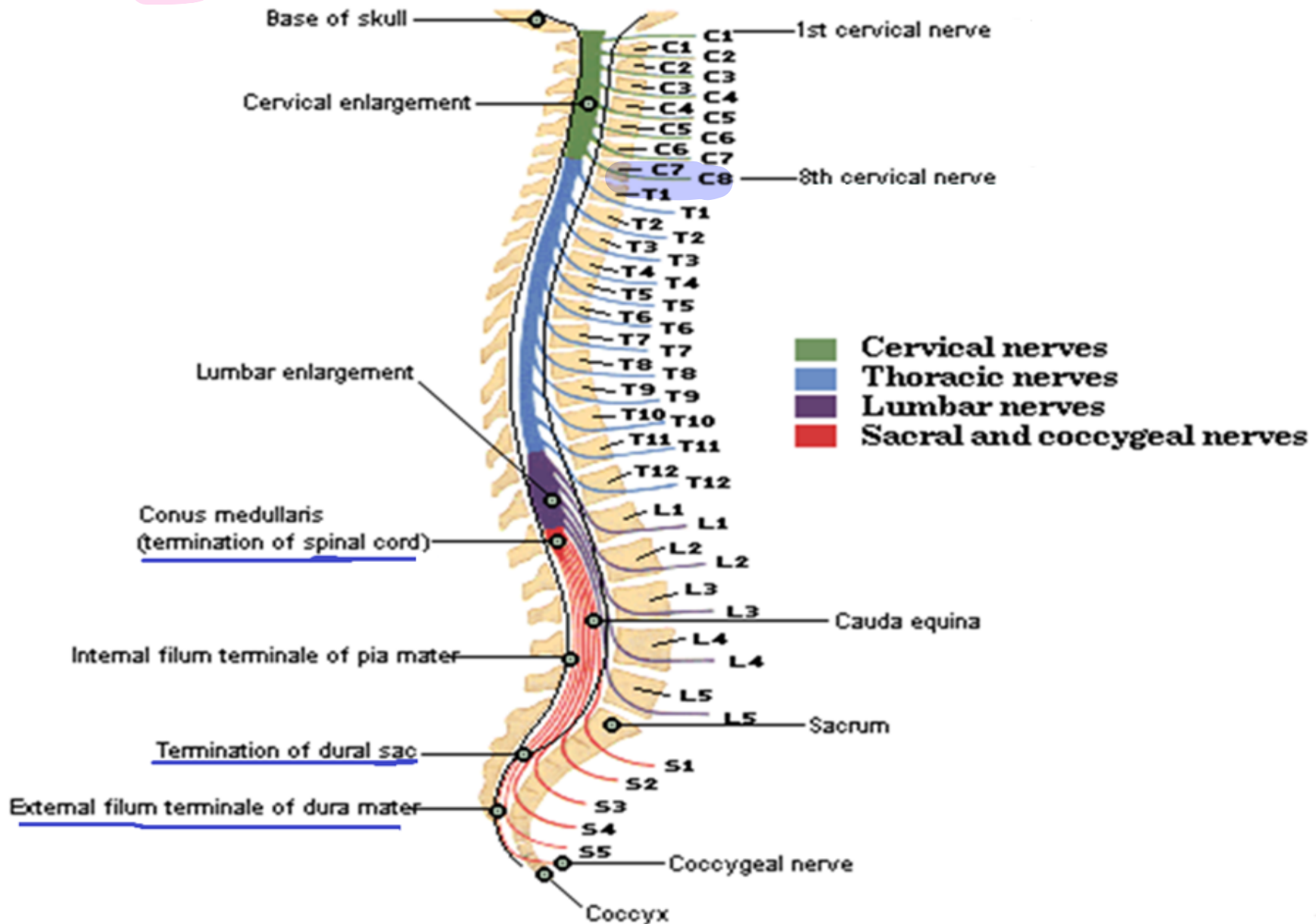
Relation of Spinal Nerve Roots to Vertebrae

The roots:

C1 → C7 above the vertebra

C8 → between C7 and T1

T1 to the end → below the vertebra

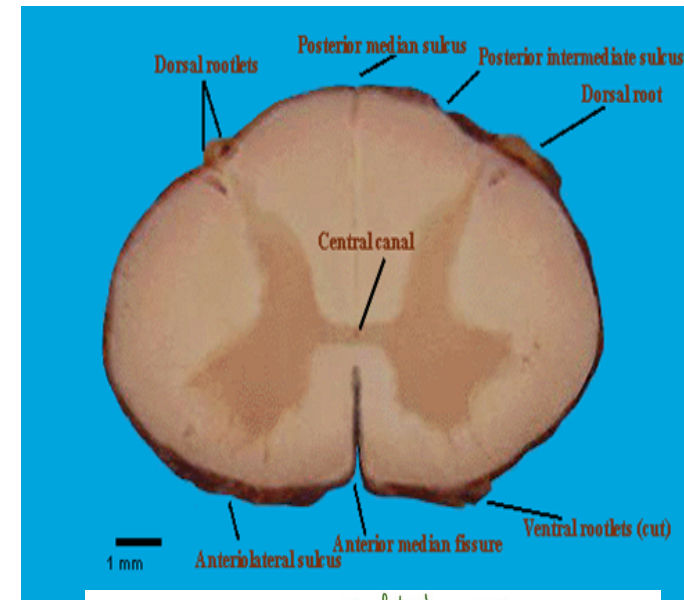
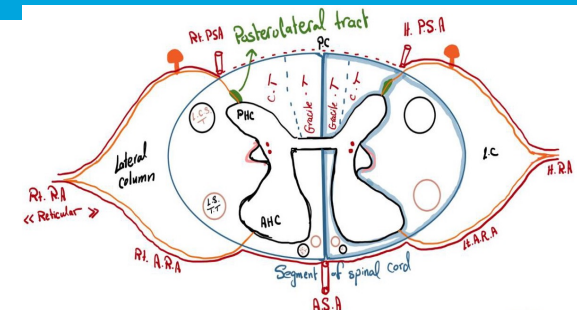


Internal Structure of the Spinal Cord

❖ A transverse section of the SC is formed of:

- White matter (outer or peripheral).
- Gray matter (inner or central).
H shape
- Central canal (1 mm in diameter): is present in gray matter.

In Brain outer is gray while inner is white



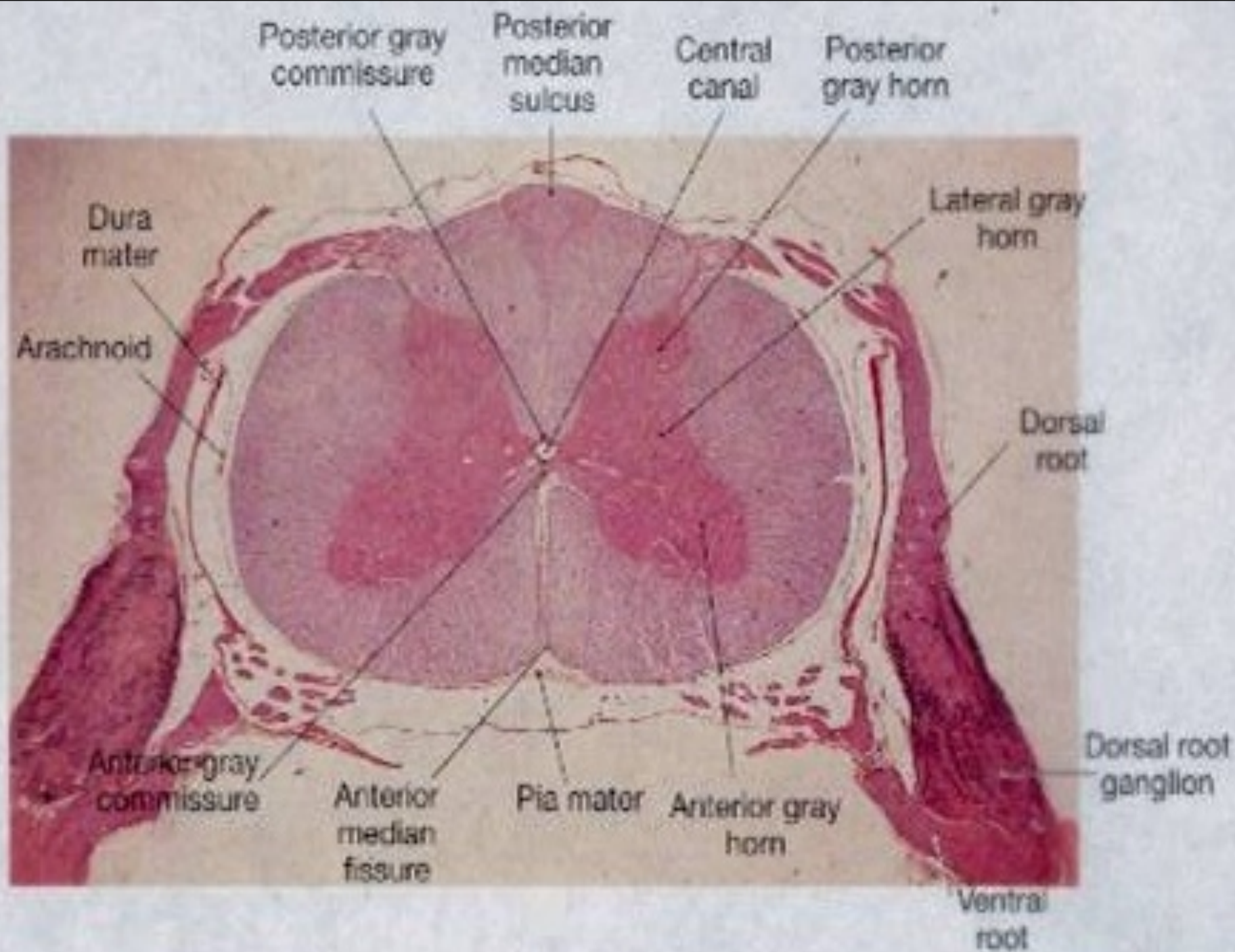
LCST → Lateral corticospinal tract
LSTT → Lateral spinothalamic tract
VCS.T → Ventral corticospinal tract

The **Gray Matter** of the Spinal Cord

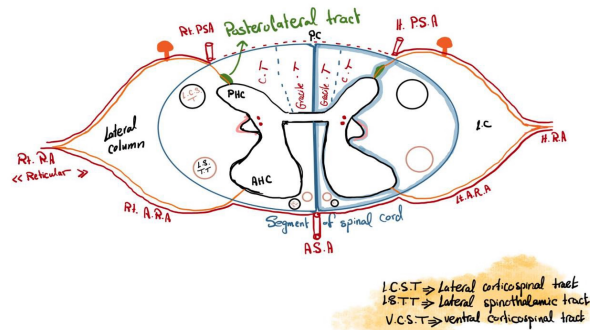
- **Structure:** it consist of nerve cells.
- **Shape:** the grey matter resembles the letter “**H**” divided into:
 1. **Anterior horns (right and left):** Consist of motor cells.
 2. **Posterior horns (right and left):** Consist of sensory cells.
 3. **Lateral horns (right and left):** In the thoraco-lumbar segments “T₁-L₂”. They contain sympathetic nerve cells.
 4. **Central canal:** The central canal contains C.S.F.
 5. **Gray commissure:** anterior and posterior gray commissure.

Absent from C1-C8 + L3 and below





① The Posterior (Dorsal) Horn Cells



Sensory

- Between the dorsal horn & posterolateral sulcus there is the **dorsolateral tract of Lissauer's**.
- The posterior horn cells receives and processes sensory input and **consist of following sensory nuclei:**

The Posterior (Dorsal) Horn Cells

1. Substantia gelatinosa of Rolandi:

- Found at all cord levels.

2nd order neuron

- For pain & temperature sensations.

2. The main sensory nucleus or nucleus Proprius:

- Found at all cord levels.

2nd order neuron

- For crude “light” touch sensation.

Poor localized touch

Like clothes

While fine touch (good localized touch) sensation

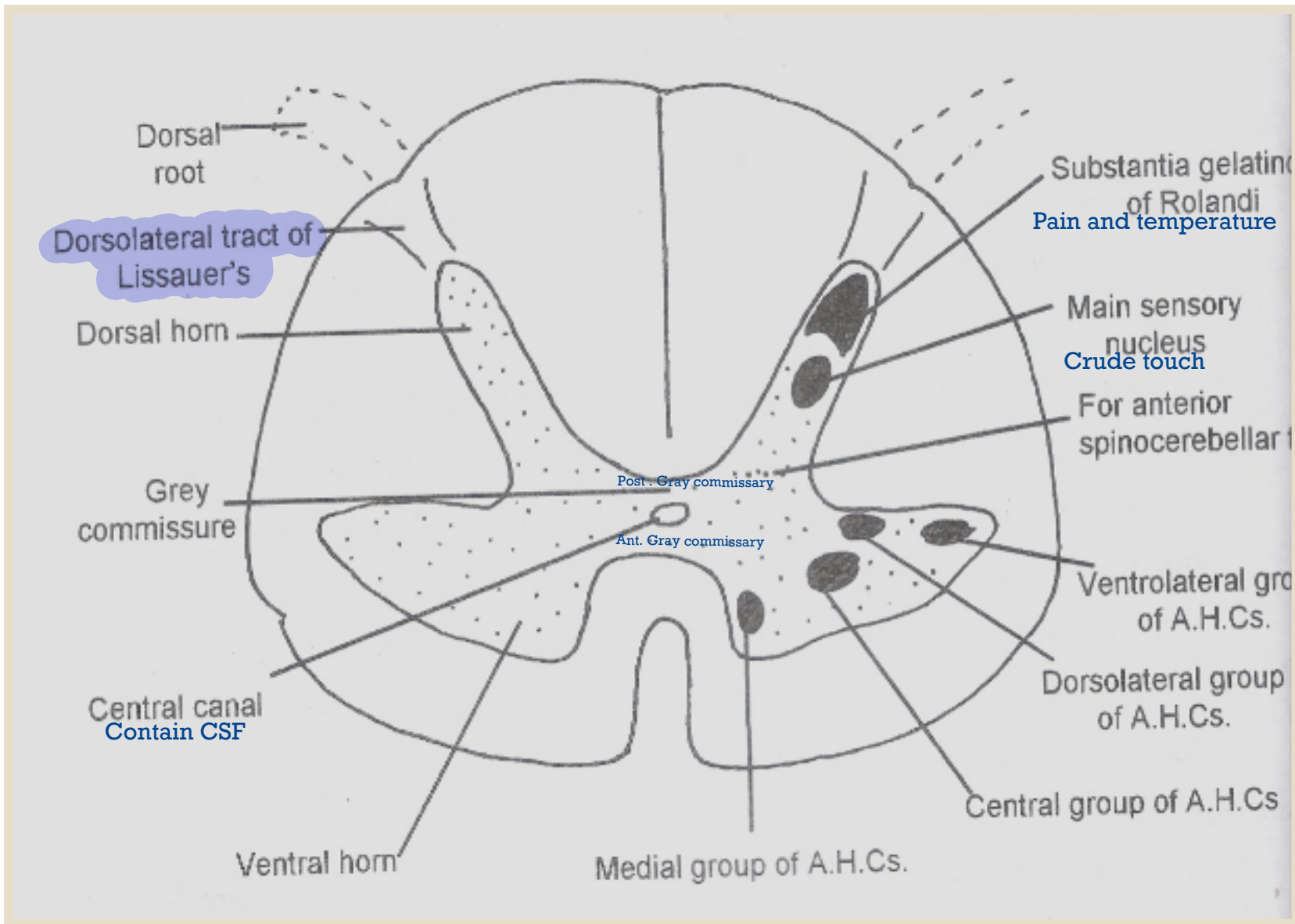
3. **Clarck's nucleus or posterior thoracic nucleus:**

- Found at the medial side of the **C8-L2** segments of the spinal cord.
- Carries unconscious proprioception to ^{D.S.T.T} **dorsal spinocerebellar tract** → **inferior cerebellar peduncle**.

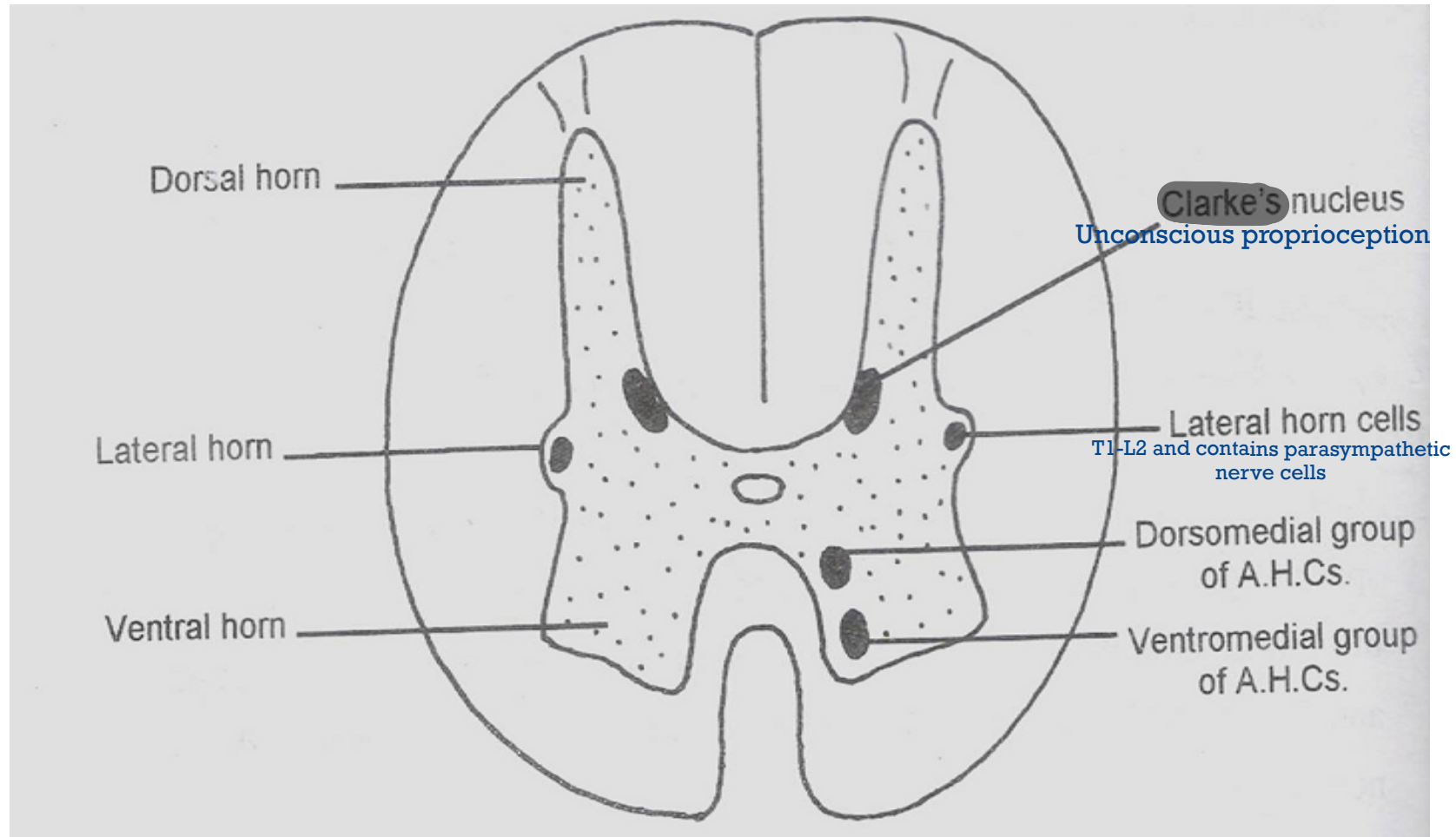
4. **Scattered nuclei:**

- Found at the **L3-S2** segments of the spinal cord.
- Carries unconscious proprioception to ^{V.S.T.T} **ventral spinocerebellar tract** → **superior cerebellar peduncle**.

The Gray Matter of the Spinal Cord



The Gray Matter of the Thoracic SC



② The Anterior (Ventral) Horn Cells

Motor

For extremities, trunk, abdominal muscles (diaphragm), special muscles (trapezius and sternocleidomastoid)

The anterior horn cells contain the following nuclei:

A. Medial group:

- Lies in the whole SC. But mainly at tho thoracic level.
- In the thoracic segments, divided into ventromedial and dorsomedial groups.

كلمة **ventro + dorsal** عشان توصف فيه لقدام وميئه لورا وبس

- **They supply muscles of the trunk.**

B. Lateral group (ventrolateral & dorsolateral):

For upper and lower extremities mainly found in cervical and lumbosacral enlargements and make the brachial plexus and lumbosacral plexus

- Present in lower C5-6-7-8 + T1 cervical, L1 → S2 lumbar and upper 2 sacral region.

- **They supply upper and lower limb muscles.**

Extremities

عشان أميز ترتيبهم وكل واحد شو بيعطي، **A.** بشكل منطقي حيغزي ال **trunk**، بينما **B.** بشكل منطقي لانه جانيه وأقرب للاطراف حيغزي ال **extremities**

C. Central group:

1. Spinal accessory nucleus:

- Lies in the upper cervical region “C₁ - C₆”.
- Their axons form **the spinal accessory nerve**.
- Innervates **the sternocleidomastoid and trapezius**. Special muscles

2. Phrenic nucleus:

- Extends from ^{C3-C4 mainly} C₃ to C₆.
- Their axons form **the phrenic nerve**.
- Innervate **the diaphragm**. Abdominal muscles

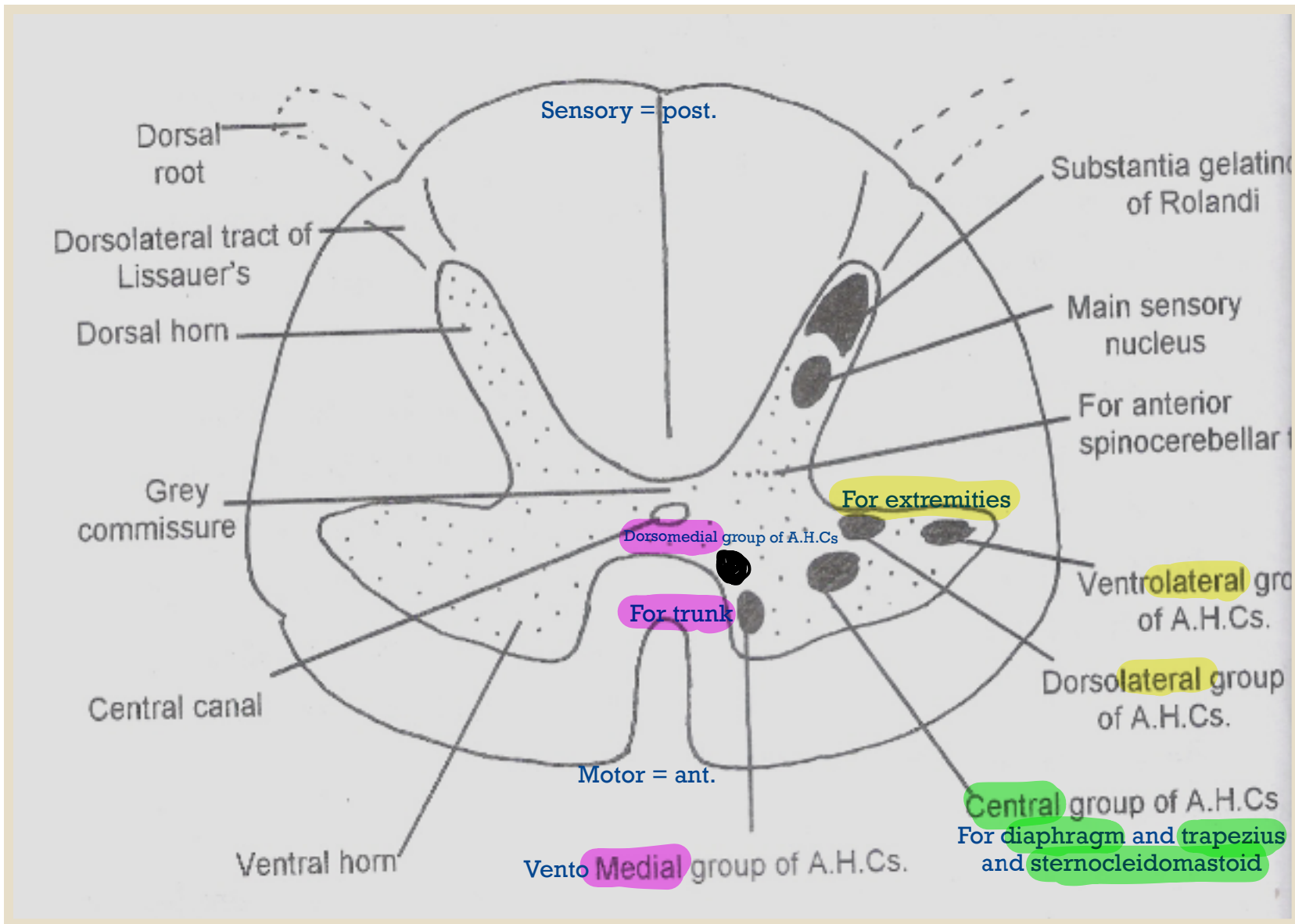
D. Sacral parasympathetic nuclei:

In ant. Horn cells cuz it is empty in relation to somatic motor neuron

Parasympathetic for defecation and micturation sphincter control

- Extends from S₂ to S₄.
- Gives rise to preganglionic parasympathetic fibers that innervate the pelvic viscera via the pelvic splanchnic nerves

The Gray Matter of the Cervical SC

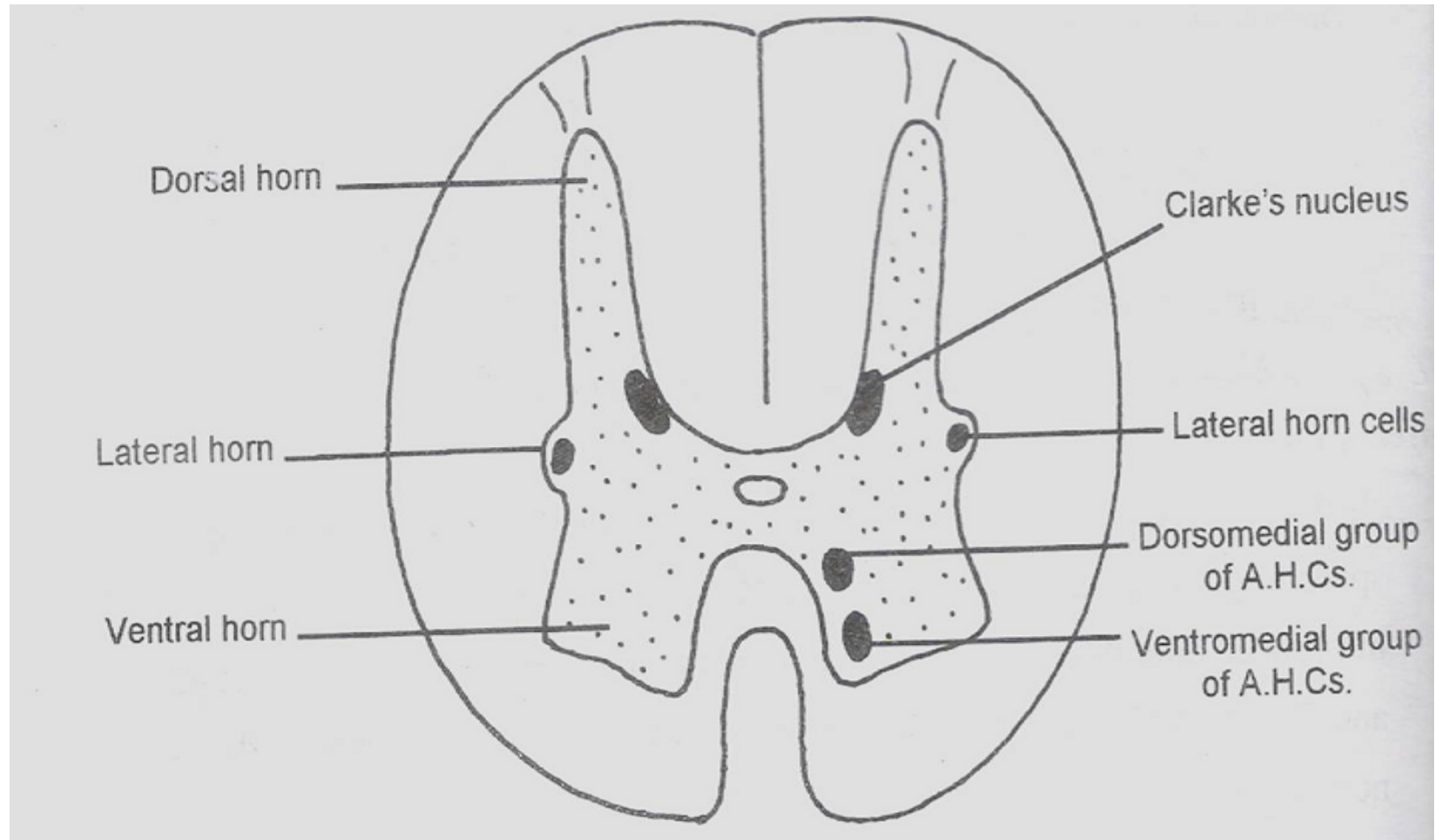


③ The Lateral Horns

- Receives viscerosensory input.
- Found between the posterior and anterior horns of “T₁-L₂” segments of the spinal cord.
- Contains the **intermediolateral nuclei** “preganglionic sympathetic neurons”. And the relay is done in the sympathetic ganglia
- At “T₁–T₂ or C₈-T₂” level located the **Ciliospinal center of Budge** (sympathetic innervation of the eye). Responsible for pupil regulation

Give long ciliary nerve

The Gray Matter of the Thoracic SC



Neurons of the Gray Matter

Revision

A. Sensory neurons: in the posterior horns.

B. Motor neurons: in the anterior horns.

- **Alpha motor neurons:** give rise to large type A alpha ($A\alpha$) motor nerve fibers for stimulation the muscle fibers.
- **Gamma motor neuron:** transmit impulses through much smaller type A gamma ($A\gamma$) motor nerve fibers for control muscle tone.

Flashback to slide 8

C. Interneurons “Intermediate”: 99%

In between

- In the intermediate areas between the ventral and dorsal horns.
- **Function:** integrative functions of the SC (reflexes center).

The **White Matter** of the Spinal Cord

- The white matter surround the gray matter and contains ascending and descending tracts.

- **It is divided into three column (fasciculus) of SC on each side:** Clear in the diagram ✓

1. **Anterior column (AC):** lying between the anterior median fissure & the attachment of anterior spinal root
Divide the SC to Rt and Lt
“anterolateral sulcus”.

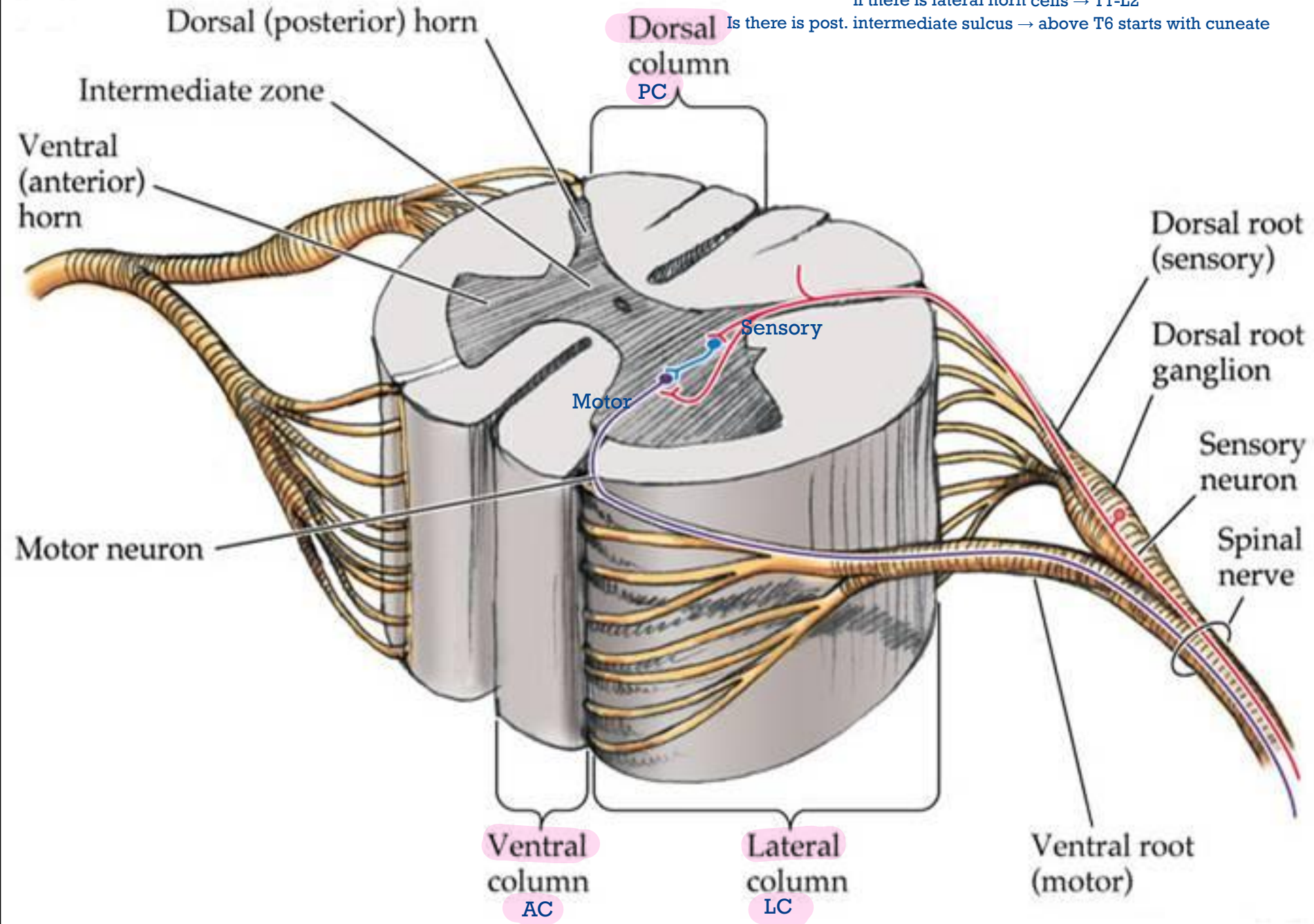
2. **Posterior column (PC):** lying between the posterior median fissure & the attachment of dorsal spinal root
“posterolateral sulcus”.

The largest 3. **Lateral column (LC):** lying between attachment of anterior and posterior spinal roots.

segment of spinal cord الـ segment of spinal cord الذي يتكون من عدة أجزاء، كل جزء له وظيفة محددة. في جسم الإنسان، يبدأ من الرقبة وينتهي في الحوض. يتكون من 31 زوجًا من الأعصاب.

if there is lateral horn cells → T1-L2

Is there is post. intermediate sulcus → above T6 starts with cuneate



Structure of White Matter

The white matter contains 3 types of nerve fibers (tract):

1. Ascending tracts of the SC:

Afferent to the Brain Sensory

Carrying sensory impulses from the SC to the brain:

e.g. **Lateral Spinothalamic Tract.** For pain and temperature sensation
Ventral spinothalamic tract for crude touch

2. Descending tracts of the SC:

Efferent from the Brain Motor

Carrying motor impulses from the brain to the SC:

Ventral corticospinal tract motor for proximal muscle
e.g. **Corticospinal Tract.** Located more posterior
Lateral So if post. part of spinal cord is injured it may affect the motor

3. Associative tracts: Connect adjacent segments of spinal cord and it is short

Containing short ascending & descending fibers which coordinate the function of the different regions of spinal cord.

Also the tracts are divided into:

1. Short Tracts:

- They begins and end in the spinal cord.
- They are found close to the gray matter.
- They are associative in function.

Type 3

2. Long Tracts:

- Ascending tracts. If starts from SC Sensory Afferent Spinothalamic tract
- Descending tracts. If ends in SC Motor Efferent Corticospinal tract

Blood Supply of the Spinal Cord

From the vertebral arteries

1. **Anterior (ventral) spinal artery.** Supplies anterolateral 2/3 of SC
2. **Posterior spinal arteries (right and left).** Supplies post. 1/3 of SC
3. **Radicular arteries.**
Segmental

✕ If occlusion of ant. spinal artery happened it cause anterior spinal cord syndrome

✕ While if the occlusion happened in one of the origin the affected organ is medial part MO
And it will cause medial medullary syndrome → has triad symptom:-
Ipsilateral tongue deviation due to damage of hypoglossal nucleus
Contralateral hemiplegia due to damage of corticospinal tract above decussation (crossing)
Contralateral loss of proprioception and fine touch due to damage of medial lemniscus

Blood Supply of the Spinal Cord

□ Arise from the:

A. Vertebral Arteries: a branch of the subclavian

The longest artery in the body starts from vertebral arteries to L1 vertebra = the end of spinal cord
Pass through anteromedial fissure

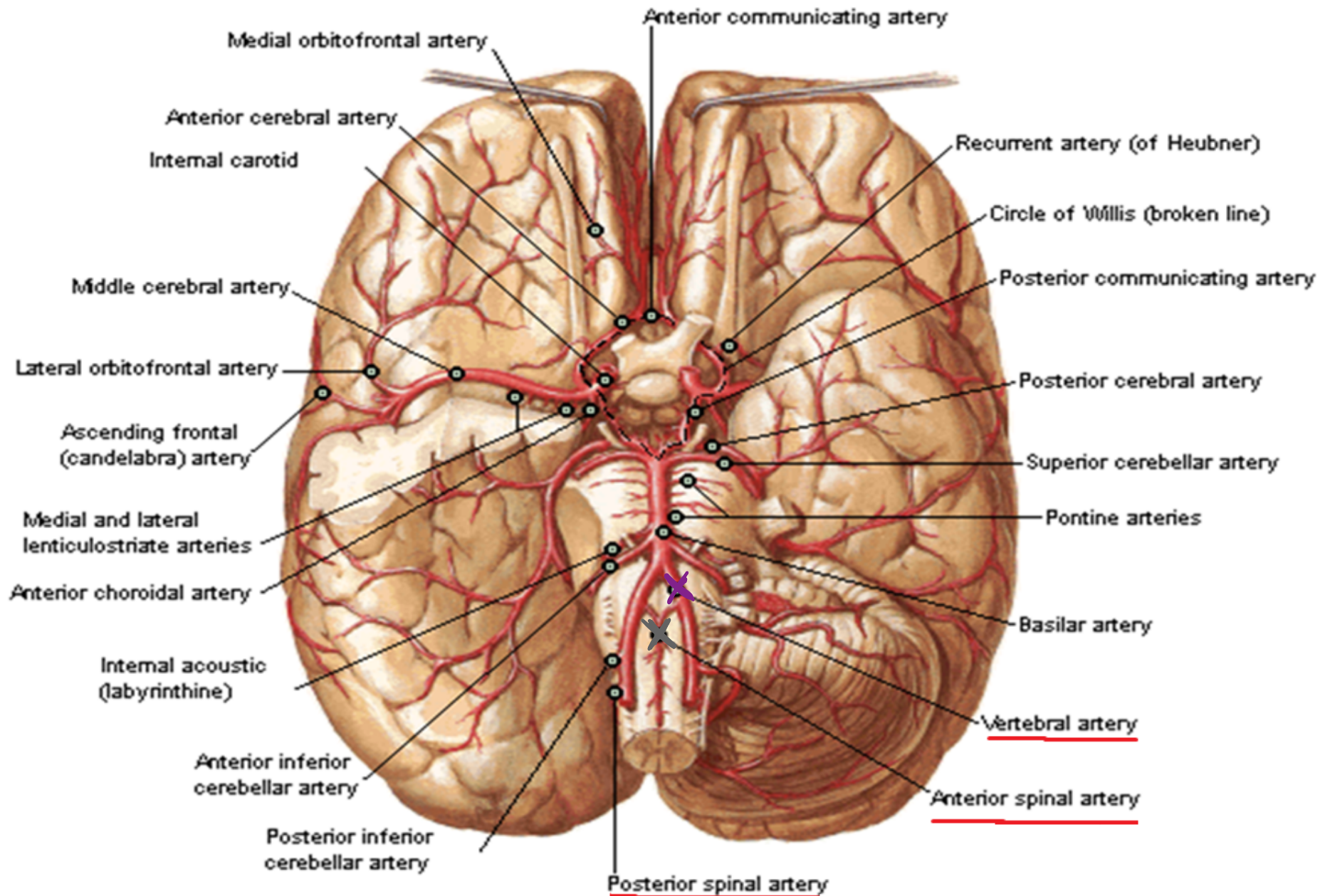
artery. Gives rise to **the anterior spinal artery** and
Responsible for anterior and lateral (horn cells and column)

may give rise to **the posterior spinal artery.**
Start from vertebral arteries and may arise from PICA
Responsible for posterior (horn cells and column)
Responsible for gracile and caudate tracts

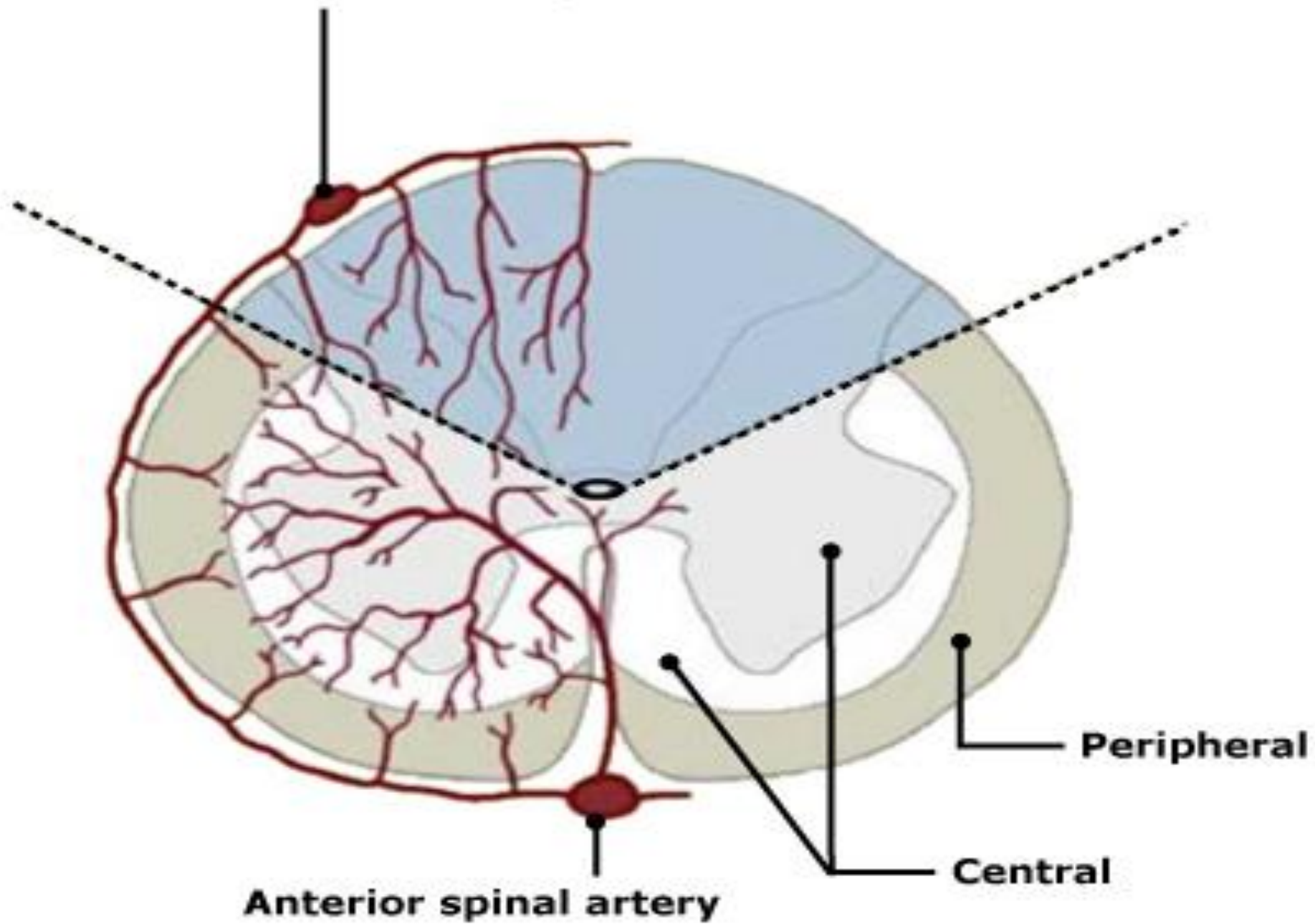
B. Segmental “Radicular or Medullary” Arteries.

Arteries of Brain

Inferior View



Posterior spinal artery



Peripheral

Central

Anterior spinal artery

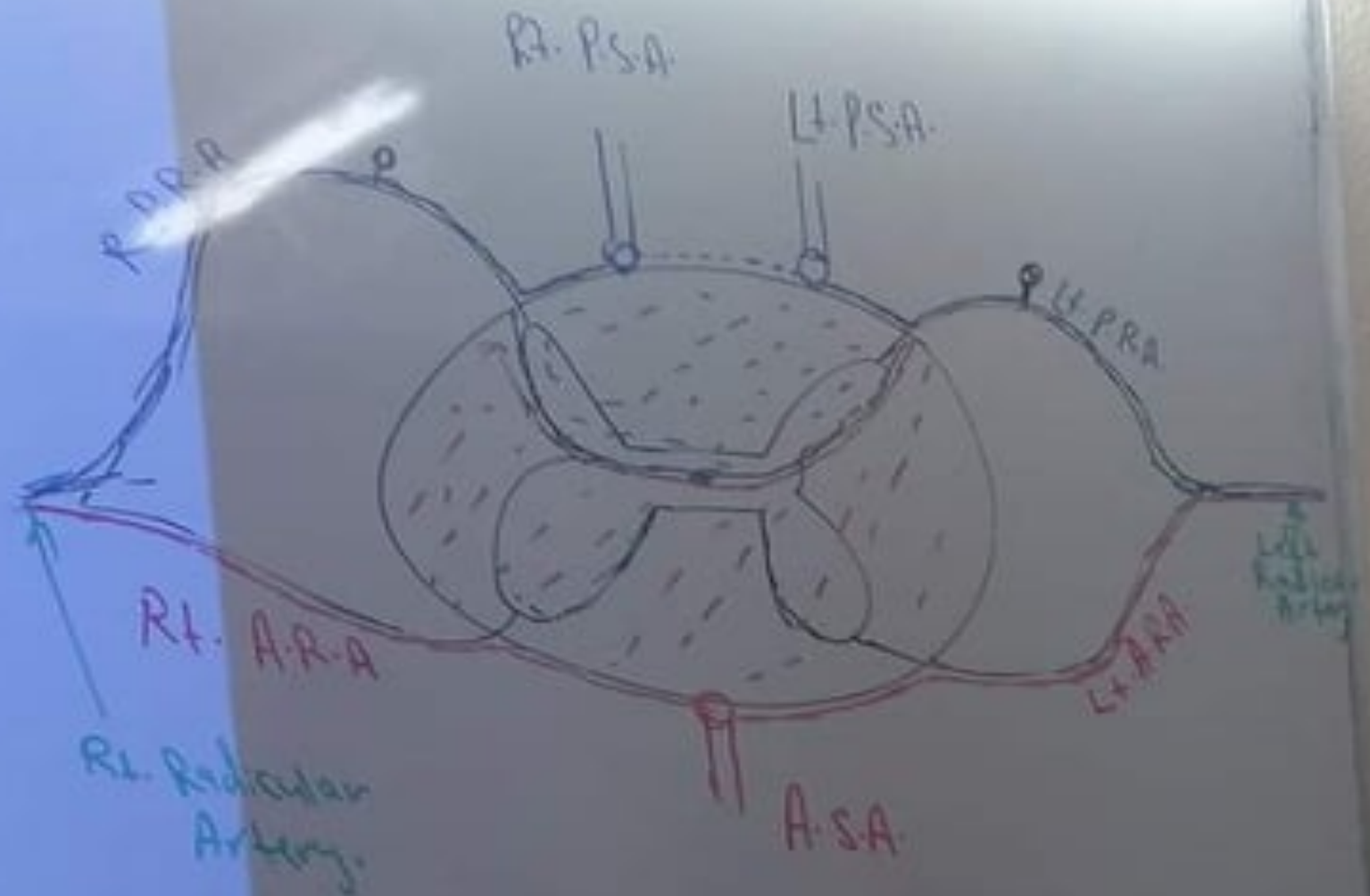
A. Vertebral Arteries

1. Anterior Spinal Artery Done ✓

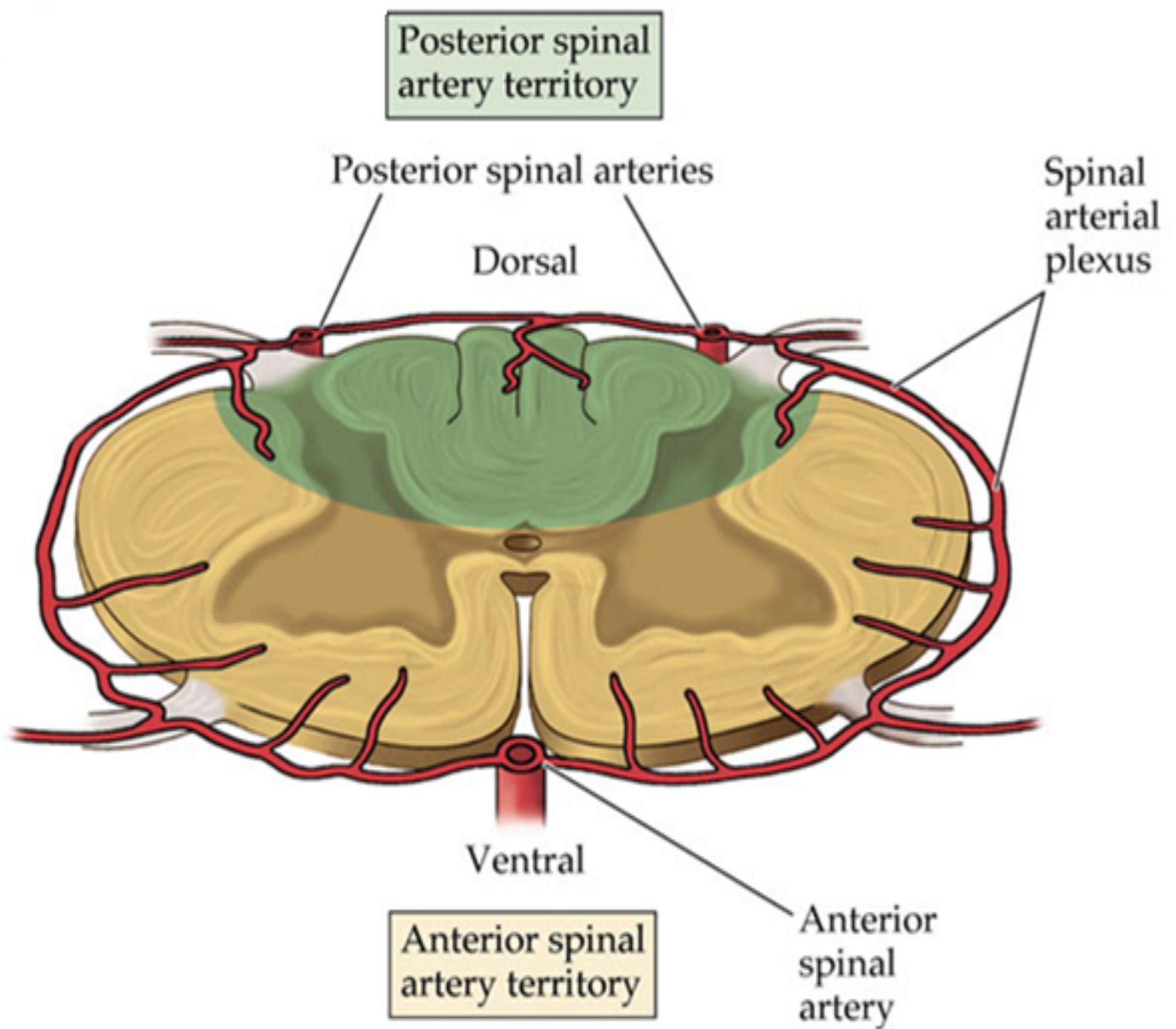
- Formed inside the cranial cavity by the union of right & left anterior spinal arteries arising from the **right and left vertebral arteries**.
- It descends in front of the anterior median fissure of the spinal cord.
- Supplies the anterior two-third of the spinal cord (**anterior and lateral columns, anterior and lateral horn cells**).
- Supplies **the pyramid, medial lemniscus, and hypoglossal nucleus in the medulla**
- The anterior spinal artery is **the longest artery in the body**.

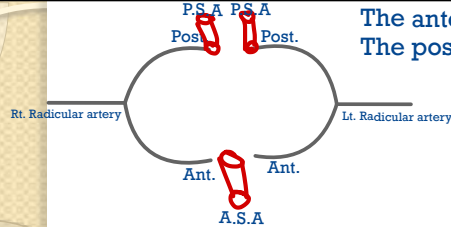
2. Posterior Spinal Arteries Done ✓

- Two posterior spinal arteries (Right & Left).
- Each artery arises inside the cranial cavity from **vertebral artery** and may be arises from **PICA**.
- Supply posterior one third of the spinal cord (**Posterior horns and posterior columns**).
- Supply the **Gracile and Cuneate nuclei in the medulla**.



Blood supply of the
Spinal cord





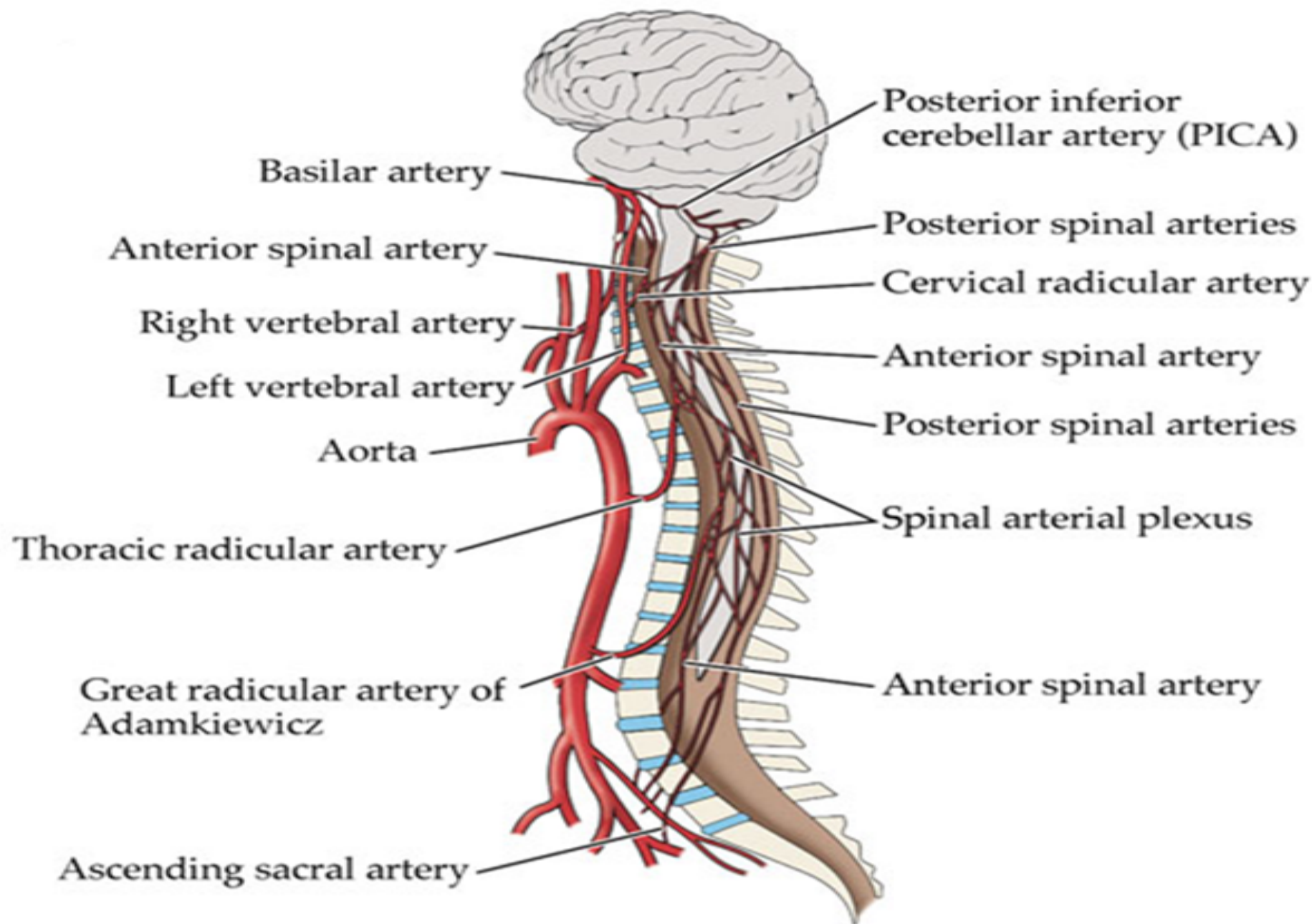
The anterior branch anastomoses with anterior spinal artery
The posterior branch anastomoses with posterior spinal artery at the same side

B. Segmental Arteries

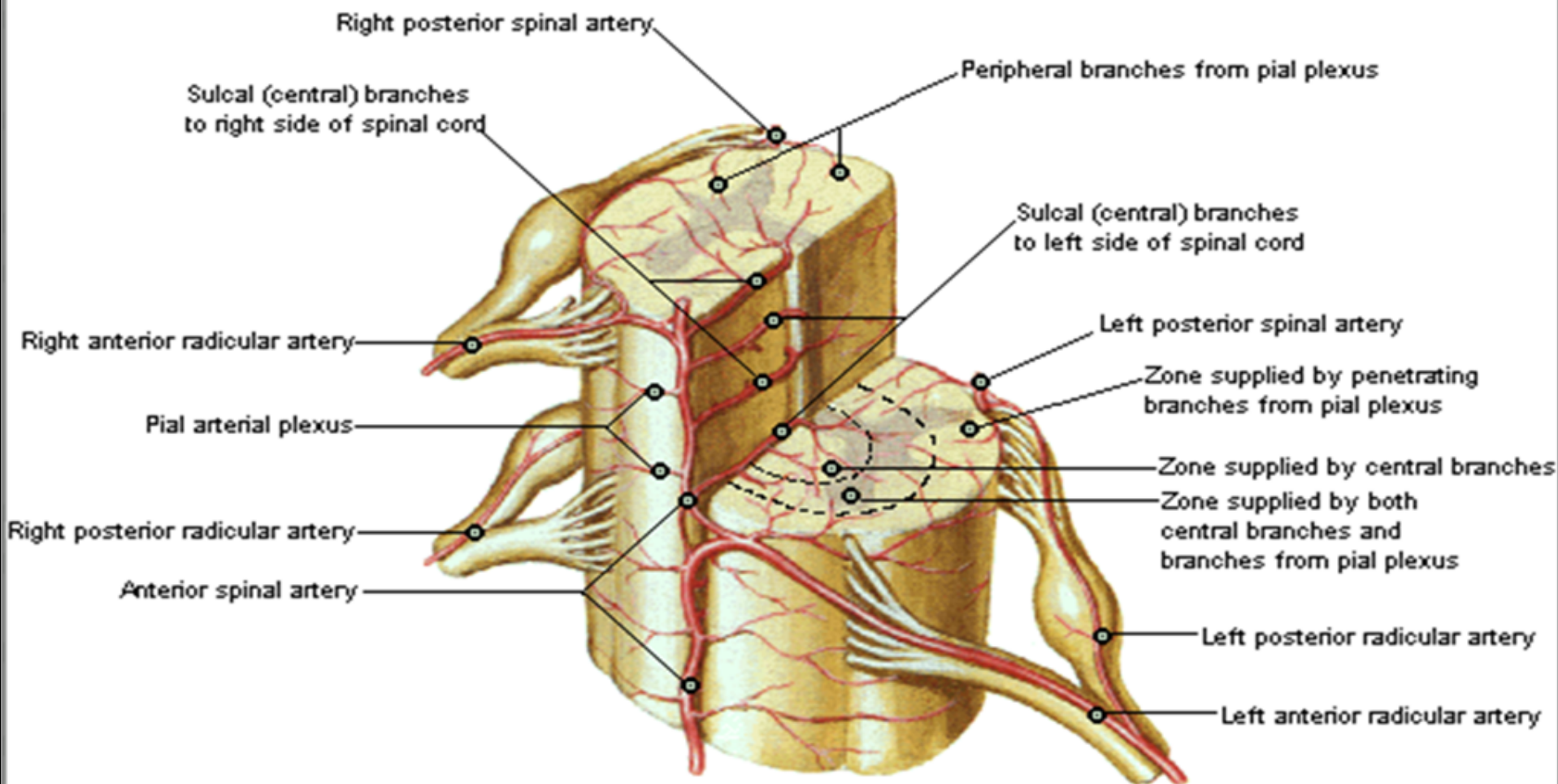
Supplies the roots → Anterior and posterior

- Arise from **the aorta, vertebral arteries, and common iliac arteries** as **medullary arteries** “**Radicular arteries**”, which anastomose with the anterior and posterior spinal arteries.
- One large “great” radicular artery (**artery of Adamkiewicz**). Its origin varies from **T12 to L4**, and it usually arises on **the left side**.

Rt Ant.
Post.
Lt Ant.
Post.



Arteries of Spinal Cord - Intrinsic Distribution



Venous Drainage of the Spinal Cord

❖ Venous blood passes from spinal veins within the **subarachnoid space** to the **epidural internal venous plexus** before draining into:

Between arachnoid and pia Externally

- Intracranial veins.
- Cervical veins.
- Thoracic veins.
- Intercostal veins.
- Abdominal veins.

Afferent to the brain → sensory

I. Ascending Tracts

All of the somatic ascending tract pass into 3 order neurons

1st order neuron → located in ganglia (post.) cause it is sensory

2nd order neuron → located either in post. horn of SC or in MO medulla oblongata

3rd order neuron → located in thalamus

- Represent functional pathways that convey sensory information from the periphery to higher levels.
- Usually consist of a chain of **three order neurons**.
- The first-order neuron is always in **the spinal ganglion**.

Proprioception and fine touch → Gracile(lower) Cuneate(upper)

Pain and temperature → Lissaurer's tract + lateral spinothalamic tract

Crude touch → Anterior (ventral) spinothalamic tract

Ascending Tracts of the Spinal Cord

1. **Gracile tract (PC)**: for proprioception & fine touch from lower half of the body.
2. **Cuneate tract (PC)**: for proprioception & fine touch from upper half of the body.
3. **Lissaurer's tract**: for pain and temperature sensation, lies between the tip of the posterior horn & posterior lateral sulcus.
With post. Root
4. **Dorsal spinocerebellar tract (LC)**: carries proprioceptive fibers from **Clarck's nuclei** to the inferior cerebellar peduncle.
5. **Ventral spinocerebellar tract (LC)**: carries proprioceptive fibers from **spinal border cells** to the superior cerebellar peduncle.
Scattered nuclei

6. **Lateral spinothalamic tract (LC)**: for pain and temperature pathway.

7. **Ventral spinothalamic tract (AC)**: for crude touch.

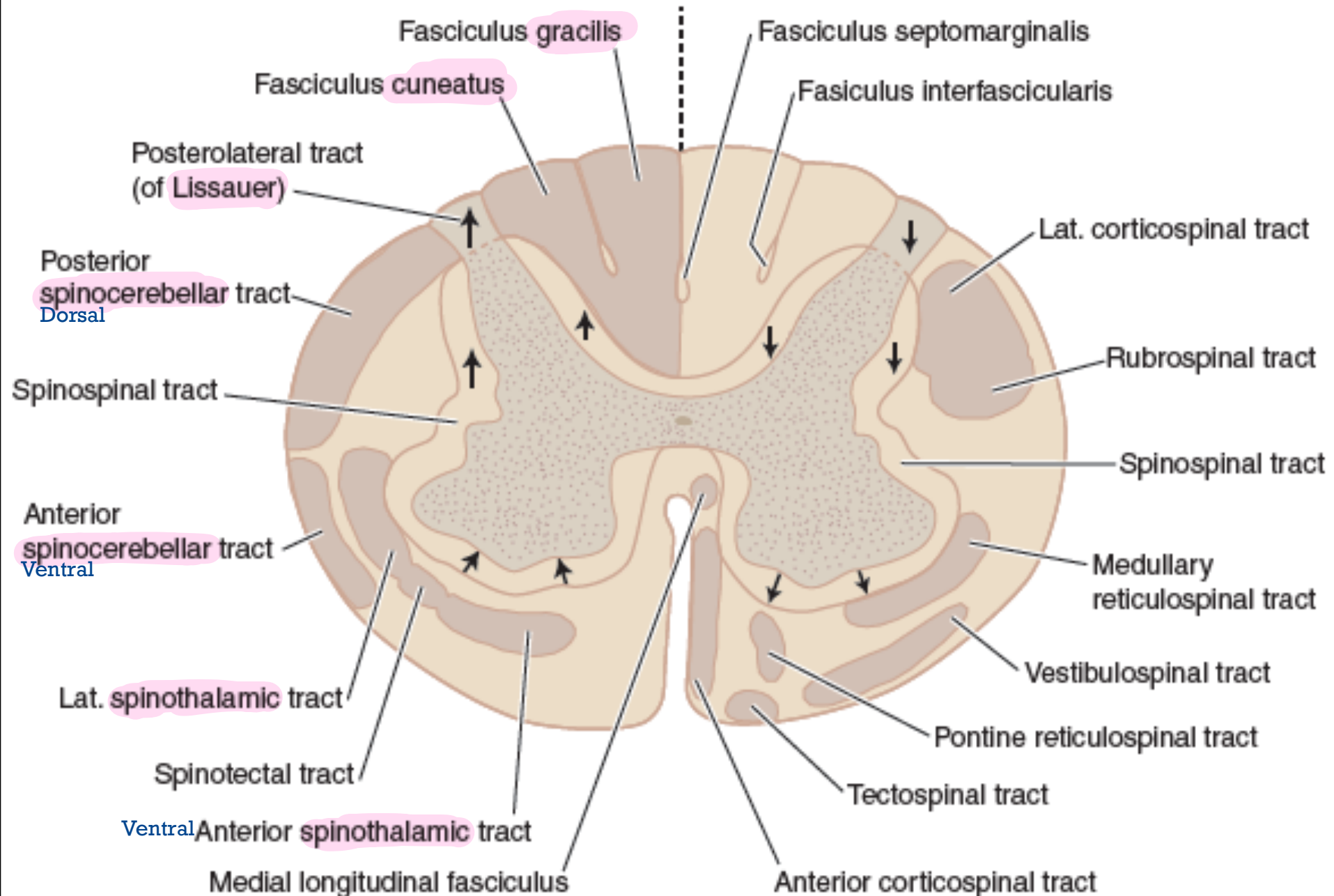
8. **Spinotectal tract (LC)**: arises from the posterior horn & ends in the superior colliculus (spinovisual reflexes).

9. **Spino-olivary tract (LC)**: carries proprioceptive impulses to accessory olivary nuclei in the medulla.

Less important

Ascending tracts

Descending tracts



Ascending tracts

Fasciculus gracilis

DORSAL COLUMNS

Fasciculus cuneatus

Descending tracts

Medial longitudinal fasciculus

Lissauer's tract

Lateral corticospinal tract

Rubrospinal tract

Pontine reticulospinal tract

Medullary reticulospinal tract

Lateral vestibulospinal tract

Tectospinal tract

Ventral corticospinal tract

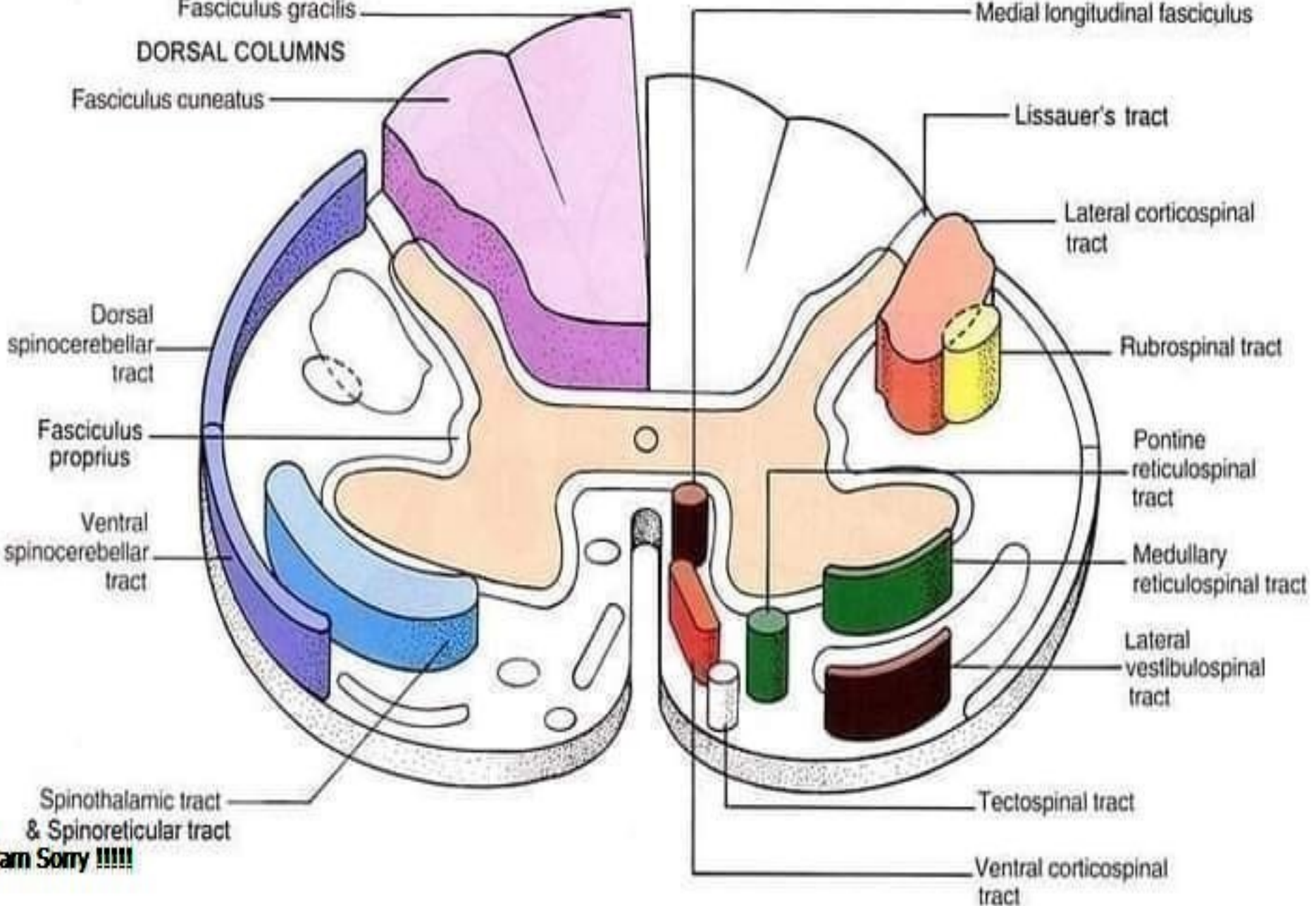
Dorsal spinocerebellar tract

Fasciculus proprius

Ventral spinocerebellar tract

Spinothalamic tract & Spinoreticular tract

I am Sorry !!!!!



A. Anterolateral System

Responsible for pain, temperature, and crude touch sensation

وجه التشابه بينهم هو انهم قرا ب علي بعض ومسارهم متشابه

1. Lateral spinothalamic tract:

- Mediates pain, and temperature sensations.
- Receives input from free nerve endings and thermal receptors.
- Receives input from A-delta and C fibers.

2. Anterior spinothalamic tract:

- Concerned with ^{nondiscriminative touch} crude touch sensation. ^{Of the body not the head}
^{Clothes sensation} ^{Poor localized touch}
- Receives input from free nerve endings and from Merkel tactile receptors.

Lateral Spinothalamic Tract

“Pathway of Pain and Temperature Sensations”

1st order neuron → dorsal spinal ganglion

2nd order neuron → substantia gelatinosa of rolandi in SC

3rd order neuron → ventral posterolateral nucleus of thalamus (VPL)

Pain stimulus in the hand → Stimulation of free nerve endings for pain
The pain receptors in the hand → It will transmit the signals to the 1st order neuron
It is posterior root ganglion that responsible for this dermatome

The ganglion:

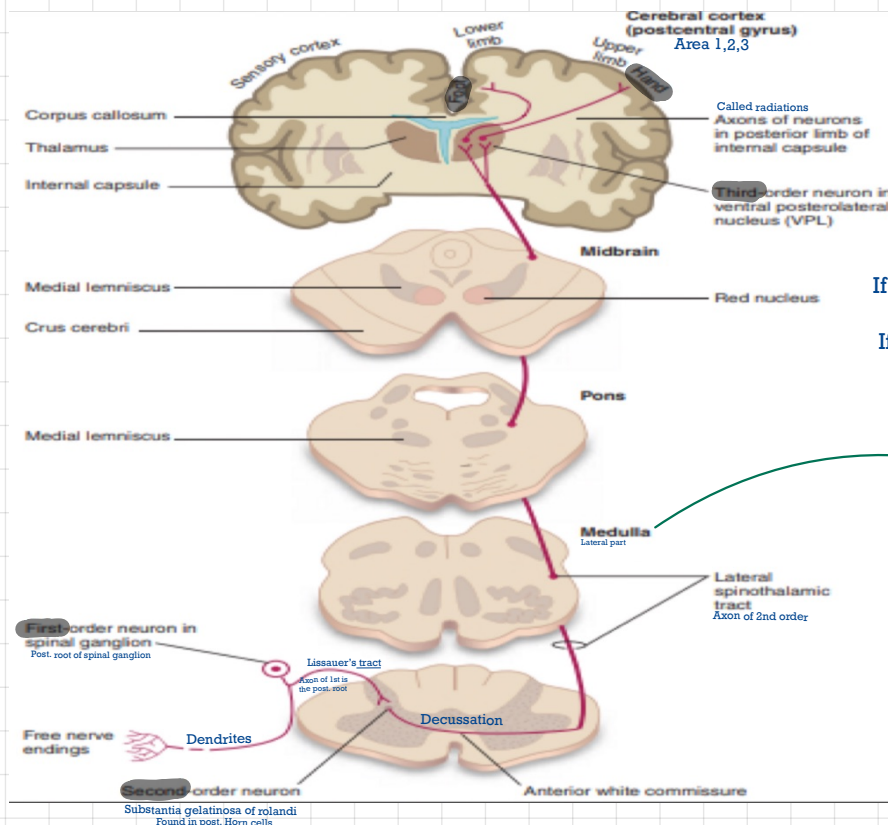
Has dendrite → peripheral nerves sensory fibers the relay happened in the ganglion
Has axon through the post. root through lissauer's tract → that transmit the signals to the 2nd order neuron

Then the signal reach substantia gelatinosa of rolandi
2nd order at the same level

Then through anterior commissure the axon of the 2nd order cross or decussate to the other side and go through an axon to the 2nd order called lateral spinothalamic tract and pass at lateral part of medulla (So is lateral medulla is damaged by PICA syndrome the result is contralateral loss of pain and temperature) then pass through the pons then reaches VPL of thalamus = 3rd order neuron of pain and temperature sensation

Then through the axon of 3rd order neuron = post. Limb of internal capsule reaching the post central gyrus
If the signal from foot → upper part
If from the hands → middle part

Each segment do the crossing step at the same segment and join two segments about and then joins the lateral spinothalamic tract



If any of the (nerve or roots ganglion or post. horn cells) are damaged → the result sensation loss is ipsilateral and the same level = same dermatome

If the tract is damaged → all the sensation is lost below the level (cause it is white matter (tract) while gray matter at the level) and contralateral

In lateral medullary syndrome if the tract is damaged
lost of pain and temperature contralateral

Rule:-

Damaged of white matter = damage of tract so symptoms below the level.

Damaged of gray matter = damage of roots ganglions and nerves → symptoms at the level.

Done ✓

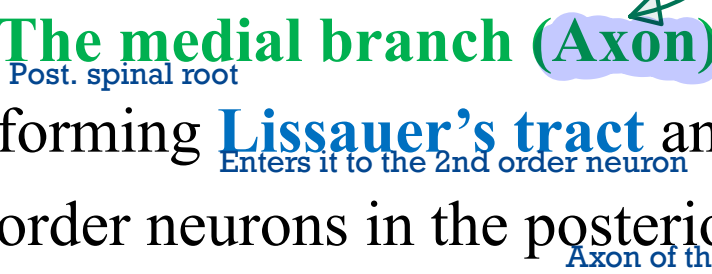
Lateral Spinothalamic Tract

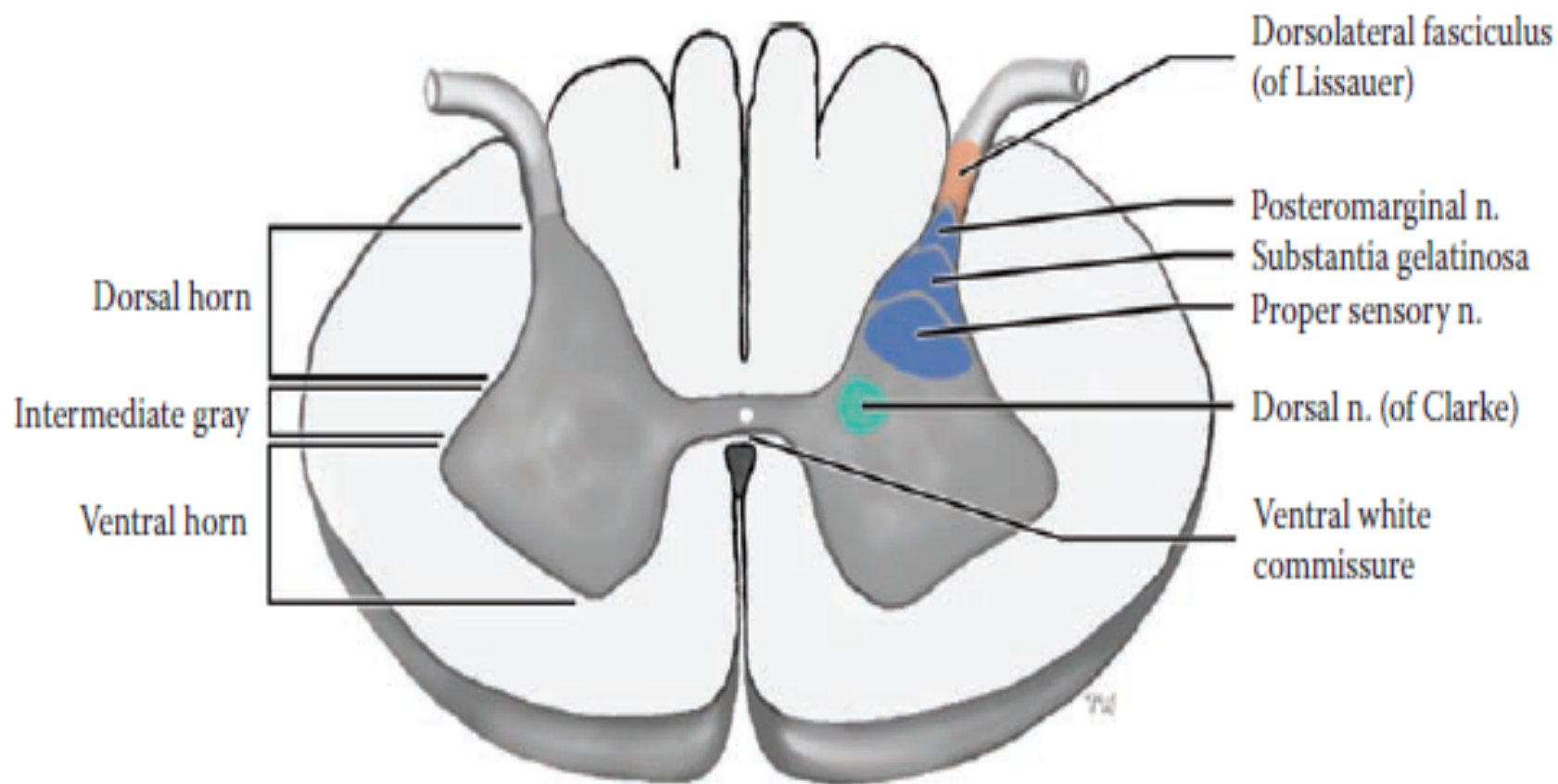
“Pathway of Pain and Temperature Sensations”

1. The first order neuron:

Found in **the posterior root spinal ganglion** at all levels.

The process divided into:

- **The lateral branch (Dendrite)**: goes peripherally forming the afferent sensory nerve (the ends of this nerve are receptors of the skin).  Cell body (ganglion)
- **The medial branch (Axon)**: enters the spinal cord, forming **Lissauer's tract** and make synapse with second order neurons in the posterior horn cells “**Substantia Gelatinosa of Rolandi**”.  Post. spinal root
Enters it to the 2nd order neuron
Axon of the 1st order



Lateral Spinothalamic Tract

2. The second neuron:

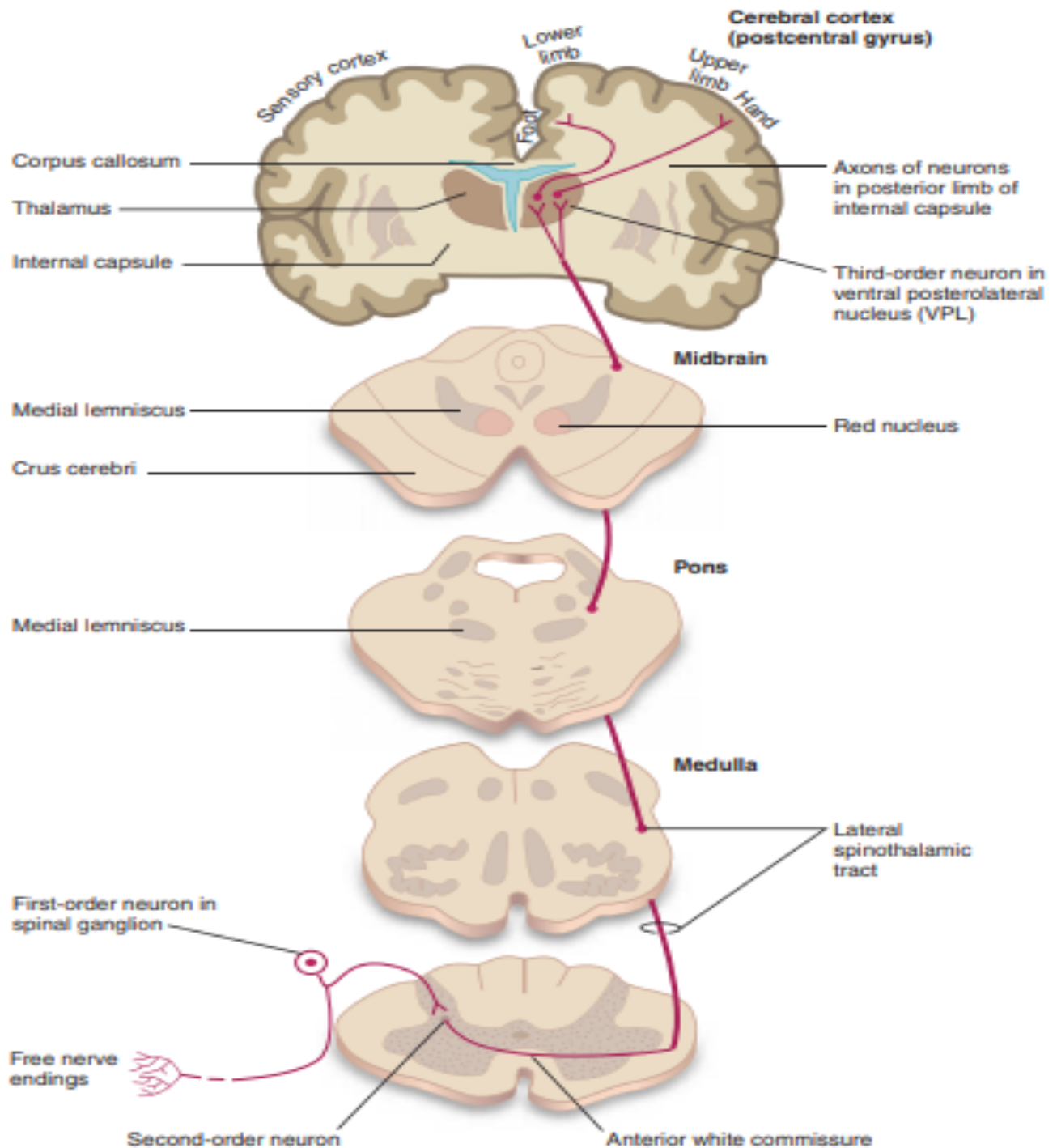
Each segment decussate at the same level and ascends to join 2-3 segments and goes to the contralateral side and join the lateral spinothalamic tract

Is the cells of **Substantia Gelatinosa of Rolandi** and its axon. This axon crosses to the opposite side cross the midline in the **ventral white commissure**, usually **within two to three segments** above the level of entry of the peripheral fibers and ascends in the lateral column of the SC as the ^{Axon of 2nd order} **lateral spinothalamic tract** → medulla oblongata → the pons → the mid brain → to relay the sensory impulse at the ^{3rd order neuron} **VPL** nucleus of thalamus.

3. The third order neuron:

Starts in the cells of **the ventral posterolateral nucleus (VPL) and intralaminar nuclei of the thalamus**, its axon ascends to pass through the **posterior limb of the internal capsule** conducting the impulse to the cortical somatic sensory area (1, 2, 3) in the upper 2/3rd of the postcentral gyrus of the **parietal lobe**.

Foot and leg → superior
Hand and arms → middle
Faces → lower, facial sensation is by trigeminal



5

The anterolateral tract terminates in the VPL of the thalamus. From the thalamus, fibers project through the internal capsule and corona radiata to terminate in the primary somatosensory cortex (postcentral gyrus).

4

In the pons and midbrain, the anterolateral tract lies lateral to the medial lemniscus.

3

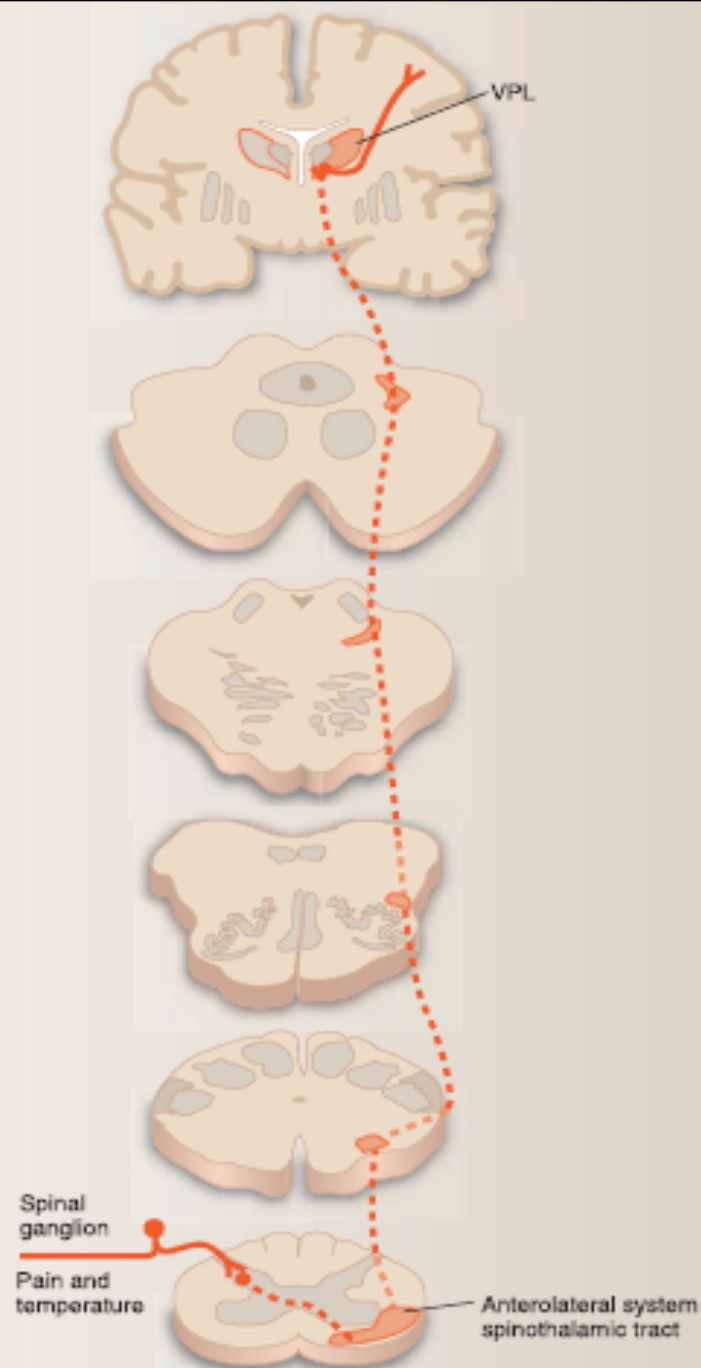
In the rostral medulla, the anterolateral tract lies between the inferior olivary nucleus and the nucleus of the spinal tract of the trigeminal nerve.

2

Anterolateral tract in the caudal medulla.

1

Axons enter the spinal cord from the spinal ganglia, travel up or down 1–2 segments in Lissauer tract, and then synapse in the posterior horn. Axons of secondary neurons cross the midline in the anterior white commissure and ascend as the anterolateral tract in the spinal cord.



Anterior Spinothalamic Tract

“Pathway of Crude Touch Sensation”

Looks like the lateral pathway

The 2nd order here is main sensory nucleus also in posterior horn

The difference is in pain and temperature pathway → lateral column through L.S.T.T

While crude touch pathway → ventral (anterior) column through A.S.T.T

- Has the same pathway as lateral spinothalamic tract but the second order neuron is **main sensory nucleus** in posterior horn cells.
Not substantia gelatinosa of rolandi
- The axons cross to the opposite side through the white ventral commissure and ascend in the ventral column of the spinal cord as the **Ventral Spinothalamic Tract**.
Not lateral
Axon of the 2nd order neuron
- Found in the **VPL nucleus** of the thalamus.

In Brain stem and in lateral medulla they get close to each other and joined and called spinal lemniscus

N.B. The spinal lemniscus = lateral spinothalamic tract + ventral spinothalamic tract

In PICA syndrome and the spinal lemniscus is damaged it will affect pain temperature and crude touch in the **contralateral side**

Lesions of the Anterolateral System

- **Lesions to the posterior horn cells:** ^{In case of Syringomyelia} **Ipsilateral** ^{Before decussation} **at the** ^{Fibers or nerve not tract} **same level** loss of pain and temperature, and nondiscriminative forms of touch sensations. ^{Crude touch}
- **Lesions to the anterolateral spinothalamic tract:** **Contralateral loss** of pain and temperature, and nondiscriminative forms of touch sensations **below the level** of lesion.
- **Lesions thalamus and postcentral gyrus:** **Contralateral loss** of pain and temperature, and nondiscriminative forms of touch sensations.

B. Posterior Column Medial Lemniscus System

Responsible for proprioception and fine touch and deep sensation for joint

- The posterior column-medial lemniscus system carries general somatic afferent (general sensory) information about **discriminative “Fine” touch, pressure, vibration and conscious proprioception.**
- Receives input from Pacinian and Meissner’s corpuscles, joint receptors, muscle spindles, and Golgi tendon organs.
- Transmitted through the fast-conducting large-diameter fibers **(A-Beta fibers).**

Pathway of Posterior Column Medial Lemniscus System

1st order neuron → posterior dorsal spinal root ganglion

2nd order neuron → Gracile and Cuneate nuclei

3rd order neuron → ventral posterolateral nucleus of thalamus (VPL)

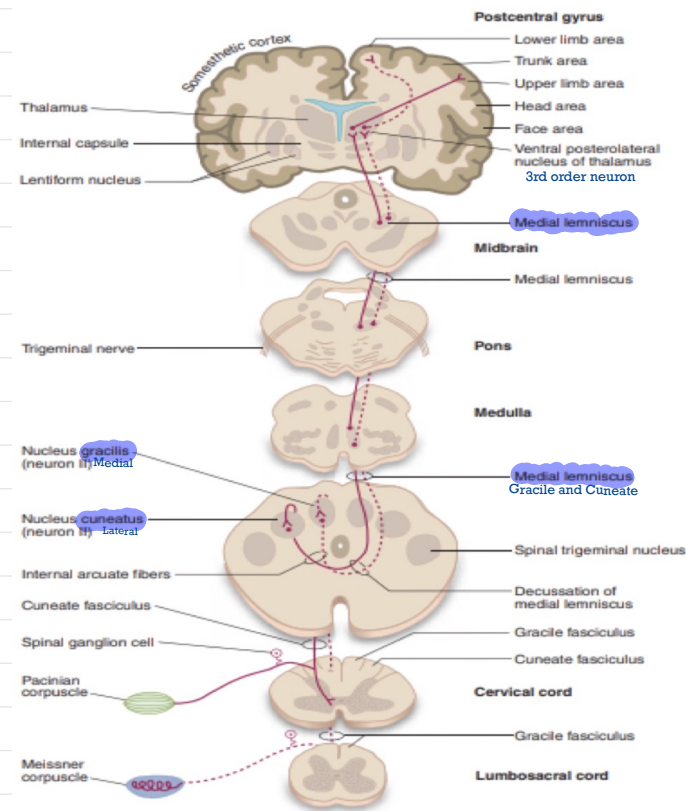
Gracile is responsible for signals from lower half = below T6

Cuneate is responsible for signals from upper half = T6 and above

Pathway of deep sensation fine touch and proprioception

Stimulation of sensation of joint receptors → Ascends in the peripheral nerves and transmit the signal to the post. Root ganglion and the relay is achieved → It has been reach the 1st order neuron → post. Root ganglion, and take the signal directly to the post. Column and do not enter the gray matter so in case of syringomyelia (affect gray matter) → so the proprioception is intact has no relation to gray matter

The signal transmits through Gracile tract medial for lower half of the body or Cuneate tract lateral for upper half of the body and arise at the ipsilateral side without decussation crossing until it reach medulla oblongata and the decussation happened and the tract become more medial and the common tract called medial lemniscus and ascends to brain stem → Ascends until it reach the thalamus and goes to ventral posterolateral nucleus of thalamus VPL Some sources confirm it is posteromedial



If Gracile tract is damaged the loss of proprioception and fine touch is in the ipsilateral lower half of the body

If Cuneate tract is damaged → the loss of proprioception and fine touch is in the ipsilateral upper half of the body

If both Gracile and Cuneate tracts is damaged → the loss of proprioception and fine touch is in the ipsilateral below the level of the lesion

If medial lemniscas is damaged → the loss of proprioception and fine touch is in the contralateral side below the level of the lesion

Before nucleus (gracilis and cuneatus) any damage is affect the ipsilateral side
From medial lemniscus to the cortex any damage is affect the contralateral side

Pathway of Posterior Column Medial Lemniscus System

1. The first order neuron:

Found in **the posterior root spinal ganglion** at all levels.

The process divided into:

- **The lateral branch (Dendrite):** goes peripherally forming the afferent sensory nerve (the ends of this nerve are receptors of the tendon).
- **The medial branch (Axon):** enters the SC and ascends directly in the Gracile and Cuneate tracts “Fasciculus” within the posterior column **at the same side** to relay in the **Gracile and Cuneate nuclei** of the medulla.

Pathway of Deep Sensation

2. The second neuron:

- Is the cells of **the Gracile and Cuneate nuclei** in the medulla→ give rise to axons, **internal arcuate fibers** that decussate to the opposite side of the medulla oblongata ascends as **Medial Lemniscus through** → the pons → the mid brain → to relay in the “PLV” nucleus of thalamus.

3. The third order neuron:

Starts in the cells of **the posterolateral ventral nucleus (PLV) nucleus of the thalamus**, its axon ascends to pass through the posterior limb of the internal capsule conducting the impulse to the cortical somatic sensory area (1, 2, 3) in the upper 2/3rd of the postcentral gyrus of the parietal lobe.

6

The medial lemniscus terminates in the VPL of the thalamus. From the thalamus, fibers project through the internal capsule and corona radiata to terminate in the primary somatosensory cortex (postcentral gyrus).

5

As the medial lemniscus continues to ascend through the rostral pons and midbrain, it moves laterally and becomes more vertical.

4

In the caudal pons, the medial lemniscus flattens horizontally.

3

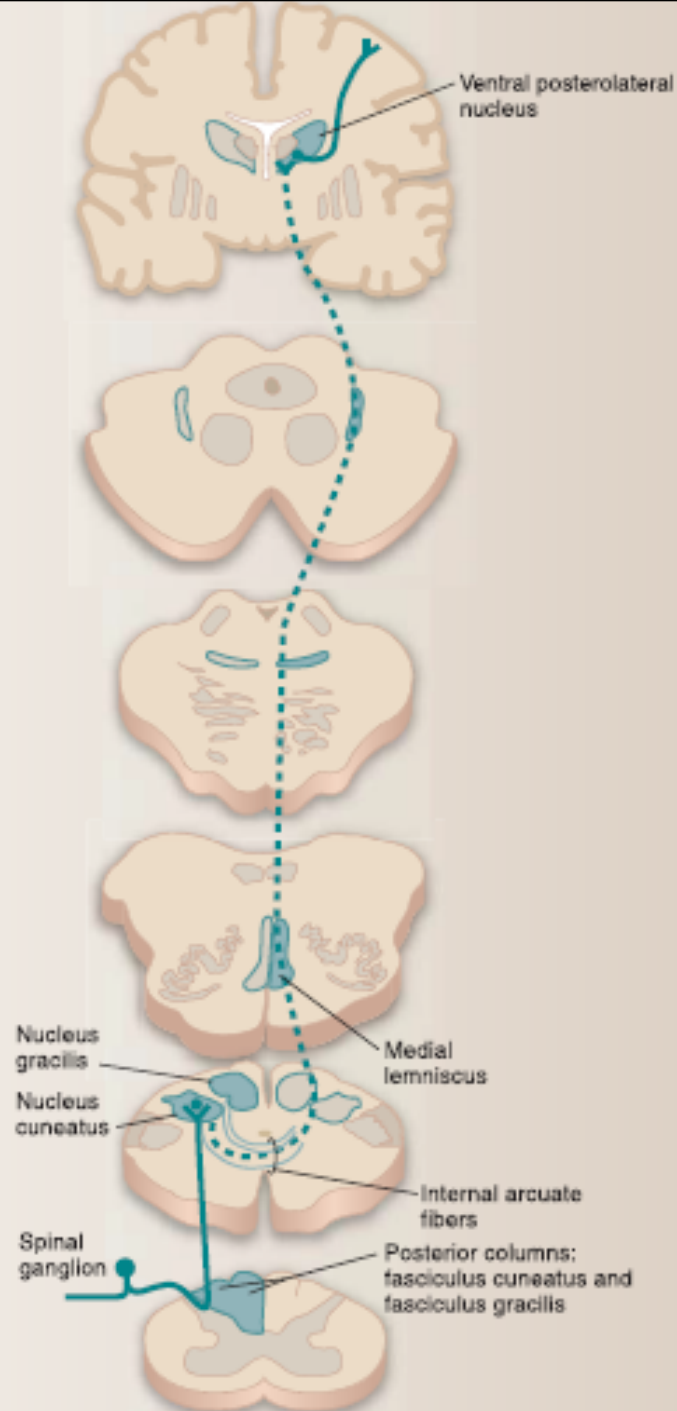
In the rostral medulla, the fibers travel as the medial lemniscus adjacent to the midline.

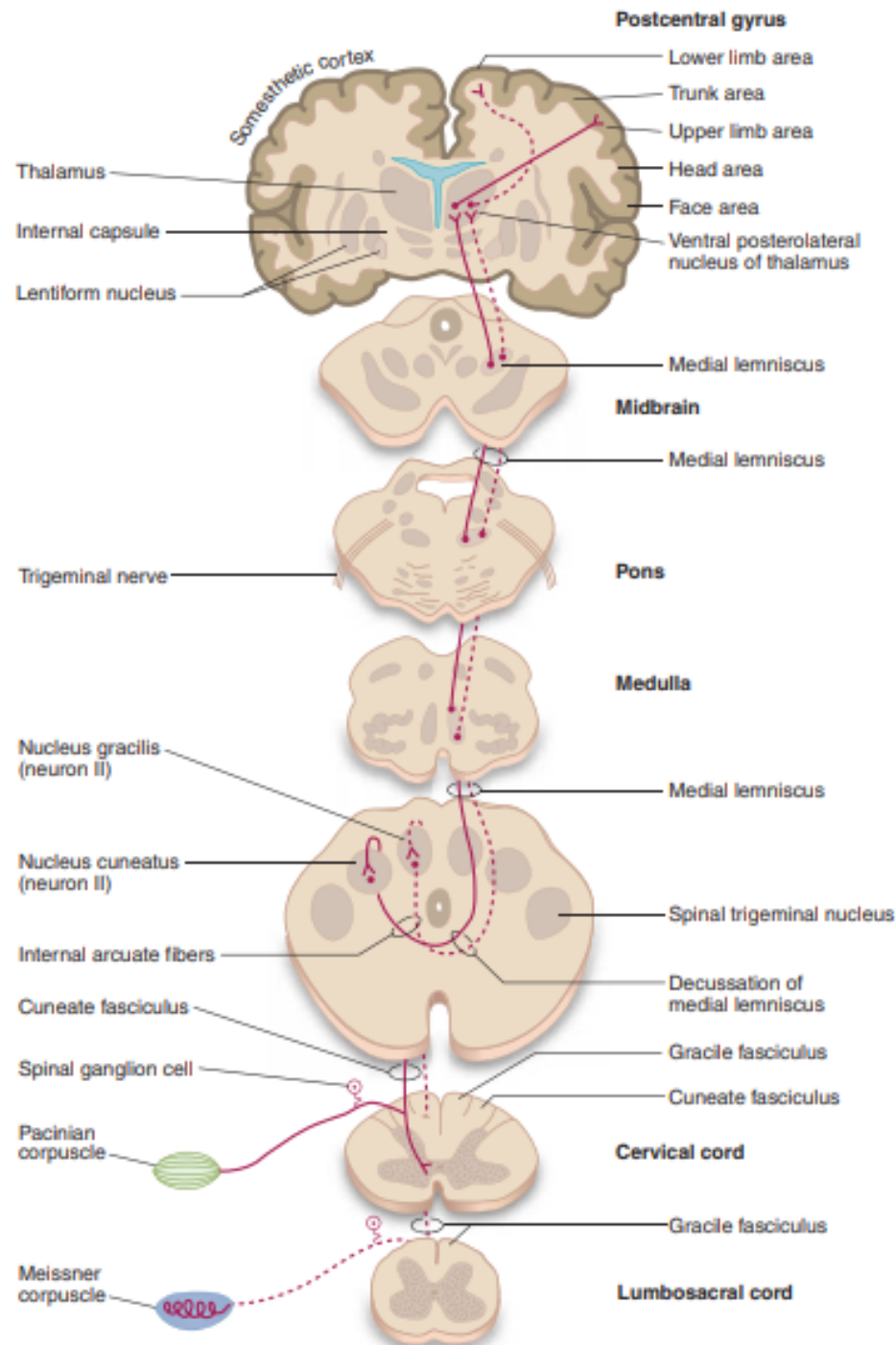
2

They terminate in nucleus gracilis and nucleus cuneatus. From these nuclei, axons of secondary neurons cross the midline as internal arcuate fibers and form the medial lemniscus.

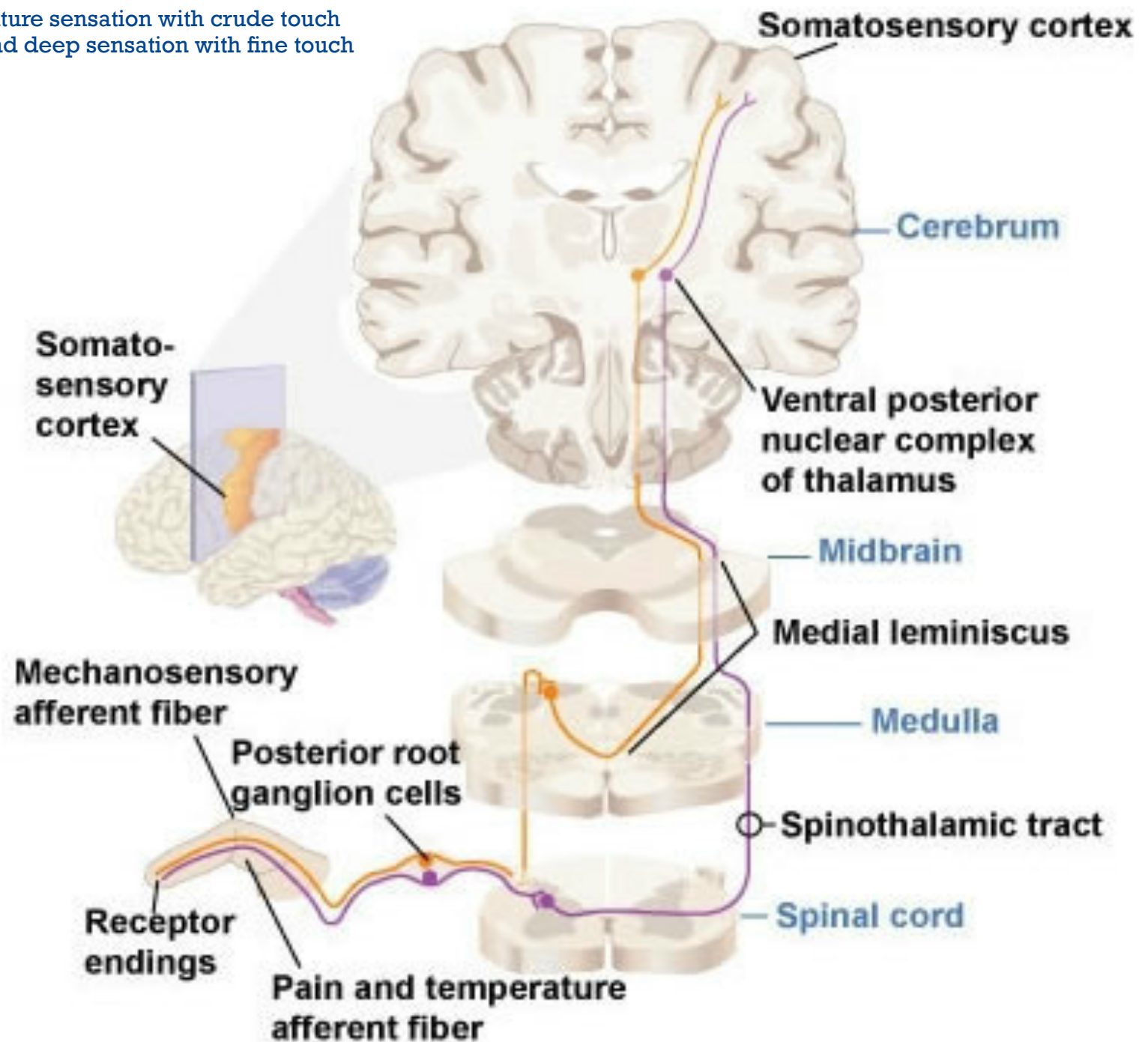
1

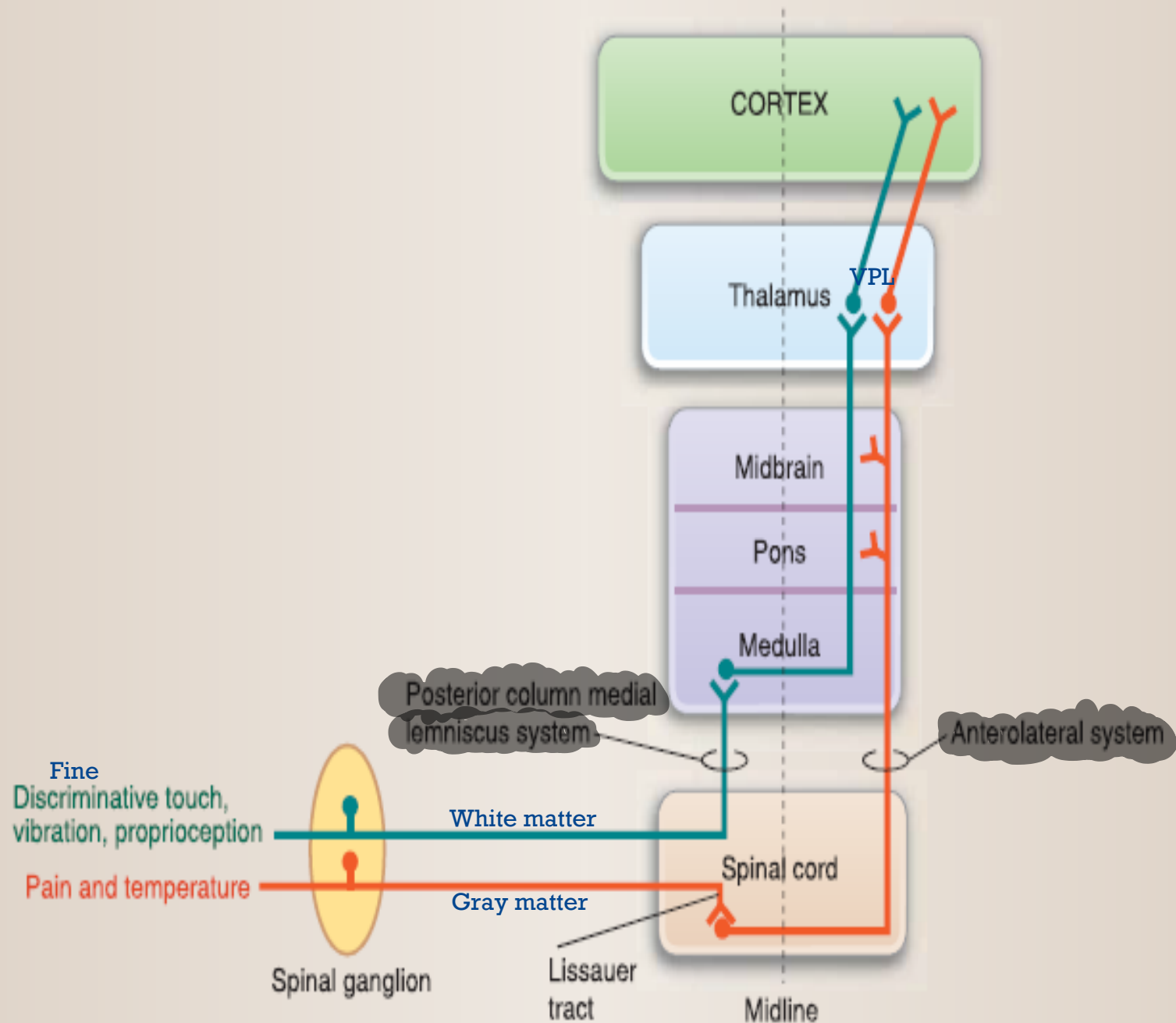
Axons enter the spinal cord from the spinal ganglia and pass directly to ipsilateral posterior column. Caudal fibers (up to and including T6) enter fasciculus gracilis (medial) and rostral fibers (above T6) enter fasciculus cuneatus to ascend.





- Pain and temperature sensation with crude touch
- Proprioception and deep sensation with fine touch





Lamination of the Gracile and Cuneate Tracts

- ❖ **The Gracile Tract:** lies more medially and received impulses from the lower part of the body (the lower limbs and lower half of the trunk).
- ❖ **Cuneate Tract:** lies more laterally and received impulses from the upper part of the body (the upper limbs and upper half of the trunk).
- ❖ **From medial to lateral side:** sacral nerve fibers → lumbar nerve fibers → thoracic nerve fibers → cervical nerve fibers.

هذه يبين ترتيب الـ fibers انوكال م بطلح ل فوق
بتصير الـ fibers على الجوانب lateral وهكذا

So the upper part of the body more lateral
While medial part is more medial

Lesions of the Posterior Column Medial Lemniscus System

- **Lesions to the posterior columns:** **Ipsilateral loss** Below the level of discriminative touch, pressure, vibration and conscious proprioception “Sensitive Ataxia”.
- **Lesions to the medial lemniscus, thalamus and** **postcentral gyrus:** Cortex **Contralateral loss** Below the level of discriminative touch, pressure, vibration and conscious proprioception “Sensitive Ataxia”.  **Conscious proprioception is done** 

 **Next: unconscious proprioception.**

C. Spinocerebellar Tracts

1. ^{Dorsal} Posterior spinocerebellar tract: Uncrossed → Goes to inf. Cerebellar peduncle

- Transmits unconscious proprioceptive information to the cerebellum.
- Receives input from muscle spindles, Golgi tendon organs, and pressure receptors.
- Carries unconscious proprioceptive information from ipsilateral lower extremity and trunk.
- An uncrossed tract.

Ps. The proprioception is related to fine touch not crude touch

2. ^{Ventral} Anterior spinocerebellar tract: Double crossing → goes to sup. Cerebella peduncle

- Transmits unconscious proprioceptive information to the cerebellum.
- Carries proprioception from the lower limb to the cerebellum .
- Receives input from muscle spindles, Golgi tendon organs, and pressure receptors.
- A crossed tract. Double crossing

3. Cuneocerebellar tract:

- The upper-extremity equivalent of the posterior spinocerebellar tract.

Uncrossed → so any damage at any site it will cause ipsilateral ataxia

1. Posterior Spinocerebellar Tract

For unconscious proprioception and fine touch for lower part of the body

“Flechsig’s Tract”

a. First-order neurons:

- Found in the ^{Same as conscious} **posterior spinal root ganglia**.
- Project in the posterior thoracic nucleus “Clarck’s nucleus”.

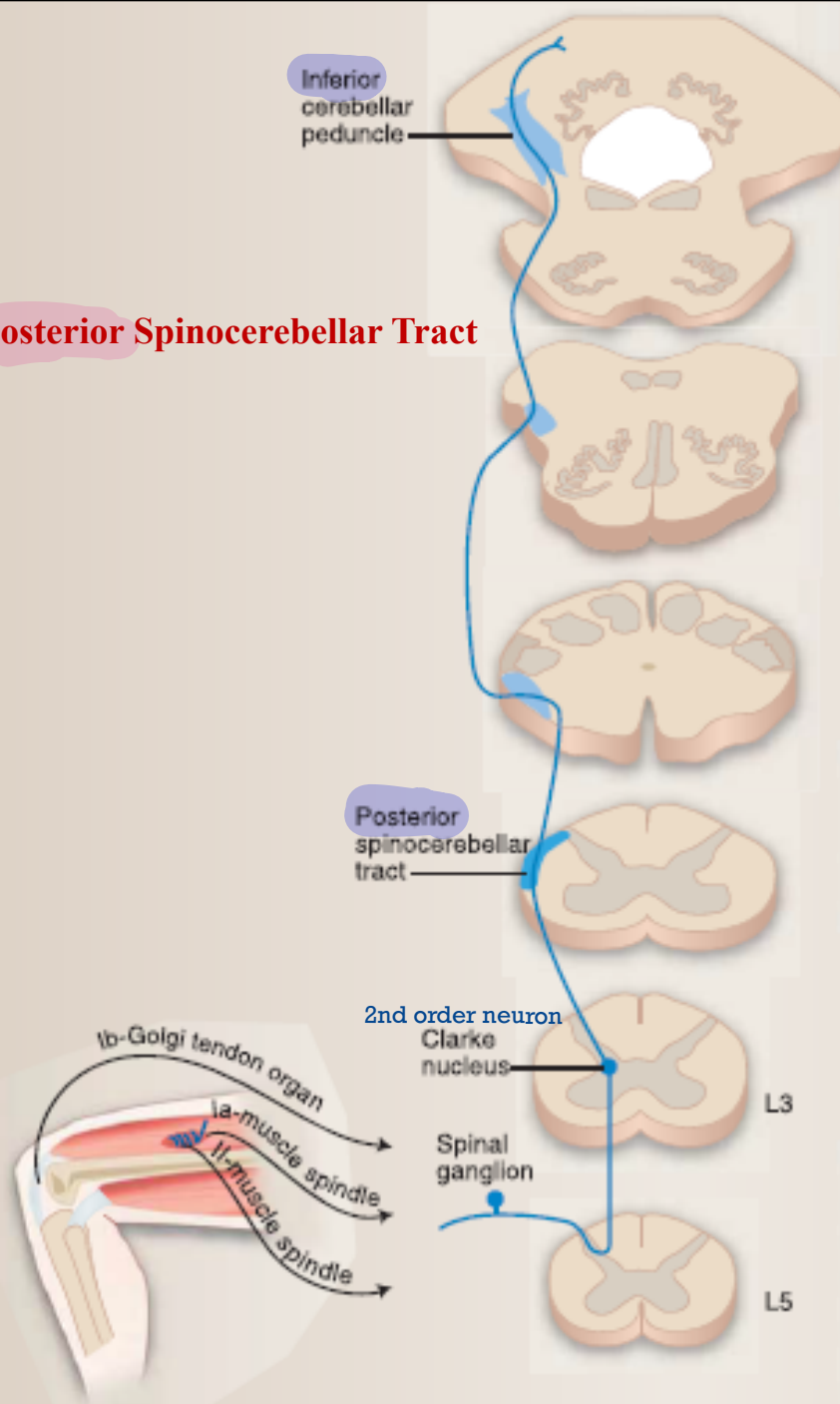
b. Second-order neurons:

- Found in ^{Differs from conscious} **the posterior thoracic nucleus “Clarck’s nucleus”** of (C8–L3).
- Give rise to axons that ascend in the lateral funiculus and reach the cerebellum via **the inferior cerebellar peduncle ipsilateral**.

Pass lateral and because it is more posterior it takes the name → post. Spinoerebellar tract

Even that it is located in the lateral column but more posteriorly

Posterior Spinocerebellar Tract



3

In the rostral medulla **posterior spino-cerebellar fibers** travel through the inferior cerebellar peduncle to the ipsilateral cerebellum, mainly to the anterior lobe and the vermis.

2

Fibers then travel in the **posterior spino- cerebellar tract** through the spinal cord and brainstem.

1

Proprioceptive information from muscle spindles and Golgi tendon organs (Ia, Ib, and II fibers) and from skin enters the spinal cord. Fibers travel in the fasciculus gracilis until they reach L3 where they synapse in the Clarke nucleus. The Clarke nucleus extends from L3 to C8.

2. Anterior Spinocerebellar Tract

For unconscious proprioception and fine touch for lower part of the body

a. First-order neurons:

- Found in the **posterior spinal root ganglia**.
- Project in the posterior horn cells and make synapse with the spinal border cells.

b. Second-order neurons:

- Found in **the spinal border cells** of anterior horns (L1–S2).
2nd order neuron
Scattered nuclei
- Give rise to axons that **decussate** in the anterior white commissure and ascend lateral to the lateral spinothalamic tract in the lateral column.
Rt. → Lt.
But more anterior
- Give rise to axons that enter the cerebellum via **the superior cerebellar peduncle contralateral**. They then cross the midline again and project the anterior lobe and vermis.
At the level of midbrain = superior cerebellar peduncle another decussation
Lt. → Rt.

Lesion: Contralateral lower limb discoordination “Ataxia”. The patient has difficulty performing the heel-to-shin test.

So if the track damaged in the spinal cord it will cause **contralateral ataxia**
After the 1st crossing

If the damage in the cerebellum = after the 2nd crossing → **ipsilateral ataxia**

Anterior Spinocerebellar Tract

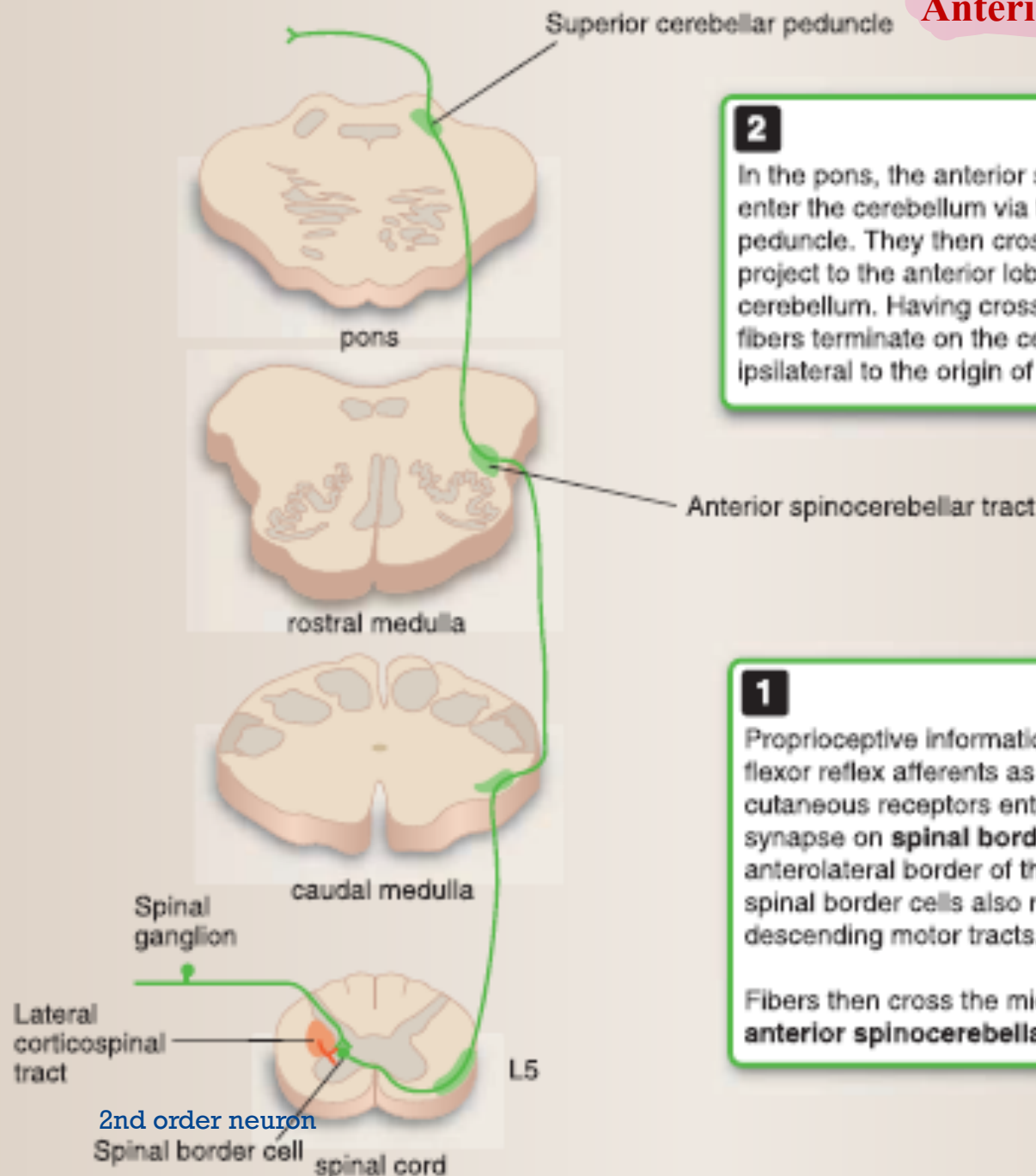
2

In the pons, the anterior spinocerebellar fibers enter the cerebellum via the superior cerebellar peduncle. They then cross the midline again and project to the anterior lobe and vermis of the cerebellum. Having crossed the midline twice, the fibers terminate on the cerebellar hemisphere ipsilateral to the origin of the stimulus.

1

Proprioceptive information from Ia and Ib fibers and flexor reflex afferents as well as information from cutaneous receptors enter the spinal cord and synapse on **spinal border cells** located in the anterolateral border of the anterior horn. These spinal border cells also receive information from descending motor tracts.

Fibers then cross the midline and travel as the **anterior spinocerebellar tract**.



3. Cuneocerebellar Tract

For unconscious proprioception and fine touch for upper part of the body

a. First-order neurons:

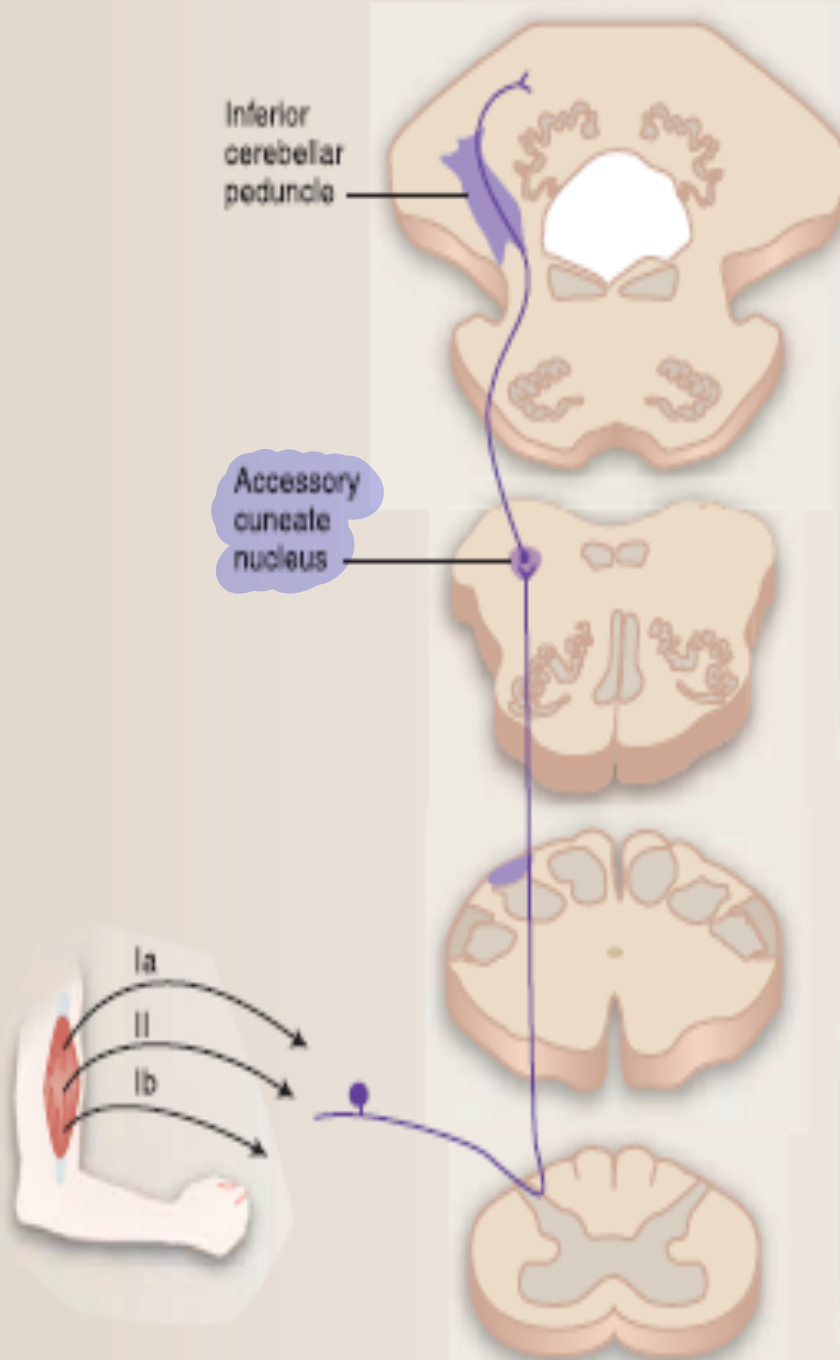
- Found in **the posterior spinal root ganglia** “C2 to T7”.
- Project their axons via the **Cuneate tract** to the medulla,
In dorsal column
where they synapse in the **accessory cuneate nucleus**
(similar to Posterior thoracic nucleus “Clarck’s nucleus”).

Pass through spinal cord without relay station
It relay in medulla oblongata

b. Second-order neurons:

- Located in **the accessory cuneate nucleus** of the medulla.
2nd order neuron
- Give rise to axons that project **ipsilaterally** to the cerebellum via **the inferior cerebellar peduncle**.
Like posterior

Cuneocerebellar Tract



2

Cuneocerebellar fibers originate in the accessory cuneate nucleus in the rostral medulla and then travel through the ICP to the ipsilateral cerebellum, mainly to the anterior lobe, vermis and intermediate zone.

1

Ia, Ib, and II fibers as well as fibers from skin receptors enter the spinal cord above C8 and travel with the fasciculus cuneatus to the rostral medulla.

Descending Tracts of the Spinal Cord

- A. **Lateral corticospinal (LC)**: ^{Indirect = crossed} crossed pyramidal tract.
- B. **Rubrospinal tract (LC)**: an extrapyramidal tract.
- C. **Lateral reticulospinal tract (LC)**: an extrapyramidal tract.
- D. **Hypothalamospinal tract (LC)**: the fibers arise from the hypothalamus & end in ^{So if damaged in PICA syndrome cause ipsilateral Horner syndrome} autonomic cells in the lateral horns.
- E. **Olivospinal tract (LC)**: an extrapyramidal tract.

F. Sulcomarginal tract (AC): is very close to anterior median fissure.

Responsible for respiratory muscles and gives ant. horn cells that responsible for chest muscles bilateral innervation so in hemiplegic patient the respiration is intact

G. Anterior corticospinal tract (AC): contains uncrossed corticospinal fibers.

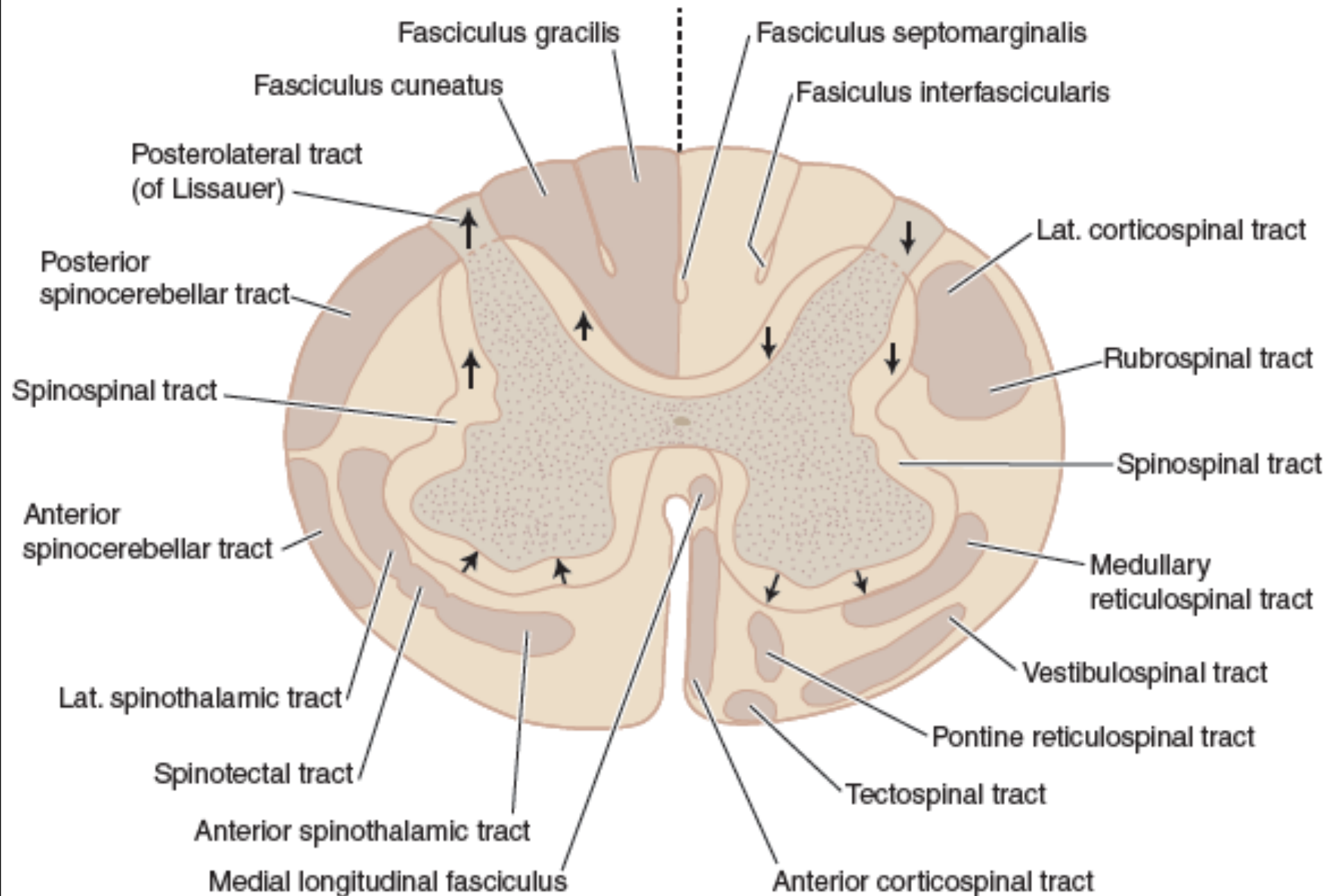
H. Medial reticulospinal tract (AC): an extrapyramidal tract.

I. Tectospinal tract (AC): arises from the superior colliculus of midbrain & the fibers end in the A.H.Cs. (spinovisual reflexes).

J. Vestibulospinal tract (LC): for equilibrium arises from vestibular nuclei & ends in the A.H.Cs.

Ascending tracts

Descending tracts



The Pyramidal Tract

- The pyramidal tract is a bundle of motor nerve fibers.
- It begins in the cerebral cortex and ends in:
 - a. **Anterior horn cells of the spinal cord**
(corticospinal tract).
 - b. **Motor nuclei of the cranial nerves** in the brain stem (corticonuclear or corticobulbar tract).

- **The pyramidal tract consists of:**

Arise from upper 2/3 precentral gyrus area 4
and descends to lower part of medulla

1. **Corticospinal tracts (lateral & ventral).**

85-90% Crossed
Responsible for lower
and upper limb

Any stroke in brain → the
hemiplegia is in the contralateral

While any damage in SC → the
motor effect is ipsilateral

10-15% Uncrossed
For respiratory muscles

مشكلة نظرية إليه

2. **Corticonuclear or corticobulbar tracts (Lateral & Medial).**

From lower part of precentral gyrus and
goes to motor nuclei in brain stem

The Upper Motor Neuron System (Corticospinal Tract)

In upper motor neuron lesion hypertonia plasticity hyperreflexia and paralysis

If damage above decussation the effect will be contralateral while if below decussation the effect will be ipsilateral

Function:

1. Initiation and control of voluntary motor activity.
2. Inhibition of muscles tone.
3. Inhibition of deep reflexes.

The Lower Motor Neuron System (Spinomuscular Fibers)

If lower motor neuron lesion hypotonia and hyporeflexia

Upper العصب

Function:

1. Stimulation of voluntary motor at the level of the same side.
2. Stimulation of muscles tone at the level of the same side.
Hypertonia= plasticity
3. Stimulation of deep reflexes at the level of the same side.

A. The Lateral Corticospinal Tract *Ends at S2 segment*

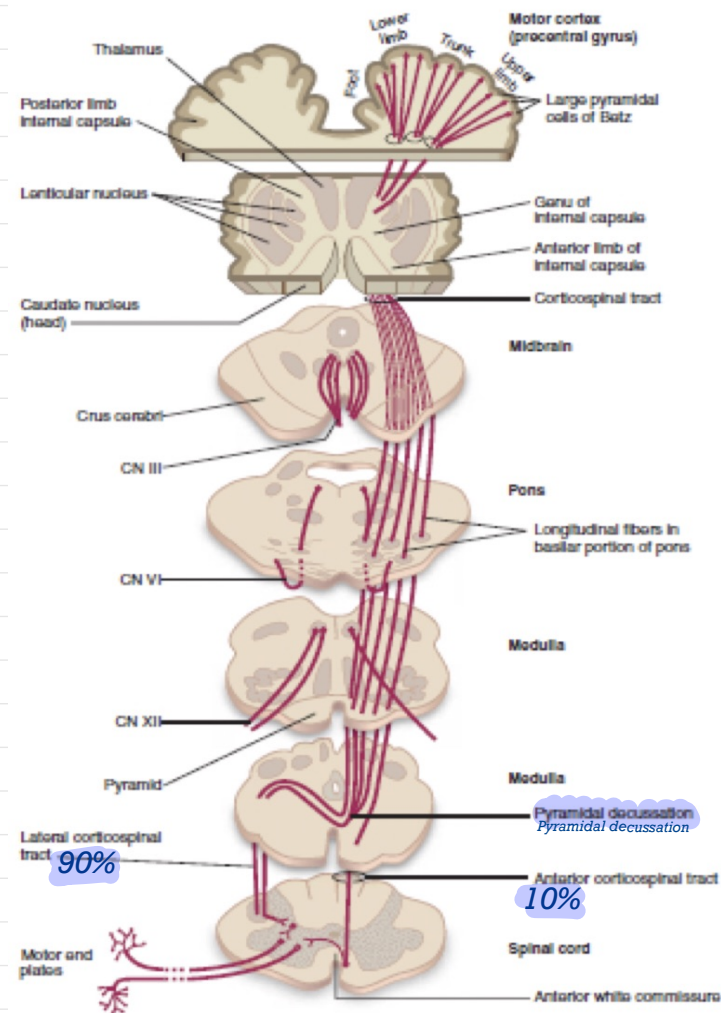
B. The Anterior Corticospinal Tract *Ends at midthoracic level Responsible for respiratory muscle*

Fibers come from upper part of the central gyrus

Then pass through post. Limb of the internal capsule → then midbrain → pons → medulla oblongata

At the lower part of MO the decussation happened and goes to the lateral column as A → lateral corticospinal tract

Each segment it gives fibers to the ant. horn cells → then give anterior root → then spinal nerve → supplies muscle



Lower motor neuron lesion

So if the anterior root or anterior horn cells or spinal nerve is damaged → the result effect is ipsilateral at the same level

While if the upper motor neuron is damaged → the result effect is contralateral below the level

If stroke (damage of cerebral hemisphere) happened → contralateral hemiplegia

If just lateral column and the cut just for lateral corticospinal tract → ipsilateral below the level of lesion

بمجرد م ال lesion بال tract يفقد النظر على أي ليقال يُعتبر upper motor neuron lesion

طول وهو ما شفي يعطي أفرج لل segments of SC فكل م ينزل تحت يقبل القطرو السماكة تاحته

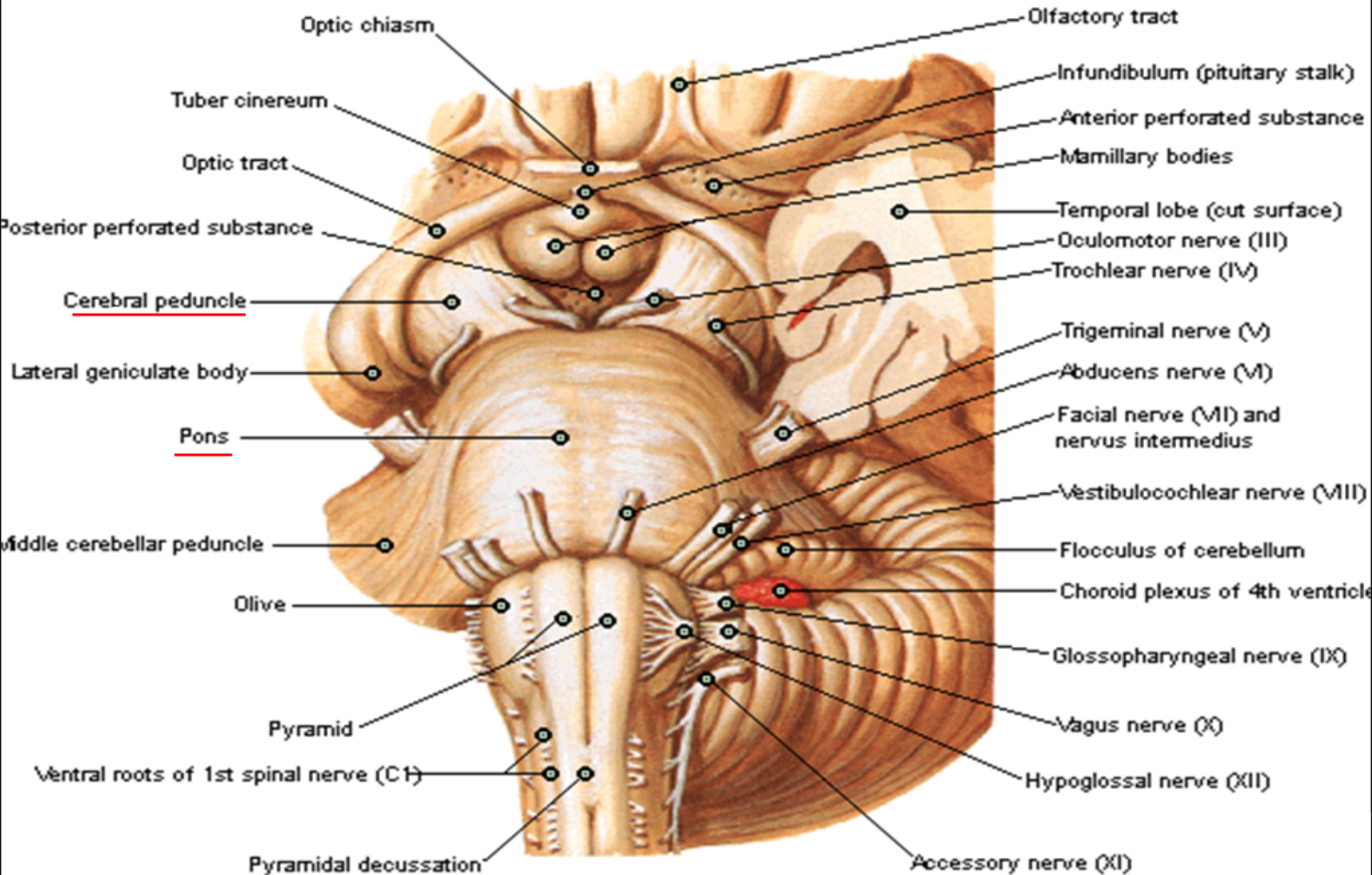
A. The Lateral Corticospinal Tract

B. The Anterior Corticospinal Tract

- ❖ From Betz cells in motor area 4 (in the upper ^{In layer 5 in the cortex} ^{In internal pyramidal layer} 2/3 ^{Motor} precentral gyrus of frontal lobe) → descends in the corona radiata → pass in the posterior limb of the internal capsule → descends in midbrain, pons and medulla oblongata.
- ❖ In the medulla the pyramidal fibers collect to form the pyramid → **pyramidal decussation.**

Brainstem

Anterioinferior View



Lower motor neurons ant. horn cells, root,
nerve → ipsilateral at the level

Form incomplete decussation

➤ **In the lower medulla:** Any damage of corticospinal tract above decussations →
cause hemiplegia in contralateral side = upper motor neuron

a. 85 - 90% of fibers decussate to descends → in the lateral column of the opposite side of the spinal cord (**indirect or lateral crossed corticospinal tract**). The tract gradually diminishes in size and ends about the level of S3 or S4 segment of the SC. **For regulation of voluntary movement.**

b. 10 - 15% of fibers descend directly → in the anterior column of the same side (**direct or anterior corticospinal tract**) then gives fibers for AHCs at the segmental level in both side. They descend in the spinal cord until they disappear in the midthoracic region.

Uncrossed

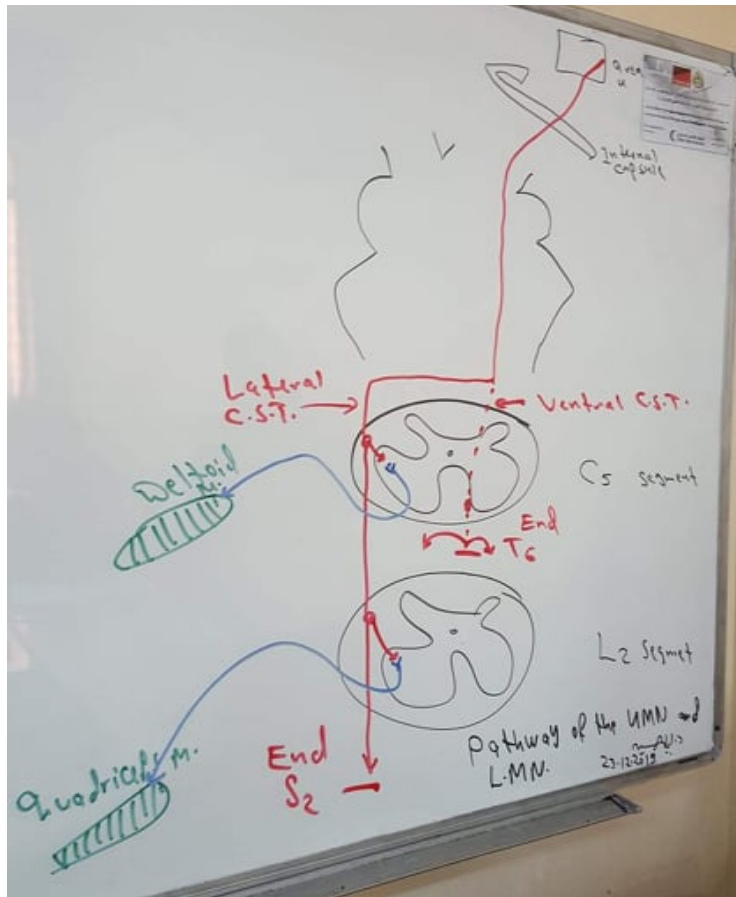
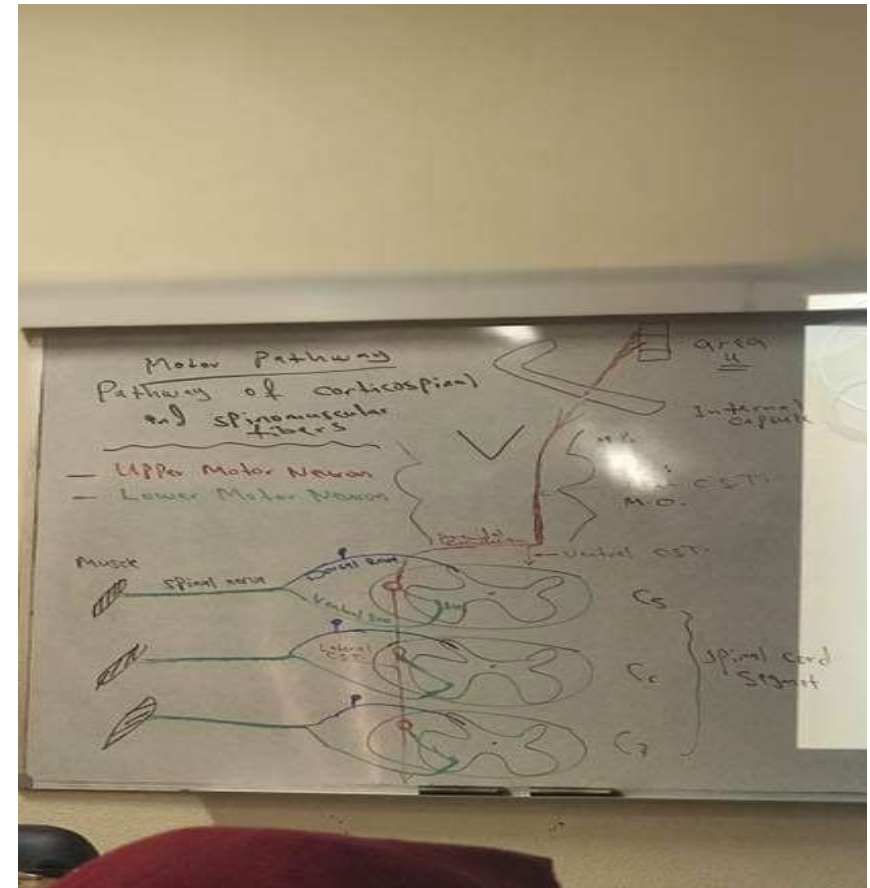
For chest muscles

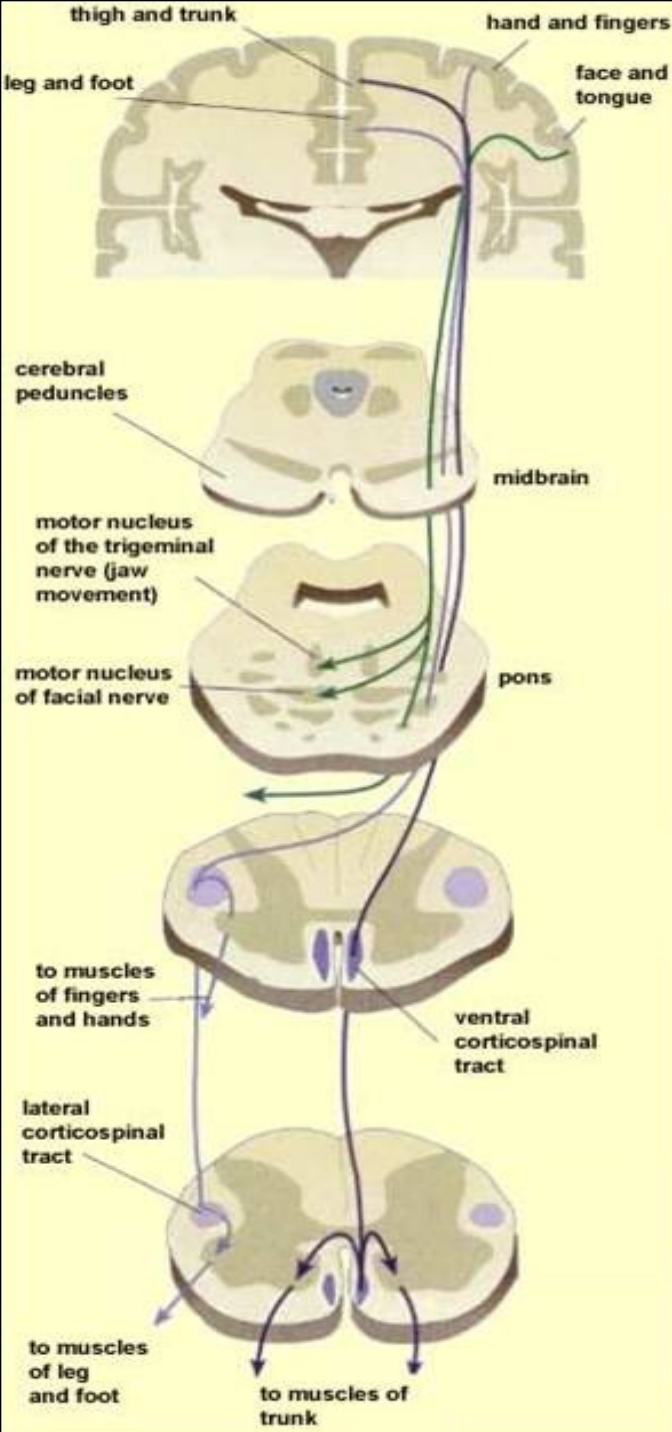
For respiratory (chest) muscle → no need after that

Anterior corticospinal tract give anterior horn cells for both sides for chest muscles

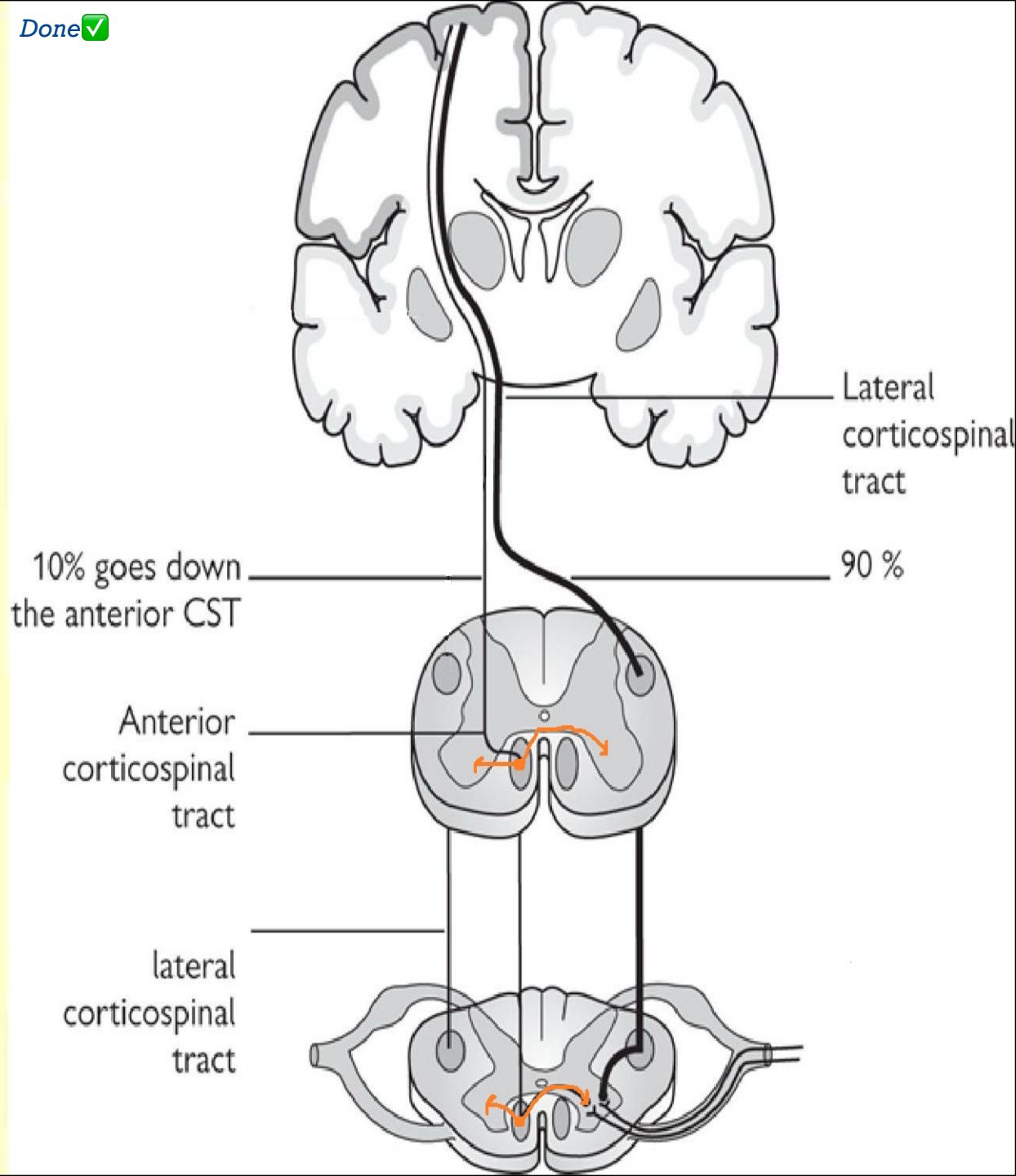
The result → chest muscles take from both cerebral hemisphere
And this explain the absence of respiratory failure in hemiplegic patient

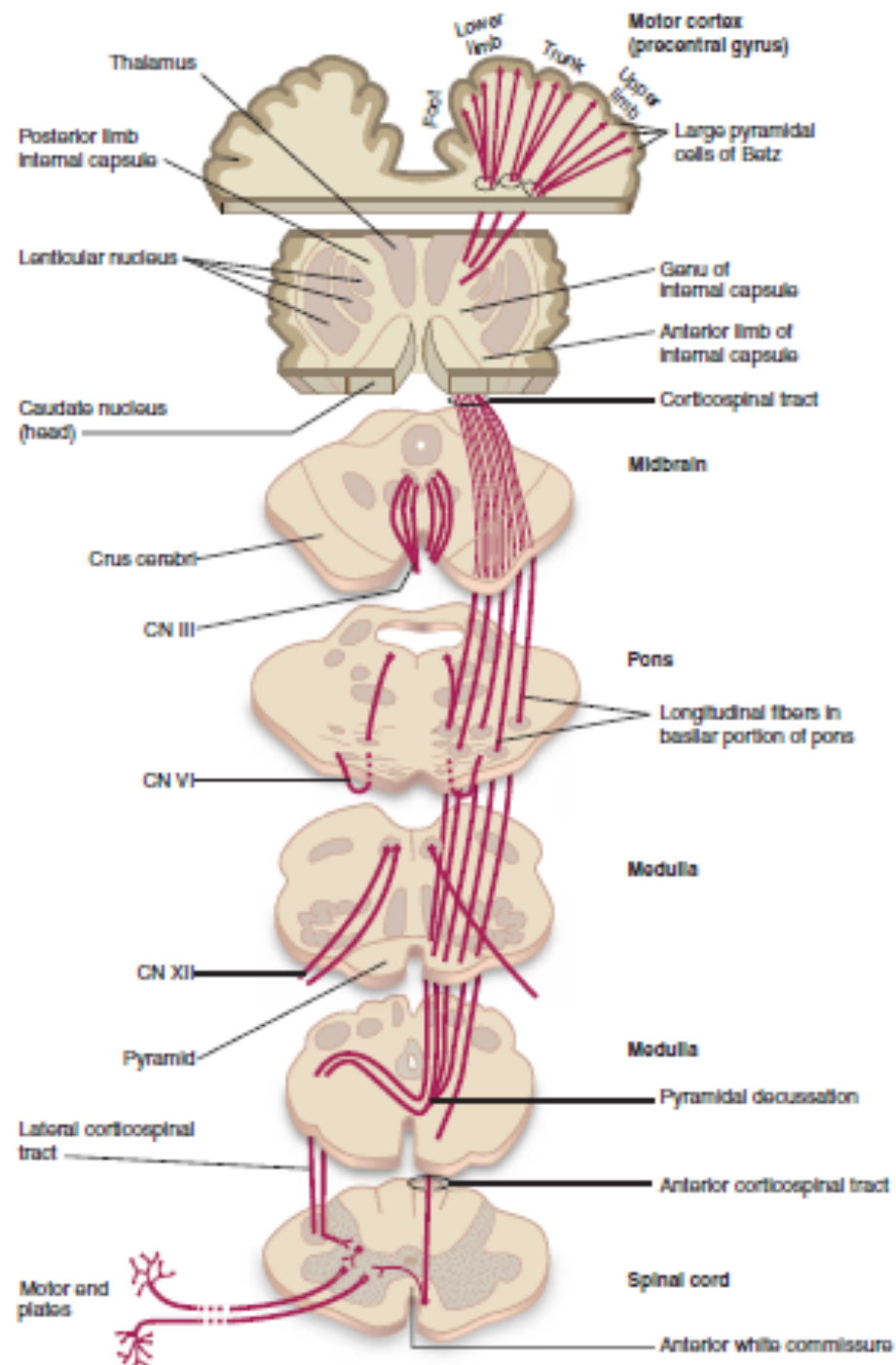
Each side take from both side
→ has dual innervation





Done ✓





The Corticospinal Tract

Above decussation Rt responsible for Lt and vice versa
Below decussation Rt responsible for Rt and so on

- The motor area of one side of cerebral hemisphere is responsible for movement of the muscles of the opposite $\frac{1}{2}$ of the body (mainly the limbs).
- Anterior or ^{Uncrossed} direct corticospinal tract end in both AHCs to supply the trunk and respiratory muscles.
- The muscles of respiration are received fibers from both cerebral hemispheres. This explain the absence of respiratory paralysis in hemiplegic person.

The Lower Motor Neuron System (Spinomuscular Fibers)

If lower motor neuron lesion hypotonia and hyporeflexia

Upper ^{عليا}

The symptoms at the level of the same side
While upper motor neuron below the level → if above
decussation contralateral if below decussation ipsilateral

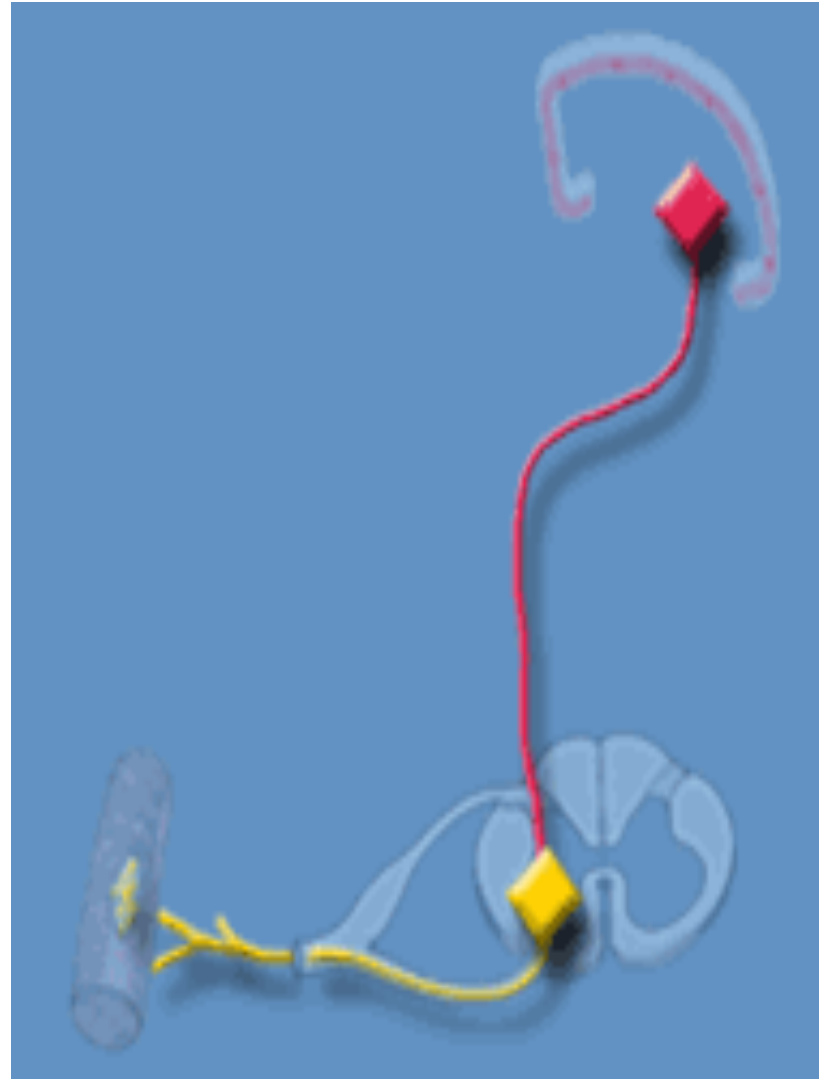
Function:

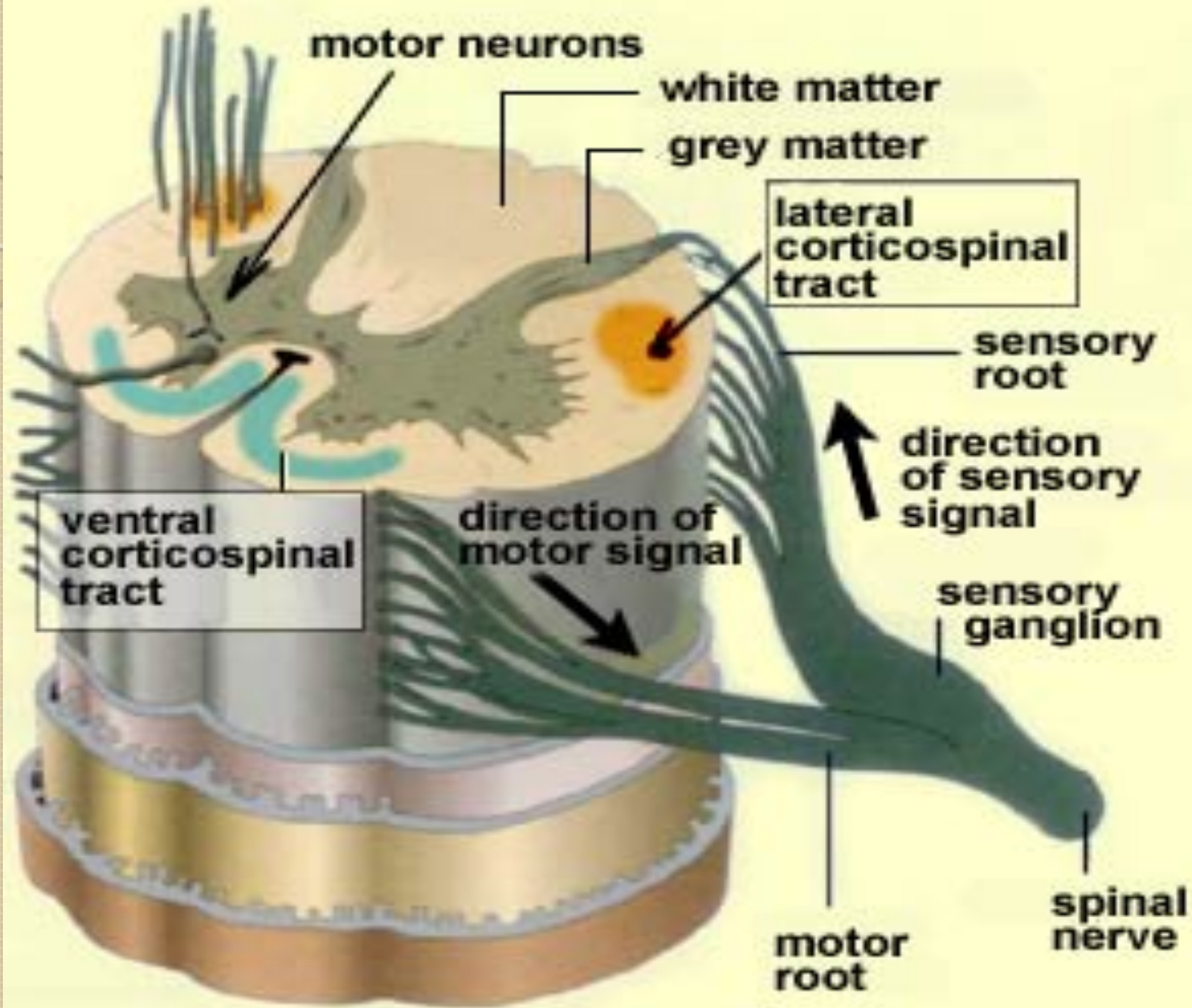
1. Stimulation of voluntary motor at the level of the same side.
2. Stimulation of muscles tone at the level of the same side.
^{Hypertonia= plasticity}
3. Stimulation of deep reflexes at the level of the same side.

Pathway of the Lower Motor Neuron System (Spinomuscular fibers)

From AHCs of the spinal cord
→ fibers exit from the spinal
cord as the anterior roots of
the same side → peripheral
nerves → motor end plate →
voluntary muscles.

If damaged the symptoms at the same level

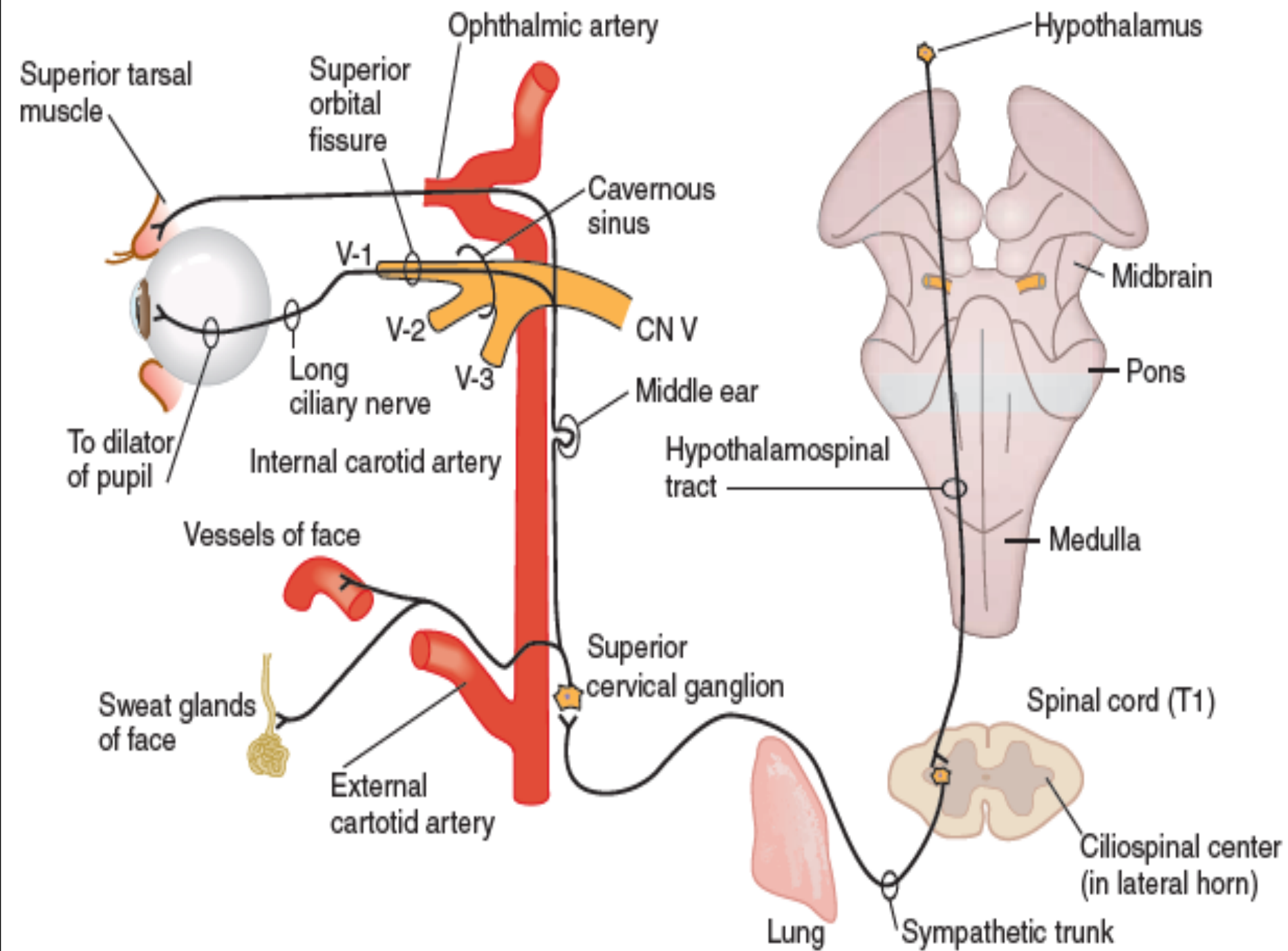




C. Descending Autonomic Tract “Hypothalamospinal Tract”

Has relation to sympathetic nervous system → if damaged it will cause Horner syndrome

- Project to sympathetic (T1–L2) and parasympathetic (S2–S4) centers in the spinal cord.
- Innervate the ciliospinal center (T1–T2), a pupillary center.
- Found in the posterior quadrant of the lateral column.
- Interruption of this hypothalamospinal tract: results in Horner syndrome.



Horner's Syndrome

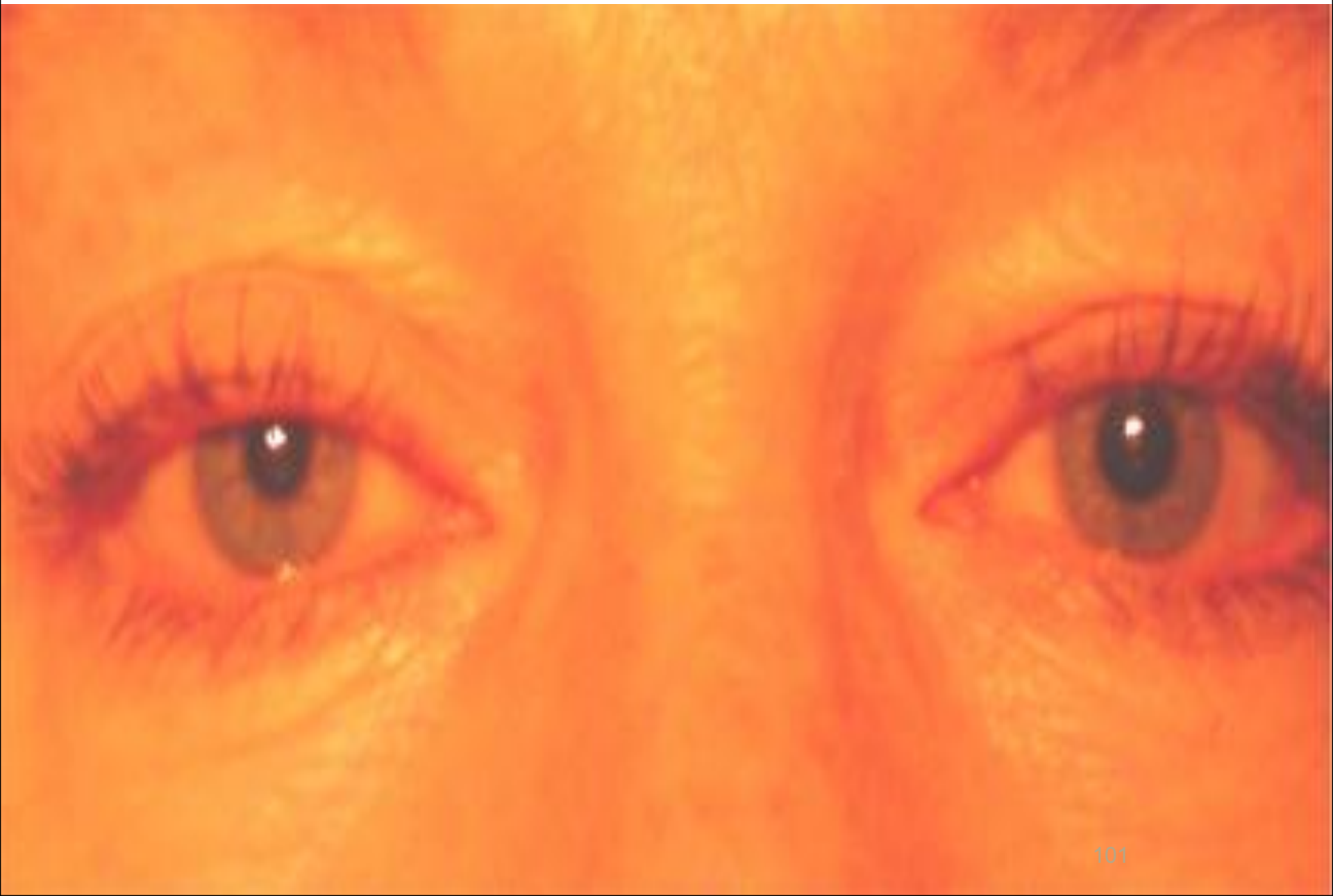
➤ Horner's Syndrome:

- Partial ^{Dropping eyelid}ptosis “paralysis of the Müller's muscle”.
- Miosis. ^{Constricted pupil}
- Enophthalmus.
- Anhydrosis. ^{Absence of lacrimal and sweat in face}

➤ Causes:

- **Brain lesion:** (massive ischemic stroke, brain stem lesion).
- **Cervical cord lesion:** ^{Affect the gray matter} (syringomyelia and cervical spinal cord tumor),
- **Neck pathology:** (Pancost tumor, cervical rib, neck surgery)

Horner's Syndrome



Classification of the Motor Neuron Lesion

I. According to the location of the lesion:

Corticospinal tract corticobulbar tract

1. Upper motor neuron lesion (spastic or central paralysis).
2. Lower motor neuron lesion (flaccid or peripheral paralysis).

Ant. horn cells spinal nerve
root motor nuclei in brainstem

II. According to the affected limbs:

1. Monoplegia (Rt. UL or LL, Lt. UL or LL): paralysis of one limb.
2. Hemiplegia (Rt. or Lt. sided): paralysis of one side of the body.
3. Paraplegia: paralysis of both limbs. 99% lower
4. Triplegia: paralysis of three limbs (one upper and two lower limbs).
5. Quadriplegia (tetraplegia): paralysis of four limbs. Same onset
6. Bilateral hemiplegia. Different onset

Lower Motor Neuron lesions (LMNL)

- Result from damage to motor neurons of the anterior horns or motor neurons of the cranial nerve nuclei.
- Result from interruption of the final common pathway connecting the neuron via its axon with the muscle fibers it innervates (the motor unit).

Signs of the Lower Motor Neuron lesions (LMNL)

1. Flaccid paralysis. Hypotonia
2. Muscle atrophy (hypotrophy). Ant. horn cells responsible for nourishment of muscles
3. Muscle hypotonia.
4. Areflexia of deep tendon and superficial reflexes.
5. Muscle fasciculations (visible muscle twitches). رَفَّة العِيْد
6. Muscle fibrillations (on electromyography).

Diseases of Lower Motor Neuron lesions

1. **Anterior horn cells lesion:** spinal muscular atrophy, ^{شلل الأطفال} poliomyelitis, and ^{Affect gray matter} syringomyelia.
2. **Peripheral nerve lesion:** mononeuropathy, polyneuropathy.
3. **Motor end plate lesion:** myasthenia.
4. **Muscle disease:** myopathy.

Upper Motor Neuron lesions (UMNL)

- Lesions of the corticospinal and corticobulbar tracts
“Pyramidal tract lesions”.
- May occur at all levels of the neuroaxis from the cerebral cortex to the spinal cord.
- When the lesion above the pyramidal decussation, the motor deficit present below the lesion, on the contralateral side.
- When the lesion below the pyramidal decussation, the motor deficit present below the lesion, on the ipsilateral side.

Signs of the Upper Motor Neuron lesions (UMNL)

1. Spastic paralysis.
2. Hyperreflexia of deep tendon reflexes.
3. Clonus: rhythmic contractions of muscles in response to sudden, passive movements (patellar, or ankle clonus).
4. Loss of superficial (abdominal and cremasteric) reflexes.
5. Muscle hypertonia “Clasp-knife spasticity”: when a joint is moved briskly, resistance occurs initially and then fades.
Rigidity type → kog wheel for Parkinson disease
6. Babinski sign: plantar reflex response that is extensor
Lat. To medial (dorsiflexion of big toe).

Diseases of Upper Motor Neuron lesions

1. **CVA.**
2. **Multiple sclerosis.**
3. **Brain and spinal cord tumors.**
4. **Inflammatory:** encephalitis, transverse myelitis.
5. **Traumatic:** head trauma, subdural hematoma, spinal cord trauma.
6. Congenital: cerebral palsy, hereditary spastic paraplegia.
7. **Degenerative:** vertebral spondylosis and myelopathy.
8. **Motor neuron disease.**